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The Effect of Proximity to Cellular Sites on Housing Prices in Israel

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השפעת קרבה לאתרים סלולריים על מחירי הדירות בישראל

דוד ג'נסוב, אלעד דה-מלאך, אסף זוסמן ונעם זוסמן

תקציר

מתחילת שנות האלפיים התרחבה מאוד פריסת האתרים הסלולריים בישראל. לאתרים עלולות להיות השפעות חיצוניות שליליות על מחירי דירות בשל החשש מנזקי קרינה ובשל המפגע החזותי. המחקר בחן סוגיה זו, לראשונה באופן שיטתי בישראל, באמצעות נתוני עסקאות בדירות מגורים ומידע מפורט על פריסת האתרים, שהתקבל מהמשרד להגנת הסביבה. נערכו אמידות של מחירי הדירות בשיטה הדונית ובגישת עסקאות חוזרות, המתחשבות בסלקטיביות אפשרית בהצבת האתרים.

לא נמצאה השפעה מובהקת של קרבה לאתרים הסלולריים על מחירי הדירות, לרבות במקרה של אתרי תורן, הבולטים מטבעם.

The Effect of Proximity to Cellular Sites on Housing Prices in Israel

Elad Demalach, David Genesove, Asaf Zussman, and Noam Zussman

Abstract

Since the beginning of the 21st century, there has been increasing deployment of cellular antennas in Israel. Such sites may have negative effects on housing prices, due to concern over radiation damage and visual obstruction. This study systematically examines this issue in Israel for the first time, using data on residential transactions and detailed information from the Ministry of Environmental Protection on the deployment of cellular antennas. Housing prices were estimated through hedonic and repeated sales methods that take into account a potential selection bias in the placement of antennas.

Cellular antennas were found to have no statistically significant effect on housing prices. The estimates remained insignificant even for proximity to pole antennas, which are naturally more visible.

1. Introduction

The use of cellular telephones in Israel began in the late 1980s, and subsequently expanded at a rapid pace. Today, approximately 95 percent of households have at least one cellular line (Central Bureau of Statistics, 2015), and the number of cellular telephone lines is nearing 10 million (World Bank, 2015a, 2015b). The number of cellular sites (places in which at least one cellular antenna has been stationed) currently exceeds 6,000.

The sharp increase in mobile communications services has been accompanied by a substantial expansion in deployment of cellular antennas and sites. The cellular sites may have negative effects on the values of the properties in their vicinity: non-ionizing radiation[1] emitted from the antennas may cause damage to health, and the large conspicuous antennas are an aesthetic nuisance.

There is no consensus in the medical research literature concerning the health damage of cellular radiation in general or of proximity to antennas in particular. The International Agency for Research on Cancer (IARC) recently classified cellular radiation as a possible carcinogen, but also found that exposure to radiation emitted from cellular antennas was usually negligible, and that its magnitude was far less than the magnitude of radiation emitted from the cellular device itself (IARC, 2013). Even in the absence of an unequivocal scientific finding about the negative effects of the radiation on health, the general public is likely to fear it, and as a result, prices of properties near to cellular sites may decrease (see Barzilai (2005) for further discussion). It is now possible to file a diminished property value claim due to proximity to a cellular site, either by filing a request at the Local Planning and Building Commission or by filing a lawsuit for damages. On the other hand, no rate has been established for the amount of compensation.

The current study systematically estimates, for the first time in Israel, the effects of cellular sites on residential housing prices. The databases for the study are files of transactions in residential housing compiled by the Israel Tax Authority for 2000–11, which have been merged with files from the Ministry of Environmental Protection about all the cellular

[1] Non-ionizing radiation is electromagnetic radiation that is incapable of ionizing atoms and molecules, because it can transmit energy to them only in packets that are not large enough to remove electrons from them.

antennas set up through the end of 2011 according to the precise location of the houses and the antennas. Estimates were made using the hedonic and repeated sales methods for the purpose of examining the effects of the distance of house from a cellular site on the housing price, according to the type of site. The estimation took into account a possible selection bias in deployment of the sites (Mundlak, 1978).

The main findings of the study indicate that before taking into account a possible selection bias in the deployment of the cellular networks, proximity to the sites has a small significant negative effect on residential housing prices. This effect is similar in magnitude to the effect found in previous studies in the literature that did not take selection into account. On the other hand, we find that after selection bias is taken into account, there is no evidence of a significant negative effect of the proximity of houses to cellular sites on the prices of those houses. These results are valid for both cellular pole antennas and other types of sites. They also remain valid for housing transactions in the same statistical area ("neighborhood"), building, or apartment (repeated sales). We emphasize that only a few cellular pole antennas were put up during the study period, a fact that complicates the causal estimation of the effect on housing prices.

This paper is arranged is as follows: Section 2 presents the possible negative externalities of cellular antennas, public opposition in Israel to their deployment, and possible methods of compensation for those affected by their placement. Section 3 presents a review of the literature dealing with the effect of proximity to cellular sites on housing prices. Section 4 describes the databases and presents descriptive statistics. Section 5 describes at length the selection problem in the placement of the sites. Section 6 explains the empirical methodology. Section 7 presents the estimation results, and Section 8 concludes.

2. Negative Externalities of Cellular Antennas, Public Opposition in Israel to Their Deployment, and Methods of Compensation

During most of the period during which the world's cellular networks were expanding, the World Health Organization found that no consistent and convincing evidence of a causal connection between exposure to cellular radiation and damage to health had been established so far (ICNIRP, 2009). It reached this conclusion even though a number of studies had suggested such a connection (for example: Wolf and Wolf, 2004 and Hutter, et al., 2006). In 2013, the IARC published a comprehensive review of the state of research dealing with the effect of non-ionizing radiation on the risk of developing cancer. The study found partial evidence of a correlation between this radiation and certain types of cancer, and the IARC therefore recommended including non-ionizing radiation among possible carcinogens (IARC, 2013).

At the same time, the study indicated that proximity to an antenna is not a good estimator for the level of exposure to radiation, given the great heterogeneity in the antennas' characteristics and the way they emit radiation. The study also showed that the magnitude of exposure to radiation from a typical antenna was considerably less than the radiation emitted by a cellular device. The main risk from prolonged exposure to cellular radiation therefore comes from the devices themselves, not from the antennas (IARC, 2013).

Given the uncertainty about the radiation risks, the Israeli Ministries of Health and of Environmental Protection decided to adopt the precautionary principle prevailing in Western countries (Ministry of Health, 2015; Ministry of Environmental Protection, 2015). According to this principle, measures with a relatively low cost should be taken to avoid potential damage even when it has not yet been scientifically proven that a risk indeed exists (Europa – Summaries of EU Legislation). The Ministry of Environmental Protection therefore set a condition for the issuing of a permit to operate a cellular antenna: radiation must not exceed 10 percent of the radiation threshold set by the World Health Organization in areas with prolonged exposure and 30 percent of the threshold in areas with brief exposure. The operating permit is required in addition to a construction permit from the Local Planning and Building Commission (Ronen, 2008).

A negative effect of the cellular antennas on prices of nearby properties is possible even if the existence of damage to health has not been proven, but the public believes that it exists. This phenomenon is described at length by Barzilai (2006). Large conspicuous antennas (such as pole antennas) are also an aesthetic nuisance that can have a negative impact on the price of properties from which they are visible.

A number of campaigns against cellular sites have been waged in Israel in recent years. In July 2015, for example, reports appeared in the media of a protest by parents against the erection of antennas near a group of kindergartens in Netanya. After classes in the kindergartens were shut down, the municipality acquiesced to the parents' demand, and decided to build shielding for the kindergartens against radiation (Kepel, 2015). A similar case occurred a year earlier in Kfar Sava (Hillman, 2014). There were also a number of cases in which cellular sites were set on fire. Two of these received extensive media coverage because of their severity—in Peqi'in Hadasha in 2007 (Raved, 2007) and in Akko in 2014 (Hilleli, 2014). The first event caused a riot in the nearby locality of Peqi'in, and the second caused the collapse of a building and the death of five people.

The public protest in Israel against the deployment of cellular antennas could be a result of two factors: The first is the increased use of antennas, accompanied by the increasing interest in the damage caused by radiation and the awareness of it, and the second is greater access by the public to information about the location of the antennas.[2] Real estate websites, which contain real estate information and data, also contain the locations of the cellular antennas.

Under Section 197 of the Planning and Building Law, 1965, if a cellular antenna is placed near a home, its residents have the option of submitting a diminished value claim for compensation to the Local Planning and Building Commission. A Supreme Court judgment (Request for Appeal 1560/13) ruled for the first time that a claim could be filed at the Local Planning and Building Commission for a decrease in the value of a home caused by the erection of a cellular antenna (cellular companies are in any case obligated to provide an indemnification deed to the Local Planning and Building Commission). The option is valid

[2] Ministry of Environmental Protection: http://www.sviva.gov.il/subjectsEnv/Radiation/Communication_Facilities/cellular/Pages/CellularMapGIS.aspx; Government maps website: http://www.govmap.gov.il/sviva.

for up to a year after a building permit is granted for the broadcasting facility or six months after the facility is built, whichever is later. The residents also have another option: filing a lawsuit in court for damages. Talks conducted with the parties dealing with the matter indicate that up until now, there has been no court verdict in such lawsuits. The reason is that the cellular companies reach out-of-court settlements with the plaintiffs. No clear rules have been set for the amount of compensation in either of these options.

3. Literature Review[3]

No comprehensive study has yet been conducted in Israel assessing the effect of cellular antennas on housing prices. However, research on the issue has increased throughout the world. The first two studies, by Bond and Wang (2005) and Bond (2007), dealt with Christchurch in New Zealand and Orange County in Florida. The New Zealand study found a decrease of 12–20 percent in housing prices on a street on which antennas were located, and the Florida study found a 2 percent decrease in housing prices at a distance of up to 200 meters from antennas (not necessarily on the same street). The criticism of the studies (Filippova and Rehm, 2011, for example – see below) mainly concerned two matters: (1) Proximity to the antennas was defined in the first study as being on the same street, despite the possible sizeable differences in the distance from the antennas between different houses on the same street or proximity to an antenna on a different street; (2) Neither study included time control variables in the estimations, even though the transaction data were spread over 10 years or more.

Banfi and Massimo (2008) focused on Zurich, Switzerland, and Brandt and Maennig (2012) on Hamburg, Germany. These studies used the distance between the houses and the antennas, and also took into account the general price trend over time. The Swiss study found a 1.8 percent drop in housing prices at a distance of up to 200 meters from the antenna, and the German study found a decline of 2 percent at a distance of up to 100 meters. Both studies were limited in scope, including 4,000–6,000 transactions. In addition,

[3] The review of the literature here addresses only the negative external effect of cellular antennas on housing prices. There is also extensive literature dealing with the negative external effects of infrastructure other than cellular antennas, such as high-voltage wires and waste sites, on housing prices. For example, see Wyman and Worzala (2013).

neither study attempted to address the selection problem caused by a possible correlation between the antenna location and factors affecting housing prices, which may cause bias in the estimates obtained.

The most extensive studies were in Auckland, New Zealand (Filippova and Rehm, 2011) and Kentucky, USA (Locke and Blomquist, 2016). The first of these included over 56,000 housing transactions over two years, and the second included 160,000 transactions over 12 years. The Kentucky study also included in the estimates tract fixed effects relevant to the purpose of taking into account area differences in housing prices and dealing with the selection problem. Filippova and Rehm found no significant negative effect of cellular antennas on housing prices, other than in proximity to concentrations of antennas. Locke and Blomquist found a decrease of 1–2 percent in the value of housing located up to 350 meters from the antennas.

Wirth and Mense (2014) focused on Nuremberg, Germany. The study encompassed 1,700 transactions over three years. This was the only study that dealt directly with the selection problem. An instrumental variable was used——instead of the actual distance between the house and the nearest antenna, the distance to the place where the antenna would have been located for considerations of area coverage only was calculated. A 4 percent decline in housing prices at a distance of 50 meters from the antenna was found, in comparison with housing at a distance of 100 meters from it.

A review of the global literature therefore shows that the decrease in housing prices resulting from proximity to cellular antennas is 1–4 percent. Only one study failed to find a significant effect (other than for proximity to concentrations of antennas). Most of the studies did not address the selection problem.

No comprehensive study has yet been conducted in Israel assessing the effect of deployment of cellular antennas on housing prices. Barzilai (2006) examined this question in a number of neighborhoods in Alfe Menashe in which cellular antennas were built with an average distance of 300 meters from private houses. A number of independent appraisers estimated that the value dropped an average of 8 percent due to proximity to antennas.

4. Database and Descriptive Statistics

The study is based on two main databases—files of transactions in residential housing (catalogue of real estate prices) compiled by the Israel Tax Authority and data for the deployment of cellular antennas obtained from the Ministry of Environmental Protection.

The housing transactions files cover 2000 to 2011. Coverage of transactions was scarce before 2000 and partial in 2000–07) (50–60 percent of the transactions, a good representation of all the transactions). It can be assumed with a high degree of certainty that the partial coverage does not depend on the antennas' location. The following information items are known for every transaction: the date, sales price and the house's characteristics—location, size (number of rooms and area), year in which construction was completed, etc. The location data for the house were cross-referenced with geographic information obtained from the Survey of Israel and the Central Bureau of Statistics, and with the help of this information, the coordinates of the houses and their statistical area (according to the 2008 census) were added.

Due to the small number of transactions reported to the Tax Authority in small communities and Arab communities, only transactions in relatively large Jewish and mixed urban localities were included—transactions used by the Central Bureau of Statistics to calculate the residential Home Price Index (Appendix Table 1). Only transactions fulfilling a number of criteria defined by the Central Bureau of Statistics were included.[4] There were 835,000 transactions recorded in the catalogue of real estate prices for 2000–11, of which 761,000 were in the communities included in the study. The number of transactions fulfilling the criteria in those communities was 548,000. To summarize, after omitting transactions for which there was no information about the coordinates or the statistical area, 393,000 transactions that took place in Jewish or mixed urban localities in 2000–11 were included in the study. The descriptive statistics of those transactions appear in Table 1.

[4] The main criteria are: sale transactions for houses with 1.5-5 rooms sold to private buyers with a reasonable ratio between the number of rooms and the area and between the transaction price per square meter and the average price in the area. For further details, see: Central Bureau of Statistics (2014).

Table 1 – Descriptive Statistics of the Houses in the Study Population, 2000-2011[1]

	Mean	Standard Deviation	Minimum	Maximum
Price (in thousands of current NIS)	780.4	476.8	40.0	7657.8
Size (in square meters)	78.9	25.0	12.0	150.0
Age of the house (in years)	26.0	18.9	0.0	111.0
Number of rooms	3.4	0.9	2.0	5.0
Socioeconomic ranking	11.3	3.5	1.0	20.0
Number of Transactions	392,851			

Source: Israel Tax Authority, Central Bureau of Statistics, and the authors' analysis.
(1) The socioeconomic ranking of the statistical areas is according to the 2008 census, as calculated by the Central Bureau of Statistics. The ranking is on a scale of 1 to 20; 20 is the value in the wealthiest area.

The Ministry of Environmental Protection made files available to us with information with annual or greater frequency about all (approximately 11,000) cellular antennas actually placed in Israel, or for which requests to place them had been submitted to the Ministry by the end of 2012. The study used information about antennas built by the end of 2011, since this was the most recent year for which the Ministry of Environmental Protection's data were exhaustive and complete when the data were delivered. The files contain comprehensive information about every antenna, including the following characteristics: the precise location (coordinates), type of antenna (a list appears below), height, dates of construction, operation, and the most recent test of the level of radiation and its maximum magnitude. Every antenna was assigned to a cellular broadcasting site.

The Ministry of Environmental Protection places the antennas into one of seven different categories (Figure 1), and we grouped these into two categories according to their visibility. The assumption is that the more visible the antenna, the greater the probability that it will be noticed, the more severe the environmental nuisance it constitutes, and the more the public is likely to fear that it emits more radiation.[5] The first category includes pole antennas located on a roof or on the ground. The second category includes sloping antennas, wireless access devices, and "stinger" antennas. Two other types of antennas

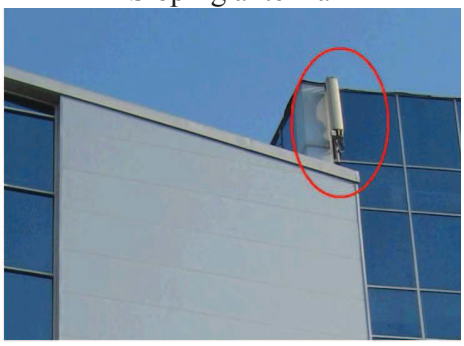
[5] A test we conducted using the database in our possession shows that there is no substantial difference in the level of radiation between pole antennas and the other types of antennas.

Figure 1 – Types of Cellular Antennas

Pole antenna (on the ground)

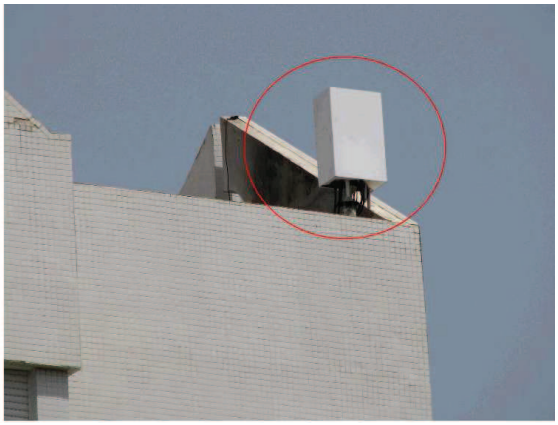
Pole antenna (on the roof)

Sloping antenna



"Stinger" antenna

Wireless access device



Miniature internal device (not included)

Miniature external device (not included)

were not included in these two categories: miniature internal and external broadcasting devices. Most of these devices are internal, i.e., stationed inside buildings, while the external ones are also very small, and sometimes even camouflaged. The visibility of these miniature broadcasting devices is therefore very negligible, and they are not considered an environmental nuisance.

36 percent of the sites were put in the first category in 2011, 31 percent in the second category, 20 percent were miniature broadcasting devices, and 13 percent of the sites were of an unknown type, and could therefore not be categorized. Sites with miniature broadcasting devices and unclassified devices were not included in the study.

In 2000–11, 2,529 new cellular sites were built in the localities in the study and 689 sites were closed. In the absence of accurate information about the date on which an antenna is removed, an approximation was used: yearly radiation testing is required for the cellular antennas in order to make sure that they do not deviate from the permitted standard. Even when an antenna ceases to operate, some time usually passes before it is removed.[6] During this time, the antenna still constitutes a visual obstruction, and the residents in the area are probably unaware that it is inactive. We have therefore defined a cellular site as inactive if more than two years have passed since the date of the most recent test of all the antennas on the site.

To sum up, only cellular sites active in 2000–11 in relatively large Jewish and mixed urban communities were included in the study. Table 2 displays the number of cellular sites active in each of the years included in the study population.

[6] It is reasonable to assume that the antennas will be removed from a site that has stopped broadcasting, for two reasons: a) The law requires the removal of the antennas within a year after they are no longer used; b) Rent is usually paid for the use of the site.

Table 2 – The Number of Cellular Sites in Israel in the Study Communities, 1999-2011 (end-of-year figures)

Year	Pole Sites	All Types of Sites
1999	1,015	1,448
2000	1,241	1,762
2001	1,464	2,107
2002	1,627	2,378
2003	1,721	2,572
2004	1,788	2,734
2005	1,807	2,914
2006	1,821	3,100
2008	1,817	3,324
2009	1,767	3,322
2010	1,771	3,327
2011	1,764	3,284

Source: The Ministry of Environmental Protection and the authors' analyses.

For each housing transaction, the aerial distance to the nearest cellular antenna was calculated just before the transaction, based on the coordinates of the house and the antenna. The distance is only a proxy of the measure of possible effect of the antenna on the house price, for two reasons: (1) We do not know whether there is a line of sight between the housing unit and the antenna, because we do not know the location of the apartment in the building (the information about the floor is extremely incomplete, and the directions of ventilation in the house are completely unknown); (2) As a result of the incompleteness of the information about which floor the apartment is on, the distance calculated is only for the horizontal plane, and does not take into account differences in height between the antenna and the apartment. Other than the calculation of the distance to the nearest cellular antenna just before the transaction, the number of sites within a radius from the house of up to 50 meters and up to 100 meters at the date of the transaction was also calculated. In these individual discrete distance ranges, the prevailing practice in the research literature is to test the effect of the antennas on housing prices. Table 3 shows that the proportion of transactions in a range of up to 50 meters from a cellular site is very low – less than 1 percent in the case of pole sites and approximately 3 percent in the case of any cellular site whatsoever. At a distance of up to 100 meters, the proportions are 4 percent

and 11 percent, respectively. Note that a radius of 100 meters from the house covers an area four times as large as the area within a radius of 50 meters.

Table 3 – The Number of Cellular Sites within a Radius of up to 50 or 100 Meters from the House at the Time of the Transaction, 2000-2011

Up to 50 Meters from the House						
	Pole Sites		Sites without a Pole		All the Sites	
Number of Sites	Share of Transactions	Number of Transactions	Share of Transactions	Number of Transactions	Share of Transactions	Number of Transactions
0	99.18%	389,645	97.93%	384,725	97.18%	381,785
1	0.75%	2,927	1.89%	7,416	2.51%	9,850
2	0.07%	267	0.16%	619	0.27%	1,073
3	0.00%	12	0.02%	89	0.03%	133
4 or more	0.00%	0	0.00%	2	0.00%	10
Up to 100 Meters from the House						
	Pole Sites		**Sites without a Pole**		**All the Sites**	
Number of Sites	Share of Transactions	Number of Transactions	Share of Transactions	Number of Transactions	Share of Transactions	Number of Transactions
0	95.94%	376,920	92.27%	362,493	89.13%	350,152
1	3.47%	13,642	6.38%	25,048	8.29%	32,570
2	0.53%	2,098	1.18%	4,620	2.09%	8,208
3	0.04%	174	0.17%	652	0.42%	1,648
4 or more	0.00%	17	0.01%	38	0.07%	273

Source: Israel Tax Authority, Ministry of Environmental Protection, and the authors' analyses.

5. The Selection Problem

The spatial distribution of the cellular sites is motivated by various considerations, including ensuring an adequate quality of reception, the geographical distribution of the cellular telephone owners, the possibility of building sites, construction costs, etc. Some of these factors are in themselves likely to affect housing prices. Due to a possible selection in the placement of the sites, the estimates obtained for the effect on housing prices caused by proximity of houses to the cellular sites could be biased.

It is important to address two different forms of selection bias in the placement of cellular antennas. Selection can result from characteristics of the area or the house that are constant over time (during the study period)—for example, the socioeconomic ranking of the area

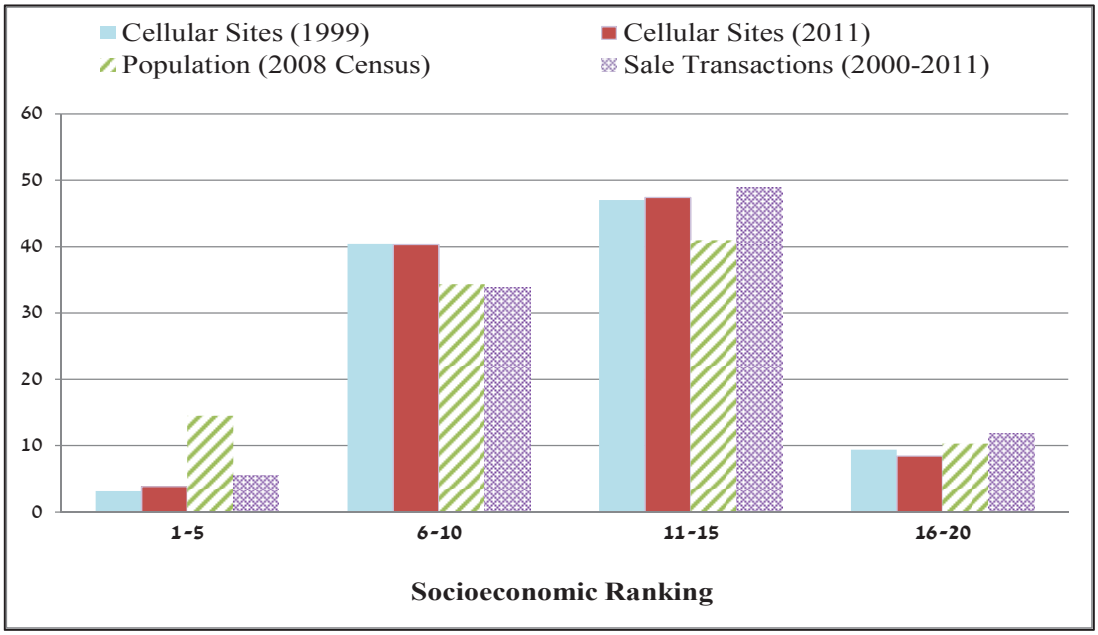
and the height of the building. Selection can also result from characteristics that change over time. For example, it is possible that deployment of new cellular sites is a result of new residential construction, the construction of public buildings and commercial buildings (in which sites are frequently located), and that these factors in themselves affect housing prices. The current chapter will address at length the two forms of selection.

5.1 Selection in Placement of Sites according to Characteristics of Houses and Statistical Regions that are Constant over Time

In order to test whether there is selection in the placement of cellular sites according to the constant characteristics of the statistical areas ("neighborhoods") in which the houses are located, or the characteristics of the houses themselves, that are constant over time, a preliminary check was conducted aimed at answering the question of whether there was a greater tendency to establish cellular sites in statistical regions with a higher or lower than average socioeconomic ranking. It can be hypothesized that the sites were initially established in well-off areas in which the rate of cellular telephone ownership was relatively high, making it more worthwhile for the cellular companies to provide high-quality service there. An alternative hypothesis is that the sites were initially deployed in less well-off areas in which awareness of the sites' negative externalities and the residents' ability to oppose their construction was less than in prosperous areas.

Figure 2 indicates that the distribution of the cellular sites (included in the study) according to the socioeconomic ranking of the statistical areas in which they are placed (the median ranking is 11) did not change during the preceding decade. Furthermore, there were no clear differences between the distribution of the transactions according to socioeconomic ranking and the distribution of the cellular sites. The proportion of the population (in the Jewish or mixed localities included in the study) living in statistical areas with a low socioeconomic ranking was greater than the proportion of cellular sites in those areas, probably because relatively few sites were established in ultra-Orthodox and Arab neighborhoods in the localities in the study.

Figure 2 – The Distribution of Cellular Sites by the Socioeconomic Ranking of the Statistical Areas in Which They are Placed: 2011 Compared with 1999



Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

(1) The socioeconomic ranking of the statistical areas is according to the 2008 census, as calculated by the Central Bureau of Statistics. The ranking is on a scale of 1 to 20; 20 is the value in the wealthiest area.

In order to check whether there is selection in the placement of cellular sites according to housing characteristics that are constant over time, the differences between the physical characteristics of the houses in whose proximity sites were established in 2000–11 and the characteristics of the other houses were checked. Since the spatial distribution of the cellular sites was very heterogeneous, and the estimations later will control for the statistical area, the check was conducted in comparison with the average characteristics of all the transactions in the statistical area in which the houses were located. (In other words, the average value of the characteristic in the statistical region in which the house was located was subtracted from the value of the characteristic).

Table 4 indicates that the differences between the characteristics of houses in whose proximity sites were established and the other houses in the same statistical area were very small. The houses in whose proximity sites were established were slightly smaller and newer. Therefore, no significant selection in the placement of sites within a statistical area based on the observed housing characteristics can be cited.

Table 4 – Characteristics of Houses in Whose Proximity Cellular Sites Were Established in 2000-2011 Compared with Other Houses –Normalized by the Average Characteristics in the Statistical Area

Distance of up to 50 Meters					
Variable	**Transactions Near Antennas**	**Other Transactions**	**The difference[1]**	**t statistic**	**p-value**
Size (in sq.m.)	-0.04	0.00	0.04	0.24	0.81
No. of rooms	-0.01	0.00	0.01	1.41	0.16
Age (in years)	-0.49	0.02	0.50	3.78	0.00
Distance of up to 100 Meters					
Variable	**Transactions Near Antennas**	**Other Transactions**	**The difference[1]**	**t statistic**	**p-value**
Size (in sq.m.)	-0.19	0.02	0.21	1.93	0.05
No. of rooms	-0.01	0.00	0.01	3.10	0.00
Age (in years)	-0.05	0.01	0.05	0.64	0.53

Source: Israel Tax Authority, Ministry of Environmental Protection, and the authors' analyses.
(1) Other transactions minus transactions proximate to cellular sites.

5.2 Selection in Placement of Cellular Sites according to Time Varying Characteristics

In addition to selection in the placement of cellular antennas according to characteristics of the neighborhood or houses that are constant over time, selection is also possible in the antennas' placement according to characteristics that vary over time. It is possible that changes occurred during the study period in areas where sites were placed, such as a large-scale surge in construction and the construction of public or commercial buildings, and that these changes affected housing prices.

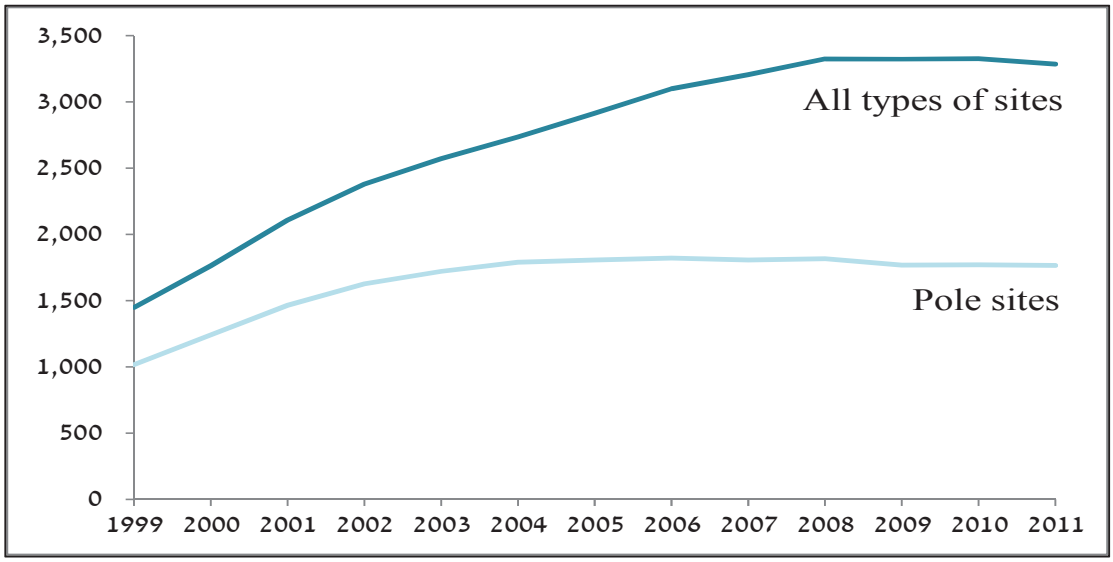
Concern about such selection arises due to the finding presented below concerning a positive correlation between the "existence of cellular sites just before the transaction" variable and the time variable, i.e., the probability that a transaction will take place in the proximity of the site increases with time. In principle, the positive correlation should not create a problem in the estimation, because dummy variables for time can be included in it that are needed in any case to control for the rising trend in housing prices during the second half of the first decade of the 21st century. After dummy variables for time are included, the estimate for the effect of proximity to cellular sites just before the transaction

on housing prices will be consistent and unbiased only if the price trends over time were the same for all the houses, whether or not they were in the proximity of cellular sites during the entire decade. On the other hand, if the price trends are not the same, the estimate will be biased, since it will reflect not only the effect of proximity to the cellular site on the house price, but also the correlation with the various price trends typical of the areas in which cellular sites were established.

Figures 3 and 4 indicate a positive correlation between the existence of a cellular site at the transaction date and the actual transaction date. The reason is that deployment of cellular sites increased during the study period (Figure 3), and the probability of a transaction in the proximity of the sites therefore rose (Figure 4).

Figure 3 indicates a rise in the number of pole sites up until 2004, followed by stability in the number. Figure 4 shows that there was an increase in the share of transactions close to the pole sites until 2004–05, following by a substantial drop, with the share reaching a level similar to the one prevailing at the beginning of the 21st century. The reason is likely to be the closure of pole sites in residential areas and the establishment of sites in industrial zones or open areas. At the same time, looking at all the sites, there is a positive time trend in the variable denoting the existence of a cellular site just before the transaction.

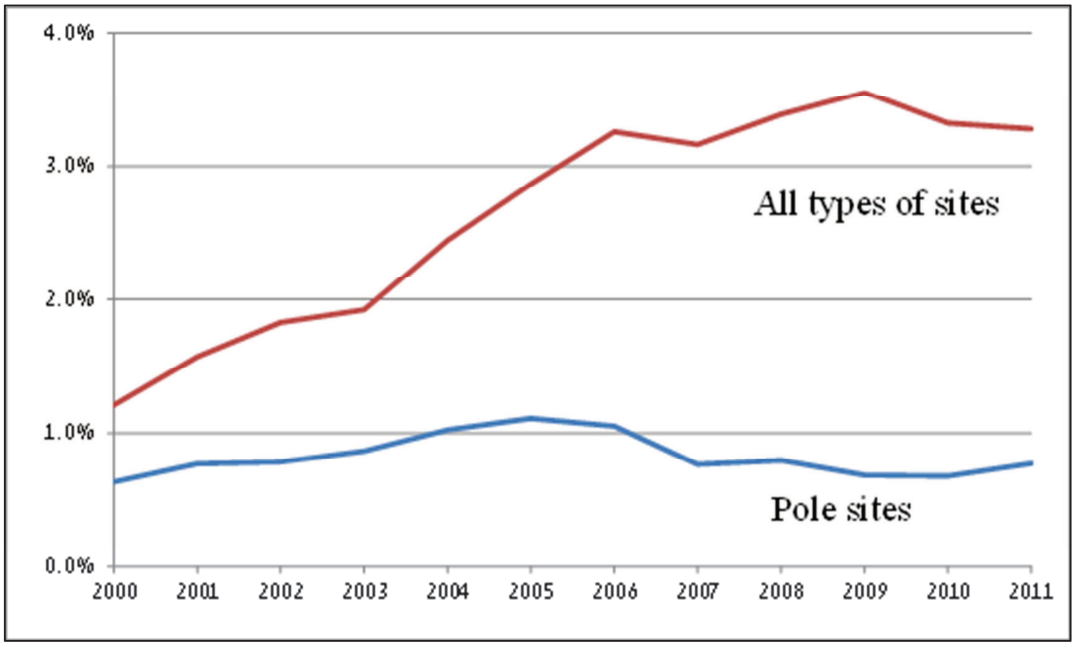
Figure 3 – The Number of Cellular Sites in Localities in the Study, 1999–2011
(End-of-Year Data)



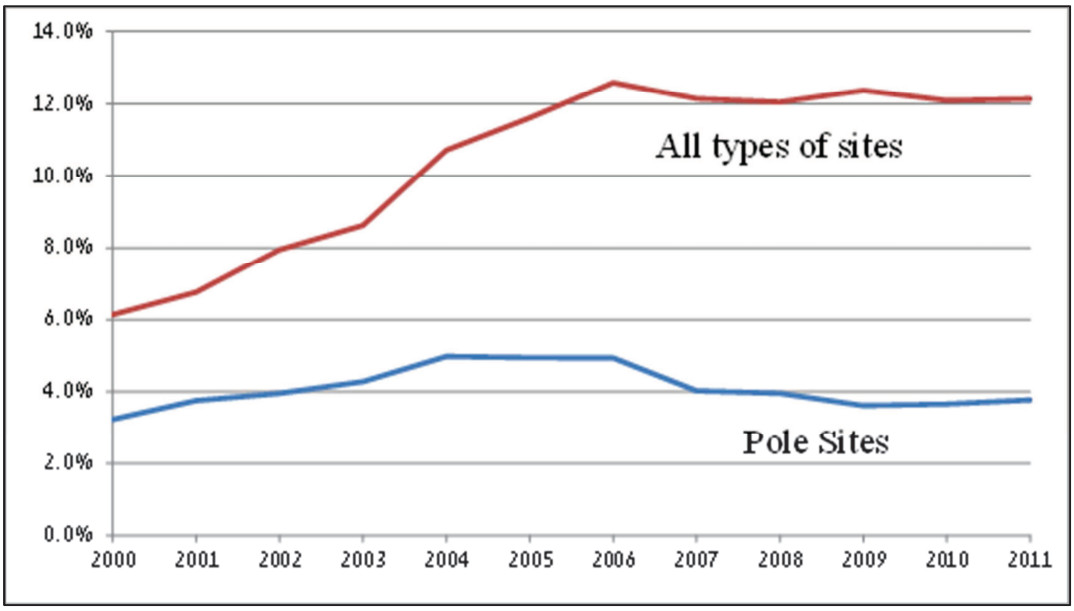
Source: Israel Tax Authority, Ministry of Environmental Protection, and the authors' analyses.

Figure 4 – Share of Transactions in Proximity to a Cellular Site, 2000–2011

a. Transactions within up to 50 meters of a cellular site



b. Transactions within up to 100 meters of a cellular site



Source: Israel Tax Authority, Ministry of Environmental Protection, and the authors' analyses.

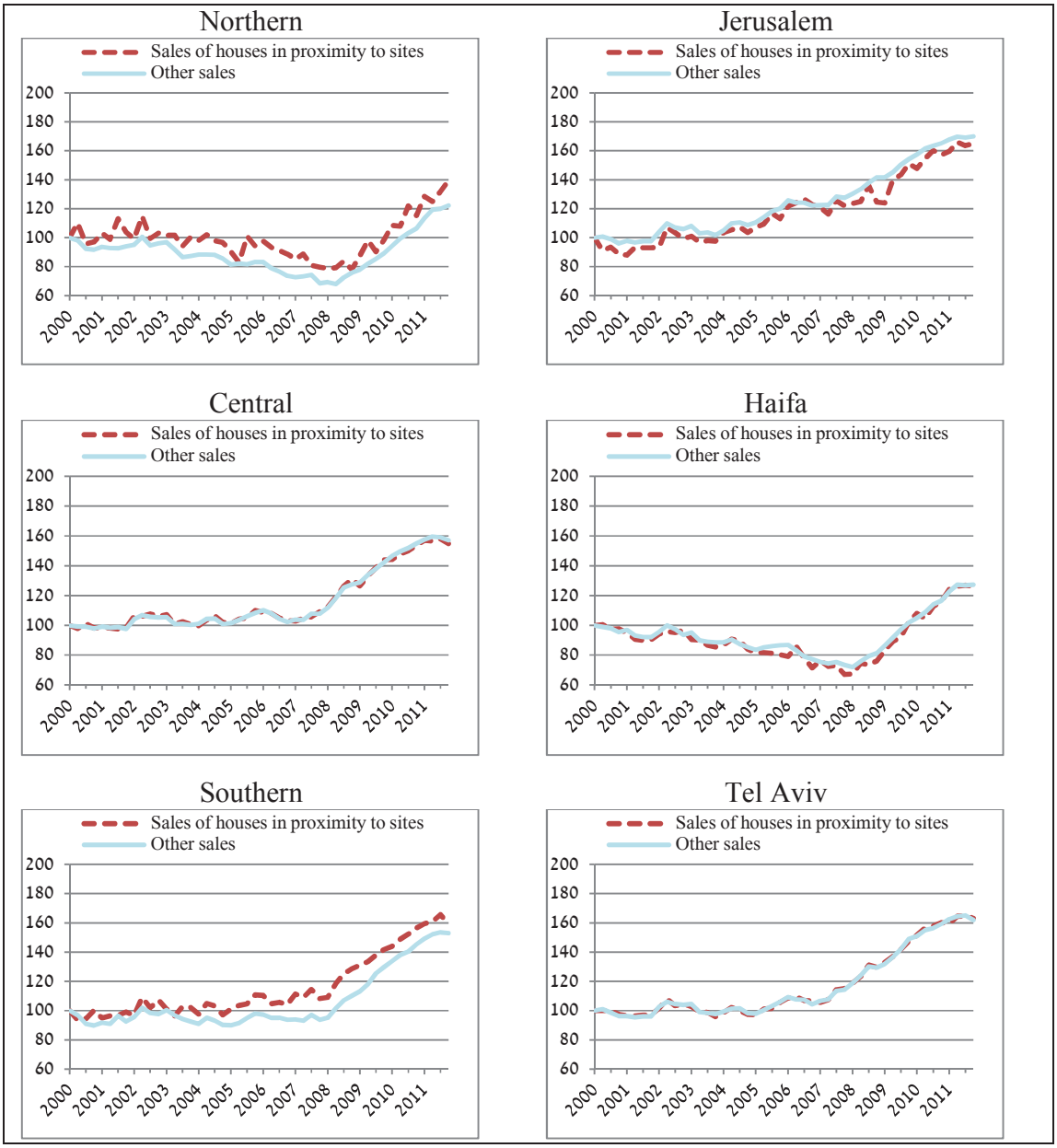
In order to check for selection in placement of the cellular sites according to characteristics that vary over time, we examined the price trends in each district (according to the Ministry of Internal Affairs) through two separate hedonic estimations—one for the prices of houses in whose proximity cellular sites were established during the study period, and the second for prices of the other houses. The explanatory variables in OLS estimations of the log of the price are the housing characteristics (number of rooms, size, and age), statistical area fixed effects, and dummy variables for the quarter and year. The time variable coefficients for transactions within up to 100 meters of a cellular site and for the other transactions are displayed in Figure 5. Appendix Figure 1 displays the coefficients for transactions within up to 50 meters of cellular sites and for the other transactions.

In order to check for selection in placement of the cellular sites according to characteristics that vary over time, we examined the price trends in each district (according to the Ministry of Internal Affairs classification) through two separate hedonic estimations—one for the prices of houses in whose proximity cellular sites were established during the study period, and the second for prices of the other houses. The explanatory variables in OLS estimations of the log of the price are the housing characteristics (number of rooms, area, and age), statistical area fixed effects, and dummy variables for the quarter and year.

The time variable coefficients for transactions within up to 100 meters of a cellular site and for the other transactions are displayed in Figure 5. Appendix Figure 1 displays the coefficients for transactions within up to 50 meters of cellular sites and for the other transactions.

The illustrations show that in the Haifa, Central, and Tel Aviv districts, the trend in housing sale prices in the proximity of a cellular site was similar to the trend of prices in the other houses. On the other hand, in the Jerusalem, northern, and southern districts, there were certain differences in the price trend after 2007. The differential time trends probably indicate unobserved changes that are not directly related to the cellular sites, and which took place over the decade in areas adjacent to the place where the cellular sites were located, and which affected housing prices. It therefore follows that addressing this selection is also important.

Figure 5 – Housing Prices Index: A Comparison between Transactions at a Distance of up to 100 Meters from a Cellular Site and the Other Transactions, according to District, 2000-2011 (January 2000 = 100)



Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

6. Methodology

6.1 Introduction

The effect of cellular sites on housing prices is estimated in the hedonic model, according to the standard literature in this topic (Rosen, 1974).

(1) $$P(Z) = (Z_1, Z_2 \dots Z_k)$$

According to Equation (1), the price of property Z is determined by a set of characteristics $Z_1, \dots, Z_k$ comprising the property. For residential housing, these consist of the physical characteristics of the housing (such as its size) and environmental characteristics—the character of the neighborhood, proximity to jobs, entertainment, and shopping places, etc. The consumer maximizes the $U(x, Z)$ utility function, subject to the budget constraint $y = x + P(Z)$ where y is the consumer's income and x is consumption (other than housing). A first order condition (2) shows that the change in the housing price resulting from a marginal change in a given characteristic of the housing (where the other characteristics are constant) equals the price that the consumer is willing to pay solely for that characteristic (the implicit price):

(2) $$\frac{\partial P}{\partial Z_i} = \frac{\frac{\partial U}{\partial Z_i}}{\frac{\partial U}{\partial x}}$$

If the characteristic is discrete, not continuous (for example, the existence of a cellular site within a range of up to 50 meters from the house as opposed to the continuous distance of the site from the house), this will be another estimator for the extra price that the consumer is willing to pay (in this case for removal of the cellular site).

The magnitude of the effect of proximity to cellular sites on housing prices can be found through hedonic estimation and inclusion of proximity to the site as an explanatory variable, together with the physical and environmental characteristics of the house. In Section 6.3 below, we will address ways of dealing with the selection problem in the placement of sites.

Note that a decrease in housing prices resulting from the establishment of a cellular site will be accompanied by a diversion of demand to similar housing that is not in the proximity of sites. The estimates that will be obtained in the estimation will therefore be overestimations. At the same time, Table 3 above shows that only a small proportion of the transactions were in the proximity of sites, and the diversion effect is therefore small.

6.2 Multivariate Estimation: The Connection between the Distance to a Cellular Site and Housing Prices

The basic estimated hedonic equation is:

(3) $$\ln P_{it} = \beta_0 + \beta_1 dist_{it} + \gamma X_i + \delta_{s(i)} + \lambda_{d(i)t} + \epsilon_{it}$$

Where:

P_{it} is the price of house *i* at time *t*

$dist_{it}$ is the distance between house *i* and the nearest cellular site at time *t*

X_i is a vector of the house's physical characteristics: number of rooms (grouped), size (in sq.m.), and age (in years).

$\delta_{s(i)}$ is a fixed effect for the statistical area in which the transaction took place.

$\lambda_{d(i)t}$ is a dummy variable for the quarter X year X district (according to the Ministry of Internal Affairs classification) in 2000-2011

ϵ_{it} is a random error

β_1 is the estimate of the effect of the distance from a cellular site on price of a house (in percentages). The equation is estimated for three different definitions of the distance, $dist_{it}$, common in the research literature. The first definition is the distance itself (in 100-meter units), assuming that the connection between the distance and the magnitude of the effect is linear. The second definition is the log of the distance, in other words assuming that the effect decreases at an increasing rate with the distance. In the third definition, the continuous distance variable is replaced by a vector of dummy variables for distances of 0-50, 51-100, and 101-200 meters; in other words, no specific functional form is assumed for the connection between the distance to the cellular site and the price of the house.

The addition of statistical area fixed effects makes it possible to take into account the average multiyear differences in housing prices between statistical areas, and to deal with the problem of selection in placing cellular antennas among statistical areas (but not within the areas). The inclusion of dummy variables for time (separately for each district), addresses the changes in housing prices over time resulting from macroeconomic factors, such as the interest rate on mortgages, the unemployment rate in the district, etc.

The estimated equation does not include explanatory variables at a more detailed geographic level than the statistical area—variables that are likely to be correlated with housing prices and are not constant over time (for example, construction of residential, commercial, and other buildings in the proximity of the house), due to a lack of information about them.

6.3 Multivariate Estimation: Dealing with the Selection Problem in the Placement of Cellular Antennas

The main limitation of Equation (3) is the absence of a suitable solution for the possibility of selection in placement of the cellular sites within the statistical areas. If such selection exists, the estimated coefficient for the effect of the distance to the site on the price of the house is biased. As described at length in Chapter 5, selection can result in a correlation between the location of the site just before the transaction and the characteristics constant over time that affect the property's value, and in a correlation between the location and trends in housing prices over time. The estimated equation is now:

(4) $$\ln P_{it} = \beta_0 + \beta_1 site_{it} + \beta_2 * site\_average_i + \gamma X_i + \delta_{s(i)} + \lambda_{d(i)t} + \lambda_{d(i)t} * A_i + \epsilon_{it}$$

where:

$site_{it}$ is a dummy variable that receives the value 1 if there was a cellular site in the proximity of the house (at a distance of up to 50 or 100 meters) just before the transaction, and 0 otherwise.[7] Alternatively, the variable is defined as the number of sites just before the transaction.

[7] A variable denoting the number of cellular sites in a statistical area was not used, because the area covers a relatively large space that is not within the accepted range of cellular sites' effect on housing prices.

$site\_average_i$ is the average value of the $site_{it}$ variable in 2000–11, according to the method employed by Mundlak (1978), described below. This variable is designed to address selection according to characteristics that are constant over time.

A_i is a dummy variable that receives the value 1 for houses in whose proximity (within up to 50 or 100 meters) sites were established in 2000–11, and 0 otherwise.

$\lambda_{d(i)t} * A_i$ is a variable of the interaction between the time trend (separately for each district) and the houses in whose proximity cellular sites were established in 2000–11. This variable is designed to address dynamic selection—various time trends in the prices of houses in whose proximity cellular sites were established.

Mundlak (1978) gives the following explanation of dealing with selection in panel estimations. Assuming that there are unobservables (constant over time) that are correlated with the locations of cellular sites, these existed also before the sites were established and after they were removed.

We assume a model similar to Equation (3):

(5) $$\ln P_{it} = \beta_0 + \beta_1 site_{it} + \gamma X_i + \delta_{s(i)} + \lambda_{d(i)t} + \epsilon_{it}$$

Where $site_{it}$ is an indicator of the existence of a cellular site in proximity to the house just before the transaction; we assume that:

(6) $$\epsilon_{it} = \alpha_i + u_{it}$$

Where α_i is the unobserved element which is constant over time in apartment i, and u_{it} is an idiosyncratic component that varies over time. Assuming that there is a correlation, so $\text{cov}(site_{it}, \alpha_i) \neq 0$, we define α_i as a linear combination of the indicator during the periods:

(7) $$\alpha_i = \gamma_1 site2000 + \gamma_2 site2001 + \cdots + \gamma_{12} site2011$$

Finally, if we assume that the correlation between the existence of a cellular site in the proximity of a house just before the transaction and the unobserved characteristics of the house's location is the same for all the years, then $\gamma_1 = \gamma_2 = \cdots = \gamma_{12} = \gamma$; in other words, $\alpha_i = 12 * \gamma * site\_average_i$ is the average of the $site_{it}$ variable over the entire period. This variable receives the value 0 for houses that have never been in the proximity of a cellular site, 1 for houses that have been in the proximity of a cellular site throughout the 2000–11

period, and an intermediate value between 0 and 1 for houses in whose proximity sites were established during this period, depending on the number of years in which the site existed. This variable can therefore be interpreted as a tendency to deploy cellular sites in the proximity of the house. The magnitude of the tendency reflects the number of years in which there was a site in the proximity of the house: the greater the number of years, the stronger the tendency.

The estimation in Equation (4) makes it possible to address another form of selection – various time trends in the prices of houses in whose proximity cellular sites were established, as shown in Figure 5 above. The $\lambda_{d(i)t} * A_i$ interaction variable enables us to take these differential trends into account, thereby avoiding a possible bias in the estimate.

The estimations were conducted once for all the transactions, and once separately for statistical areas with a high socioeconomic ranking (higher than the median ranking – 11) and those with a low ranking. The reason for this is twofold: (a) an effect of proximity to cellular sites on housing prices is likely to be differential according to the socioeconomic level of the residents; (b) a key factor in a possible selection between statistical areas in deployment of cellular sites is certain differences in the socioeconomic distribution of the areas in which the sites were established, in comparison with the distribution of the transactions (Figure 2 above); separate estimation greatly reduces the effect of that selection, if it exists.

6.4 Estimation in Different Years: The Effect of the Cellular Sites within a Given Range

The equations presented thus far are multiyear. The basic assumption is that proximity to cellular sites affects housing prices the same way in each year. This assumption, however, is not necessarily valid. It can be hypothesized that the effect of the sites was less at the beginning of the preceding decade, and increased later when public discourse concerning the possible health damage of radiation became more widespread. A contrasting hypothesis is that the sites had a more pronounced negative effect on housing prices in the earlier years, due to the great uncertainty prevailing then in the scientific community about the radiation's effect, which later partly eased with time, when it emerged that the main radiation damage was from cellular telephones, not the antennas. Furthermore, it is possible

that with time, the public became used to the existence of the cellular sites. Estimations were therefore conducted separately for each of the years during 2000–11 like those in Equation (4), with the omission of the dummy variables for time. The estimations were conducted for all the transactions, and with a division into high and low socioeconomic rankings.

7. Results

The results of the basic estimations of the effect of the distance from a cellular site on housing prices, based on Equation (3) without taking selection in the placement of the sites into account, are displayed in Table 5.[8] For pole sites, we found a significant positive connection between the distance to the site and the price of the house: the closer the house was to the site, the lower the price. In models in which we assumed a linear connection between the distance and the price, an increase of 0.22 percent in the price of the house for each 100 meters of distance from the pole site was estimated (Column 1) and an increase of 0.34 percent for all the other sites (Column 3). In models in which we assumed that the effect on the price decreased more rapidly with the distance, we found, for example, an increase of 1.38 percent with a shift from a distance of 10 meters from a pole site to a distance of 50 meters from it, and an increase of 0.59 percent with a shift from a distance of 50 meters to one of 100 meters (Column 2).[9] For all the sites, the coefficients are 1.54 percent and 0.66 percent. A similar picture is also obtained in a model in which the distance variables are dummy variables for the ranges: the price of the houses located at a distance of 0-50 meters from pole sites is 2.56 percent lower than the price of houses located at a distance of over 300 meters (Column 3). For sites without pole antennas, the price is 1.3 percent lower (Column 6), and for all types of sites, it is 2.0 percent lower (Column 9). The coefficient of the decrease in price resulting from proximity to both pole sites and all types

[8] We did not include the distance from the location of the transaction to cellular sites that are not the closest site in the estimations. In estimations in which we added the distance to the two next closest sites, we found that the estimates of the effect of the distance to those two sites on the transaction prices were small and not significant in the vast majority of cases.

[9] The estimated value of the change in housing prices is 5^{β} in a shift from a distance of 10 meters between the house to a cellular site to a distance of 50 meters ($1.38=5^{0.0085}$) and 2^{β} in a shift from 50 meters to 100 meters ($0.59=2^{0.0085}$). The increase involved is 5 or 2 times as great in the distance of the house from the site, respectively. β is the coefficient of the log of the distance in Equation (3).

of sites ceases to be significant at a distance of over 200 meters from them. For sites other than pole sites, the estimate ceases to be significant at a distance of over 100 meters from the houses. The results obtained in the above estimations are similar in magnitude to those found in previous studies around the world that did not address the problem of selection in the placing of the cellular sites.

We will now turn to estimations that address the selection problem. Tables 6 and 7 display the results of estimates testing the connection between prices of houses and the existence of a cellular site at distances of up to 50 meters and up to 100 meters from the those houses just before the transaction. The estimation is conducted once without taking possible selection in the placement of the sites into account. The second estimation takes into account selection according to characteristics that are constant over time, according to the method of Mundlak (1978) discussed in Section 6.3, but without taking into account selection over time. The third estimation is a complete estimation of Equation (4) taking into account all types of selection—both according to characteristics that are constant over time and price trends that are differential over time. After all the selection effects were taken into account, it was found that the estimates of the causal effect of proximity of houses to cellular sites on the prices of those houses were insignificant for pole sites as well as for the rest of the sites.

Table 5 – Estimates of the Effect of the Distance of Residential Units from Cellular Sites on the Housing Prices by Type of Site: Multivariate Estimations that do not Take Selection in Placement of the Sites into Account[1]

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Distance to the cellular site (in hundreds of meters)	0.0022**			-0.0003			0.0034***		
	(0.0008)			(0.0005)			(0.0010)		
Log of the distance to the cellular site		0.0085***			0.0038*			0.0095***	
		(0.0027)			(0.0023)			(0.0024)	
Dummy for distance of 0-50 meters[2]			-0.0256***			-0.0128			-0.0198**
			(0.0078)			(0.0099)			(0.0082)
Dummy for distance of 51-100 meters[2]			-0.0188***			-0.0130***			-0.0184***
			(0.0056)			(0.0046)			(0.0042)
Dummy for distance of 101-200 meters[2]			-0.0076*			-0.0044			-0.0086**
			(0.0041)			(0.0035)			(0.0033)
Dummy for distance of 201-300 meters[2]			-0.0002			-0.0033			-0.0042
			(0.0028)			(0.0029)			(0.0027)
Housing characteristics[3]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1 percent level, ** Significant at a 5 percent level, * Significant at a 10 percent level
The standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) Based on Equation (3).
(2) In comparison with a distance of 300 meters or more from a cellular site.
(3) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

We will first describe the findings pertaining to the effect of proximity of houses to cellular sites within a range of up to 50 meters (Table 6). In the case of pole sites, taking selection into account reduced the estimate of the negative effect from 2.0 percent (Column 1) to 0.5 percent (Column 3), and the estimate was no longer significant. For the rest of the sites, a very small and insignificant negative effect was found (Column 6). The decrease in significance results from regression coefficients close to zero, and from an increase in the standard error.[10] In the case of all the sites, the estimate is about 0.5 percent (Column 9) and the standard error is about 0.7, so the confidence interval of the estimate (at a 5 percent level of significance) is between a 0.9 percent rise in price and a 2.0 percent decline in price.

The findings concerning the effect of proximity of houses to cellular sites at a range of up to 100 meters (Table 7) are similar to those obtained for a range of up to 50 meters. The estimate for the negative effect on prices in the case of pole sites is 0.68 percent (Column 3), 0.57 percent for sites with no pole (Column 6), and 0.52 percent for all of the sites (Column 9).

Appendix Tables 2 and 3 display the results of estimations in which the dummy variable for the existence of cellular sites in the proximity of the houses is replaced by the number of sites.[11] The results were similar to those described above. Similar estimations were also calculated in which all the cellular sites were included, including sites with no visibility (miniature devices). In this case as well, no significant effect of proximity to sites on the housing prices was found after selection was taken into account. In addition, an estimation was conducted in which all the transactions in houses were omitted when there was a cellular site on the roof of the building, in order to eliminate concern that the

[10] The increase in the standard errors is due, among other things, to a high correlation between the probability that a site existed nearby just before the transaction (site) and the selection variable for placement of a site (site_average). The correlation is especially high (0.85) in the case of pole sites because few such sites were established during the study period (Figures 3 and 4). In the case of other sites, the correlation is lower, but still high (0.71). The high correlation widens the confidence interval of the estimates, but does not make them biased.

[11] Outlier observations of transactions involving houses in whose proximity there was a large number of cellular sites were omitted from the estimations. Of the houses in whose proximity there was at least one site, those in the top one percentile of the number of sites were omitted. Transactions involving houses in whose proximity there were more than two cellular sites within a range of up to 50 meters and those involving houses in whose proximity there were more than three sites within a range of up to 100 meters were omitted.

prices in the transactions are affected by the payments received by the tenants from the cellular companies in exchange for the right to place the site on the roof. The estimates remained unchanged.

In order to test the robustness of the results, estimations were also conducted like those above, in which fixed effects for the building and the apartment were substituted for the dummy variables for the statistical area (the repeated sales approach). The estimates were not conducted for proximity to pole sites only because the sample was too small;[12] they were conducted for proximity to non-pole cellular sites, and for proximity to all the cellular sites. The estimates obtained were insignificant, and were very close to zero, similar to the results of the preceding estimations (Tables 8-9).

It is possible that deployment of cellular sites followed the construction of public/commercial buildings and residential neighborhoods, which in itself can affect housing prices (see the discussion in Section 5.2 above). In order to test this hypothesis, GIS layers of land uses for 2003 and 2014 were obtained from the Central Bureau of Statistics (there were none for other years). We classified the land uses into three categories: open space/agricultural, residential, and other buildings (see Appendix Table 4 for details). The land use was checked for every transaction in 2003 and 2014. The 81,973 transactions in which the land use changed between these two years were then omitted. The proportion of omissions was 25 percent of the transactions up to 100 meters from cellular sites established after 2003 and 20 percent of other transactions. The estimation results for the remaining transactions for houses up to 100 meters of cellular sites are displayed in Table 10. The results are not substantially different from the earlier results (Table 7) – after taking selection into account, the effect of the sites remains slightly negative and insignificant.

Separate estimations were also conducted for transactions involving houses in statistical areas with a high socioeconomic ranking and a low one (selection variables were included in all of them). The results for the effect of the existence of cellular sites up to 50 meters from the houses on the prices of those units are displayed in Table 11.

[12] In only 418 of the buildings (0.4 percent of them) and 290 of the houses (0.16 percent) was there both more than one transaction and either the buildings or the houses were at a distance of up to 50 meters from a pole cellular site established in 2000-2011.

The estimates are insignificant. Appendix Table 5 displays similar results for the effect of the existence of sites up to 100 meters from the houses.

We will now describe the results of the estimations according to year of the effect of proximity to cellular sites to houses on the price of those units. These estimations will show us whether changes in the effect have occurred over the years.

Table 12 and Figure 6 show that without taking selection into account, the estimated coefficients are negative and significant in most of the years. When the selection variable is included, however, the coefficients are no longer significant.[13] A similar picture arises in separate estimations for pole sites and the other sites (Appendix Tables 6 and 7 and Appendix Figures 2 and 3).

[13] In some of the years, it appears that the effect (estimated coefficient with a correction for selectivity) is more negative for housing units up to 100 meters from cellular sites, in comparison with housing units up to 50 meters. This result is probably because the proportion of housing units up to 50 meters from sites is very small, and the yearly coefficients are therefore volatile. In any case, the confidence intervals of the coefficient for up to 100 meters in the yearly estimations are contained within the confidence intervals of the coefficient for up to 50 meters in the yearly estimations, and the differences in the coefficients are therefore not significant.

Table 6 – Estimates of the Effect of the Existence of Cellular Sites in the Proximity of Residential Units on the Housing Prices by Type of Site, Multivariate Estimations that Take Selection into Account

Cellular Sites at a Distance of up to 50 Meters from the Houses[1]

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cellular site at the time of the transaction	-0.0198***	-0.0041	-0.0053	-0.0085	0.0038	-0.0061	-0.0116	0.0021	-0.0053
	(0.0071)	(0.0132)	(0.0142)	(0.0093)	(0.0072)	(0.0074)	(0.0073)	(0.0070)	(0.0073)
Average of the sites over time		-0.0185	-0.0223		-0.0187	0.0060		-0.0189*	-0.0097
		(0.0191)	(0.0192)		(0.0132)	(0.0233)		(0.0100)	(0.0132)
Housing characteristics[2]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	X	X	V	X	X	V	X	X	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) Based on Equation (3).

(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Table 7 – Estimates of the Effect of the Existence of Cellular Sites in the Proximity of Residential Units on the Housing Prices by Type of Site, Multivariate Estimations that Take Selection into Account

Cellular Sites at a Distance of up to 100 Meters from the Houses[1]

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cellular site at the time of the transaction	-0.0169***	-0.0074	-0.0068	-0.0098**	-0.0009	-0.0057	-0.0129***	-0.0034	-0.0052
	(0.0046)	(0.0077)	(0.0074)	(0.0042)	(0.0045)	(0.0046)	(0.0035)	(0.0045)	(0.0045)
Average of the sites over time		-0.0111	-0.0154*		-0.0134*	-0.0022		-0.0129**	-0.0104
		(0.0089)	(0.0086)		(0.0073)	(0.0099)		(0.0061)	(0.0070)
Housing characteristics[2]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	X	X	V	X	X	V	X	X	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) Based on Equation (3).

(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Table 8 – Estimates of the Effect of the Existence of Cellular Sites in the Proximity of Residential Units on the Housing Prices by Type of Site: Comparison between Estimations with Statistical Area Fixed Effects and Estimations with Building or Apartment Fixed Effects[1]

Cellular Sites at a Distance of up to 50 Meters from the Houses

	Sites without Poles			All the Sites		
	(1) Statistical area fixed effects	(2) Building fixed effects	(3) Apartment fixed effects	(4) Statistical area fixed effects	(5) Building fixed effects	(6) Apartment fixed effects
Cellular site at the time of the transaction	-0.0061	-0.0091	-0.0078	-0.0053	0.0007	-0.0007
	(0.0074)	(0.0071)	(0.0149)	(0.0073)	(0.0080)	(0.0132)
Average of the sites over time	0.0060	-	-	-0.0097	-	-
	(0.0233)	-	-	(0.0132)	-	-
Housing characteristics[2]	V	V	V	V	V	V
Statistical area fixed effects	V	X	X	V	X	X
Building fixed effects	X	V	X	X	V	X
Apartment fixed effects	X	X	V	X	X	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	V	V	V	V	V	V
Number of observations	392,851	358,059	95,806	392,851	358,059	95,806
Number of buildings/apartments		(68,165)	(44,867)		(68,165)	(44,867)
Adjusted R^2	0.868	0.917	0.924	0.868	0.917	0.924

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.
The standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) Based on Equation (3).
(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.
(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Table 9 – Estimates of the Effect of the Existence of Cellular Sites in the Proximity of Residential Units on the Housing Prices by Type of Site: Comparison between Estimations with Statistical Area Fixed Effects and Estimations with Building or Apartment Fixed Effects[1]

Cellular Sites at a Distance of up to 100 Meters from the Houses

	Sites without Poles			All the Sites		
	(1) Statistical area fixed effects	(2) Building fixed effects	(3) Apartment fixed effects	(4) Statistical area fixed effects	(5) Building fixed effects	(6) Apartment fixed effects
Cellular site at the time of the transaction	-0.0057	-0.0065	0.0031	-0.0052	-0.0043	-0.0007
	(0.0046)	(0.0041)	(0.0081)	(0.0045)	(0.0038)	(0.0132)
Average of the sites over time	-0.0022	-	-	0.0145	-	-
	(0.0099)	-	-	(0.0164)	-	-
Housing characteristics[2]	V	V	V	V	V	V
Statistical area fixed effects	V	X	X	V	X	X
Building fixed effects	X	V	X	X	V	X
Apartment fixed effects	X	X	V	X	X	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	V	V	V	V	V	V
Number of observations	392,851	358,059	95,806	392,851	358,059	95,806
Number of buildings/apartments		(68,165)	(44,867)		(68,165)	(44,867)
Adjusted R^2	0.868	0.917	0.924	0.868	0.917	0.924

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.
The standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) Based on Equation (3).
(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.
(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Table 10 – Estimates of the Effect of the Existence of Cellular Sites in the Proximity of Residential Units on the Housing Prices by Type of Site, Multivariate Estimations that Take Selection into Account

Not Including Transactions Involving Houses for which the Uses of the Land in their Proximity Changed between 2003 and 2014

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cellular site at the time of the transaction	-0.0083 (0.0055)	-0.0051 (0.0089)	-0.0044 (0.0085)	-0.0033 (0.0048)	-0.0005 (0.0047)	-0.0061 (0.0051)	-0.0050 (0.0040)	-0.0011 (0.0047)	-0.0037 (0.0049)
Average of the sites over time		-0.0037 (0.0097)	-0.0116 (0.0098)		-0.0043 (0.0082)	0.0084 (0.0123)		-0.0053 (0.0066)	-0.0029 (0.0080)
Housing characteristics[2]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	X	X	V	X	X	V	X	X	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) Based on Equation (3).

(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Table 11 – Estimates of the Effect of the Existence of Cellular Sites at a Distance of up to 50 Meters from the Residential Units on the Housing Prices According to Socioeconomic Ranking[1] and Type of Site
Annual Multivariate Estimations that Takes Selection into Account[2]

a. Low socioeconomic ranking

	Pole Sites	Sites without Poles	All of the Sites
	(1)	(2)	(3)
Cellular site at the time of the transaction	-0.0141 (0.0174)	-0.0023 (0.0119)	0.0020 (0.0123)
Average of the sites over time	0.0042 (0.0188)	0.0433 (0.0516)	0.0138 (0.0263)
Housing Characteristics[3]	V	V	V
Statistical areas fixed effects	V	V	V
Dummy variables for quarter X year X district	V	V	V
Differential time trends according to tendency to place a cellular site[4]	V	V	V
Number of observations	203,415	203,415	203,415
Adjusted R^2	0.842	0.842	0.842

b. High socioeconomic ranking

	Pole Sites	Sites without Poles	All of the Sites
	(4)	(5)	(6)
Cellular site at the time of the transaction	0.0024 (0.0236)	-0.0140 (0.0090)	-0.0094 (0.0090)
Average of the sites over time	-0.0429 (0.0266)	-0.0183 (0.0149)	-0.0270** (0.0118)
Housing Characteristics[3]	V	V	V
Statistical areas fixed effects	V	V	V
Dummy variables for quarter X year X district	V	V	V
Differential time trends according to tendency to place a cellular site[4]	V	V	V
Number of observations	189,436	189,436	189,436
Adjusted R^2	0.838	0.838	0.838

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.
The standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) The socioeconomic ranking of the statistical areas is according to the 2008 census, as calculated by the Central Bureau of Statistics. The ranking is on a scale of 1 to 20; 20 is the value for the wealthiest area. A low socioeconomic ranking is one lower than the median – 11 or lower.
(2) Based on Equation (3).
(3) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.
(4) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

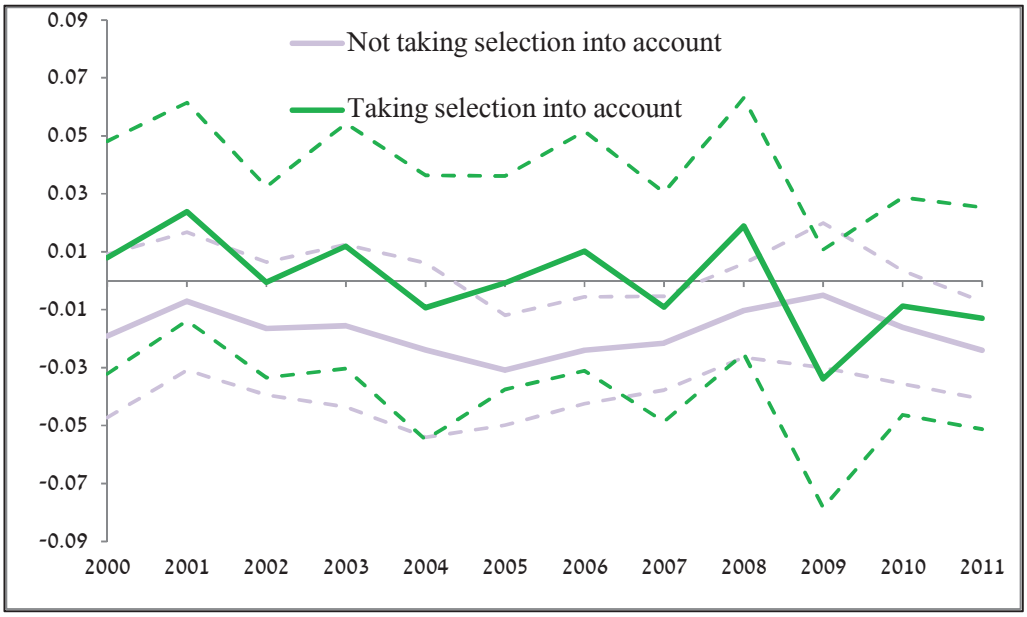
Table 12 – Estimates of the Effect of the Existence of Cellular Sites of All Types at a Distance of up to 50 Meters and up to 100 Meters from the Residential Units on the Housing Prices, both with and without Taking into Account Selection in Placement of the Sites[1]

	50 Meters		100 Meters	
	Not Taking Selection into Account	Taking Selection into Account	Not Taking Selection into Account	Taking Selection into Account
2000	-0.0191	0.0080	-0.0032	-0.0103
	(0.0144)	(0.0205)	(0.0085)	(0.0073)
2001	-0.0071	0.0238	-0.0103	-0.0058
	(0.0122)	(0.0192)	(0.0073)	(0.0108)
2002	-0.0165	-0.0005	-0.0058	0.0032
	(0.0117)	(0.0168)	(0.0065)	(0.0105)
2003	-0.0155	0.0119	-0.0181***	-0.0023
	(0.0143)	(0.0216)	(0.0066)	(0.0111)
2004	-0.0240	-0.0093	-0.0213***	-0.0055
	(0.0154)	(0.0233)	(0.0071)	(0.0120)
2005	-0.0309***	-0.0007	-0.0193***	-0.0115
	(0.0097)	(0.0188)	(0.0060)	(0.0126)
2006	-0.0240**	0.0102	-0.0121**	-0.0002
	(0.0094)	(0.0211)	(0.0055)	(0.0118)
2007	-0.0215***	-0.0092	-0.0104**	-0.0049
	(0.0083)	(0.0202)	(0.0051)	(0.0104)
2008	-0.0103	0.0189	-0.0106**	0.0059
	(0.0083)	(0.0225)	(0.0054)	(0.0115)
2009	-0.0050	-0.0339	-0.0215***	-0.0059
	(0.0128)	(0.0227)	(0.0057)	(0.0117)
2010	-0.0161	-0.0088	-0.0119**	-0.0024
	(0.0100)	(0.0192)	(0.0054)	(0.0099)
2011	-0.0240***	-0.0130	-0.0158***	0.0006
	(0.0086)	(0.0195)	(0.0050)	(0.0107)

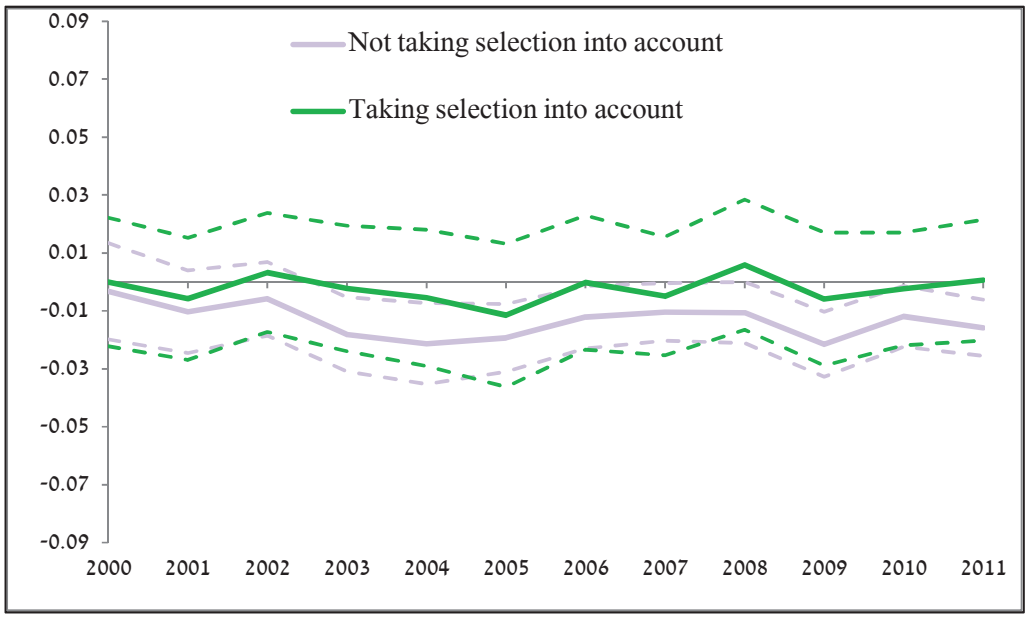
Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.
Standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) Based on Equation (4), with the omission of the time trend and a variable for the interaction between the time trend and houses in the proximity of which cellular sites were established in 2000-2011.

Figure 6 – Annual Estimates of the Effect of the Existence of Cellular Sites of all Types in the Proximity of Residential Units on Housing Prices

a. Cellular Sites at a Distance of up to 50 Meters from the Houses



b. Cellular Sites at a Distance of up to 100 Meters from the Houses



Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
Dashed lines indicate 5% confidence intervals.

9. Conclusion

The deployment of cellular sites in the proximity of houses may have negative effects on housing prices, due to the public's concern about damage to health caused by non-ionizing radiation and visual obstruction. The accelerating expansion of mobile communications networks over the past two decades has highlighted the need to assess this question. The current study systematically assesses, for the first time in Israel, the effect of proximity of houses to cellular sites on the prices of those houses in Jewish municipal communities and in mixed communities in 2000–11.

The database for the study is the result of combining the Israel Tax Authority's files of housing transactions and detailed information about all the cellular antennas in Israel obtained from the Ministry of Environmental Protection, by exact geographic location. Hedonic estimations (as well as the repeated sales method) were conducted of the prices of houses as dependent on their physical characteristics, their location, and their proximity to cellular sites. The possibility of a non-random selection of locations for placing the cellular antennas was taken into account, a phenomenon that has been virtually ignored in most of the research literature in this field.

The main findings of the study indicate that before taking possible selection in placement of the cellular sites into account, there is a small and significant negative effect of proximity to sites on housing prices. This effect is similar in magnitude to the effect found in previous studies in the literature that did not take selection into account. After selection was taken into account, a very small and insignificant negative effect of proximity of houses to cellular sites on housing prices was found. This finding is also valid for proximity to pole antenna sites, which are naturally more visible. No significant differences in results between neighborhoods where residents have a high socioeconomic ranking and neighborhoods where residents have a low socioeconomic ranking were found.

The study has a few limitations: we lack information about the existence of a line of sight between the cellular site and the house, a factor that is likely to make a considerate contribution to the power of the negative effect. It is possible that unobserved factors

exist that are simultaneously correlated with placement of cellular antennas and the price of a house – factors that change over time. Only a few pole antennas were deployed during the study period, which makes it difficult to detect the effect. The study assumes that the tendency to build cellular antennas is constant over time; it does not take into account the possibility that a decrease in the prices of houses in the proximity of the antennas will increase the likelihood that additional antennas will be built in the future, or that the existing antennas will not be removed (for example, due to lower rent paid by the cellular companies to owners of the properties, the value of which decreased). Furthermore, establishing an antenna is likely to reduce the likelihood of conducting a transaction in the area, or to alter the characteristics of the parties making transactions, and these factors in themselves may affect the house price.[14] The study focused on Jewish and mixed localities, since these are the few Arab localities with enough transactions. The findings in rural and non-Jewish communities may be different.

[14] Estimation of Equation (4) with controlling for the number of transactions in a statistical area and in the quarter in which a transaction took place shows that the estimate of the number of transactions is very small and not significant, while there is almost no change in the other estimates.

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Appendix

Appendix Table 1 – List of Localities Included by the Central Bureau of Statistics in Calculating the Index of Residential Home Prices

Locality	District	Locality	District
Ofaqim	Southern	Ma'ale Adummim	Central
Or Yehuda	Central	Ma'alot-Tarshiha	Northern
Eilat	Southern	Nahariyya	Northern
El'ad	Central	Ness Ziyyona	Central
Ashdod	Southern	Nazareth[2]	Northern
Ashqelon	Southern	Nazareth Illit	Northern
Be'er Sheva	Southern	Nesher	Northern
Bet Shemesh	Central	Netivot	Southern
Betar Illit	Central	Netanya	Sharon
Bnei Brak	Greater Tel Aviv	Akko	Northern
Bat Yam	Greater Tel Aviv	Afula	Northern
Giv'at Shmu'el	Central	Arad	Southern
Giv'atayim	Greater Tel Aviv	Pardes Hanna-Karkur	Northern
Gedera	Southern	Petah Tiqwa	Central
Dimona	Southern	Zefat	Northern
Hod HaSharon	Sharon	Qiryat Ono	Central
Herzliyya	Sharon	Qiryat Atta	Haifa suburbs
Zikhron Ya'aqov	Northern	Qiryat Bialik	Haifa suburbs
Hadera	Sharon	Qiryat Gat	Southern
Holon	Greater Tel Aviv	Qiryan Tiv'on	Northern
Haifa	Haifa	Qiryat Yam	Haifa suburbs
Tiberias	Northern	Qiryat Motzkin	Haifa suburbs
Tirat Karmel	Northern	Qiryat Mal'akhi	Southern
Yavne	Central	Qiryat Shemona	Northern
Yehud	Centeral	Rosh HaAyin	Central
Yoqne'am Illit	Northern	Rishon Leziyyon	Central
Jerusalem	Jerusalem	Rehovot	Central
Kfar Sava	Sharon	Ramla	Central
Karmi'el	Northern	Ramat Gan	Greater Tel Aviv
Lod	Central	Ramat HaSharon	Sharon
Mevasseret Ziyyon	Central	Ra'anana	Sharon
Migdal HaEmek	Northern	Sderot	Southern
Modi'in-Makkabbim-Re'ut	Central	Tel Aviv-Jaffa	Tel Aviv
Modi'in Illit	Central		

Source: Central Bureau of Statistics
(1) Starting in 2011.
(2) Not included in the current study.

Appendix Table 2 – Estimates of the Effect of the Number of Cellular Sites in the Proximity of Residential Units on the Housing Prices according to Type of Site, Multivariate Estimations Taking into Account Selection in Placement of the Sites:

Cellular Sites at a Distance of up to 50 Meters from the Houses[1]

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Number of cellular sites at the time of the transaction	-0.0198***	-0.0041	-0.0053	-0.0085	0.0038	-0.0061	-0.0116	0.0021	-0.0053
	(0.0071)	(0.0132)	(0.0142)	(0.0093)	(0.0072)	(0.0074)	(0.0073)	(0.0070)	(0.0073)
Average of the sites over time		-0.0185	-0.0223		-0.0187	0.0060		-0.0189*	-0.0097
		(0.0191)	(0.0192)		(0.0132)	(0.0233)		(0.0100)	(0.0132)
Housing characteristics[2]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	X	X	V	X	X	V	X	X	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) Based on Equation (3).

(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Appendix Table 3 – Estimates of the Effect of the Number of Cellular Sites in the Proximity of Residential Units on the Housing Prices according to Type of Site, Multivariate Estimations Taking into Account Selection in Placement of the Sites: Cellular Sites at a Distance of up to 100 Meters from the Houses[1]

	Pole Sites			Sites without Poles			All of the Sites		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Number of cellular sites at the time of the transaction	-0.0124***	-0.0042	-0.0029	-0.0055	0.0025	-0.0016	-0.0074**	0.0014	-0.0014
	(0.0038)	(0.0068)	(0.0067)	(0.0044)	(0.0047)	(0.0044)	(0.0031)	(0.0042)	(0.0202)
Average of the sites over time		-0.0095	-0.0146*		-0.0120	0.0021		-0.0115**	-0.0049
		(0.0078)	(0.0078)		(0.0079)	(0.0114)		(0.0057)	(0.0069)
Housing characteristics[2]	V	V	V	V	V	V	V	V	V
Statistical area fixed effects	V	V	V	V	V	V	V	V	V
QuarterXyearXdistrict dummy	V	V	V	V	V	V	V	V	V
Differential time trends according to tendency to place a cellular site[3]	X	X	V	X	X	V	X	X	V
Number of observations	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851	392,851
Adjusted R^2	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868	0.868

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) Based on Equation (3).

(2) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(3) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Appendix Table 4 – Classification of Land Uses

The Study Categories	Land Use 2003	Land Use 2014
Open Space/Agriculture	Public open space	Livestock growing sites
	Forest and groves	Plant nursery
	Orchards and olive trees	Archeological excavation
	Cultivated fields	Other type of excavation
	Other open spaces	Roads
		Artificial bodies of water
		Natural bodies of water
		Public park landscaping
		Forest and grove
		Orchards
		Field crops
		Leafy bushes and scrubland
		Rocky area
		Mining and quarrying
		Land
Residential	Residential	Residential
Other Land Use	Education	Education
	Health and welfare	Health and welfare
	Public services	Religious services
	Culture, leisure, vacation, and sports	Emergency and rescue
	Commerce	Public administration services
	Industry and infrastructure	Cemetery
	Transportation	Culture, leisure, and sports
	Agricultural buildings	Hotels and rural guest houses
		Commerce and residential in an urban center
		Fuel stations and road services
		Commerce and offices
		Industry
		Rail transportation facilities
		Air transportation facilities
		Sea transportation facilities
		Electricity and communications
		Waste removal
		Wet and closed infrastructure
		Unspecified agricultural structures
		Parking lots and central stations
		Unspecified public services

Source: Central Bureau of Statistics.

Appendix Table 5 – Estimates of the Effect of the Number of Cellular Sites at a Distance of up to 100 Meters from Residential Units on the Housing Prices according to Socioeconomic Ranking[1] and the Type of Site

Multivariate Estimations Taking into Account Selection in Placement of the Sites[2]

a. Low socioeconomic ranking

	Pole Sites	Sites without Poles	All of the Sites
	(1)	(2)	(3)
Number of Cellular sites at the time of the transaction	-0.0117 (0.0113)	-0.0017 (0.0072)	-0.0025 (0.0062)
Average of the sites over time	0.0041 (0.0119)	0.0166 (0.0173)	0.0048 (0.0103)
Housing Characteristics[3]	V	V	V
Statistical areas fixed effects	V	V	V
Dummy variables for quarter X year X district	V	V	V
Differential time trends according to tendency to place a cellular site[4]	V	V	V
Number of observations	203,415	203,415	203,415
Adjusted R^2	0.842	0.842	0.842

b. High socioeconomic ranking

	Pole Sites	Sites without Poles	All of the Sites
	(4)	(5)	(6)
Number of Cellular sites at the time of the transaction	-0.0038 (0.0090)	-0.0087 (0.0062)	-0.0085 (0.0063)
Average of the sites over time	-0.0307*** (0.0116)	-0.0178* (0.0102)	-0.0220** (0.0091)
Housing Characteristics[3]	V	V	V
Statistical areas fixed effects	V	V	V
Dummy variables for quarter X year X district	V	V	V
Differential time trends according to tendency to place a cellular site[4]	V	V	V
Number of observations	189,436	189,436	189,436
Adjusted R^2	0.838	0.838	0.838

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

The standard errors, clustered at the level of statistical areas, are displayed in parentheses.

(1) The socioeconomic ranking of the statistical areas is according to the 2008 census, as calculated by the Central Bureau of Statistics. The ranking is on a scale of 1 to 20; 20 is the value for the wealthiest area. A low socioeconomic ranking is one lower than the median – 11 or lower.

(2) Based on Equation (3).

(3) The number of rooms (in groups of 1.5-2.0, 2.5-3, 3.5-4, 4.5-5), size and age of the house.

(4) A variable for the interaction between the time trend (separately for each district) and houses in whose proximity cellular sites were established in 2000-2011.

Appendix Table 6 – Yearly Estimates of the Effect of the Existence of *Cellular Pole Sites* at Distance of up to 50 Meters and up to 100 Meters from the Residential Units on the Housing Prices, both with and without Taking into Account Selection in Placement of the Sites[1]

	50 Meters		100 Meters	
	Not Taking Selection into Account	Taking Selection into Account	Not Taking Selection into Account	Taking Selection into Account
2000	-0.0278	-0.0284	-0.0065	-0.0184**
	(0.0200)	(0.0389)	(0.0114)	(0.0093)
2001	-0.0104	0.0309	-0.0184**	-0.0101
	(0.0190)	(0.0395)	(0.0093)	(0.0180)
2002	-0.0017	0.0567	-0.0098	0.0240
	(0.0166)	(0.0469)	(0.0089)	(0.0187)
2003	-0.0090	0.0485	-0.0122	0.0370
	(0.0169)	(0.0584)	(0.0094)	(0.0255)
2004	-0.0317**	0.0569	-0.0163	0.0425*
	(0.0152)	(0.0366)	(0.0109)	(0.0226)
2005	-0.0197	-0.0404	-0.0238***	-0.0294
	(0.0147)	(0.0444)	(0.0090)	(0.0233)
2006	-0.0200	0.0280	-0.0158*	-0.0012
	(0.0169)	(0.0530)	(0.0087)	(0.0219)
2007	-0.0380**	0.0269	-0.0170*	-0.0171
	(0.0150)	(0.0436)	(0.0090)	(0.0190)
2008	-0.0237	-0.0047	-0.0187**	-0.0375*
	(0.0181)	(0.0598)	(0.0091)	(0.0204)
2009	-0.0182	0.0443	-0.0305***	0.0055
	(0.0143)	(0.0425)	(0.0082)	(0.0191)
2010	-0.0301**	-0.0636	-0.0248***	-0.0407**
	(0.0151)	(0.0477)	(0.0086)	(0.0187)
2011	-0.0238	-0.0397	-0.0144	0.0007
	(0.0184)	(0.0368)	(0.0093)	(0.0193)

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.

Standard errors, clustered at the level of statistical areas, are displayed in parentheses.

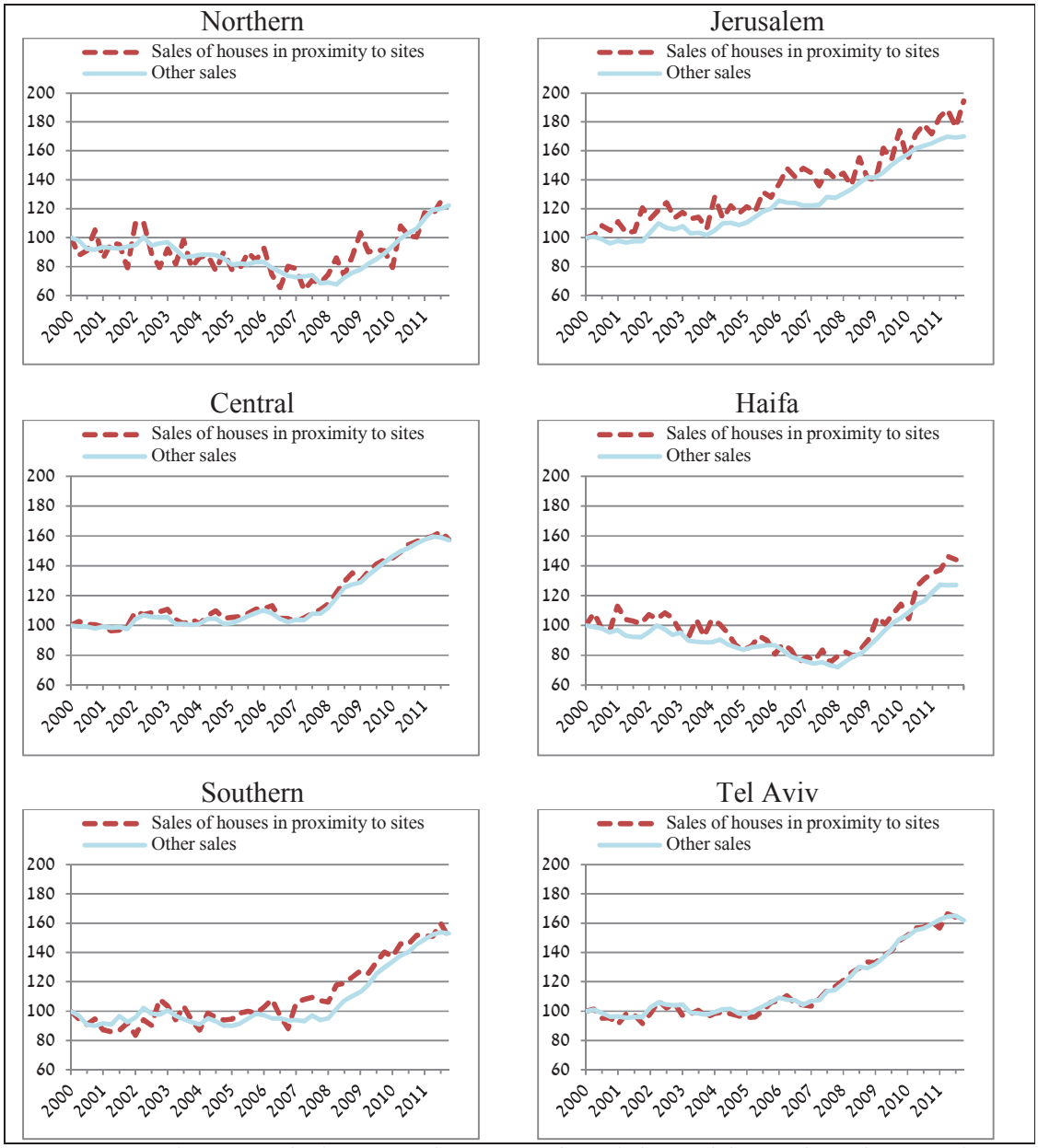
(1) Based on Equation (4), with the omission of the time trend and a variable for the interaction between the time trend and Houses in the proximity of which cellular sites were established in 2000-2011.

Appendix Table 7 – Yearly Estimates of the Effect of the Existence of *Cellular Sites without Poles* at Distance of up to 50 Meters and up to 100 Meters from the Residential Units on the Housing Prices, both with and without Taking into Account Selection in Placement of the Sites[1]

	50 Meters		100 Meters	
	Not Taking Selection into Account	Taking Selection into Account	Not Taking Selection into Account	Taking Selection into Account
2000	-0.0160	0.0096	0.0025	-0.0034
	(0.0210)	(0.0238)	(0.0114)	(0.0104)
2001	-0.0065	0.0182	-0.0034	-0.0006
	(0.0137)	(0.0184)	(0.0104)	(0.0128)
2002	-0.0214	-0.0090	-0.0038	0.0003
	(0.0152)	(0.0190)	(0.0088)	(0.0122)
2003	-0.0160	-0.0012	-0.0216***	-0.0095
	(0.0186)	(0.0230)	(0.0079)	(0.0114)
2004	-0.0149	-0.0088	-0.0194**	-0.0125
	(0.0212)	(0.0261)	(0.0095)	(0.0138)
2005	-0.0364***	-0.0008	-0.0131*	0.0025
	(0.0120)	(0.0188)	(0.0067)	(0.0233)
2006	-0.0263**	0.0101	-0.0088	0.0084
	(0.0105)	(0.0222)	(0.0069)	(0.0129)
2007	-0.0145	-0.0169	-0.0064	-0.0007
	(0.0096)	(0.0213)	(0.0059)	(0.0112)
2008	-0.0028	0.0274	-0.0030	0.0197
	(0.0089)	(0.0235)	(0.0061)	(0.0130)
2009	-0.0026	-0.0548*	-0.0169**	-0.0141
	(0.0151)	(0.0303)	(0.0067)	(0.0138)
2010	-0.0126	0.0064	-0.0082	0.0018
	(0.0117)	(0.0228)	(0.0060)	(0.0109)
2011	-0.0268***	-0.0058	-0.0183***	-0.0001
	(0.0095)	(0.0203)	(0.0055)	(0.0120)

Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
*** Significant at a 1% level, ** Significant at a 5% level, * Significant at a 10% level.
Standard errors, clustered at the level of statistical areas, are displayed in parentheses.
(1) Based on Equation (4), with the omission of the time trend and a variable for the interaction between the time trend and Houses in the proximity of which cellular sites were established in 2000-2011.

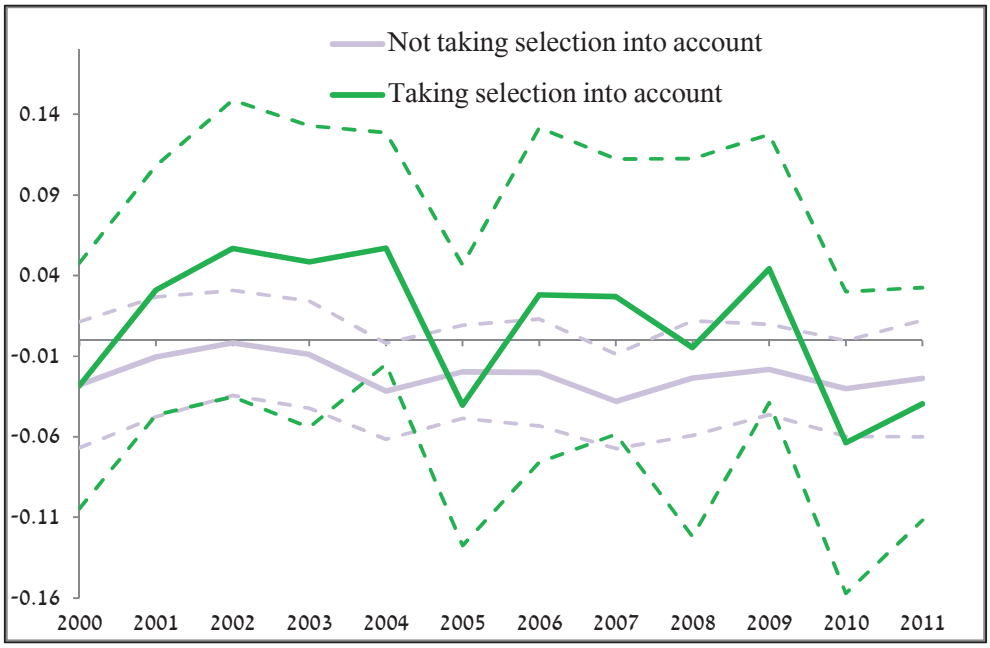
Appendix Figure 1 – Housing Prices Index: Comparison Between Transactions at a Distance of up to 50 Meters from a Cellular Site and Other Transactions, according to District, 2000–2011 (January 2000 = 100)



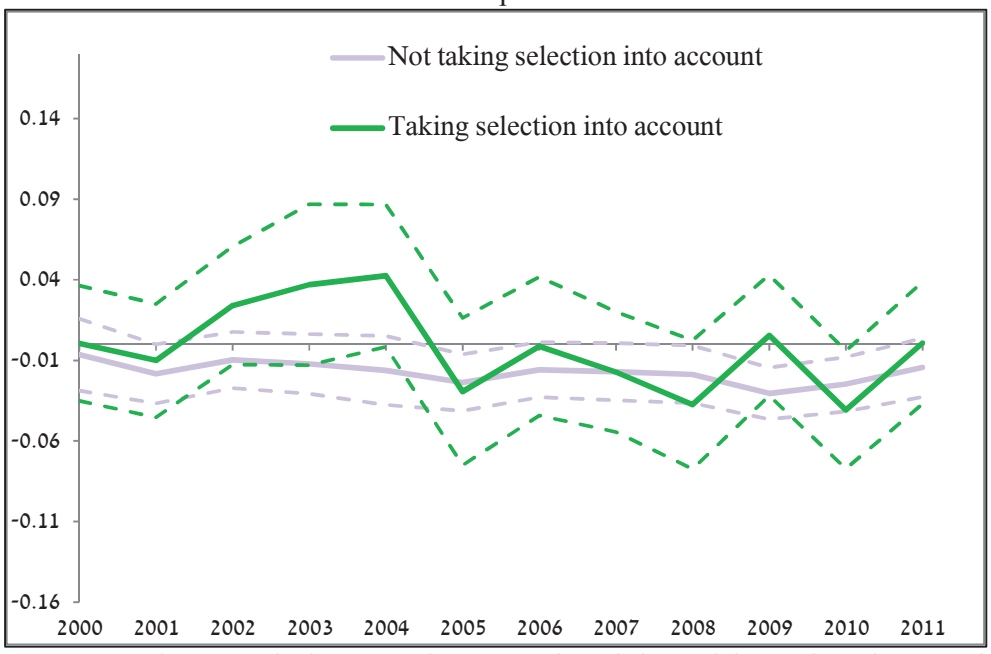
Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.

Appendix Figure 2 – Annual Estimates of the Effect of the Existence of *Cellular Pole Sites* in the Proximity of Residential Units on Housing Prices

a. Cellular Sites at a Distance of up to 50 Meters from the Houses



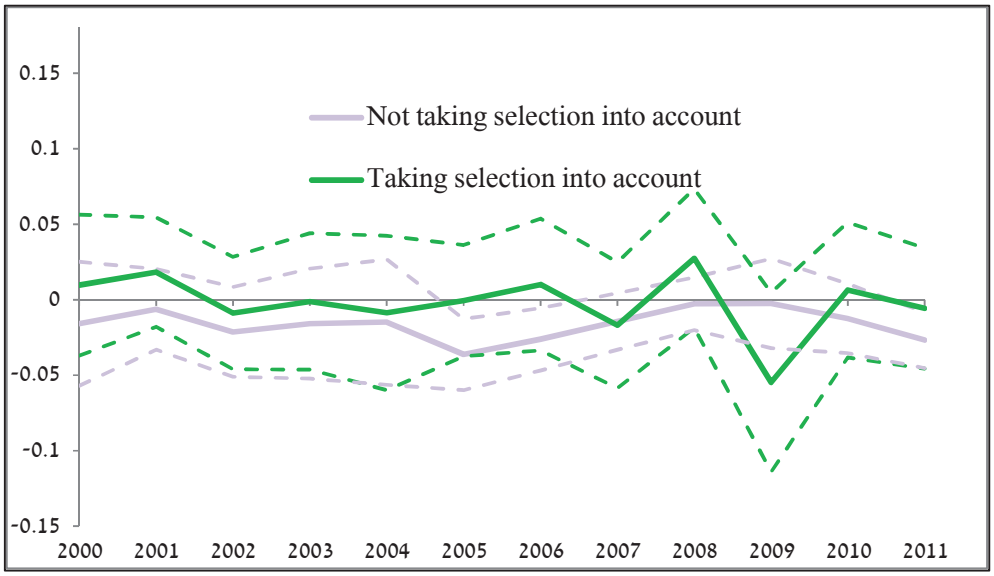
b. Cellular Sites at a Distance of up to 100 Meters from the Houses



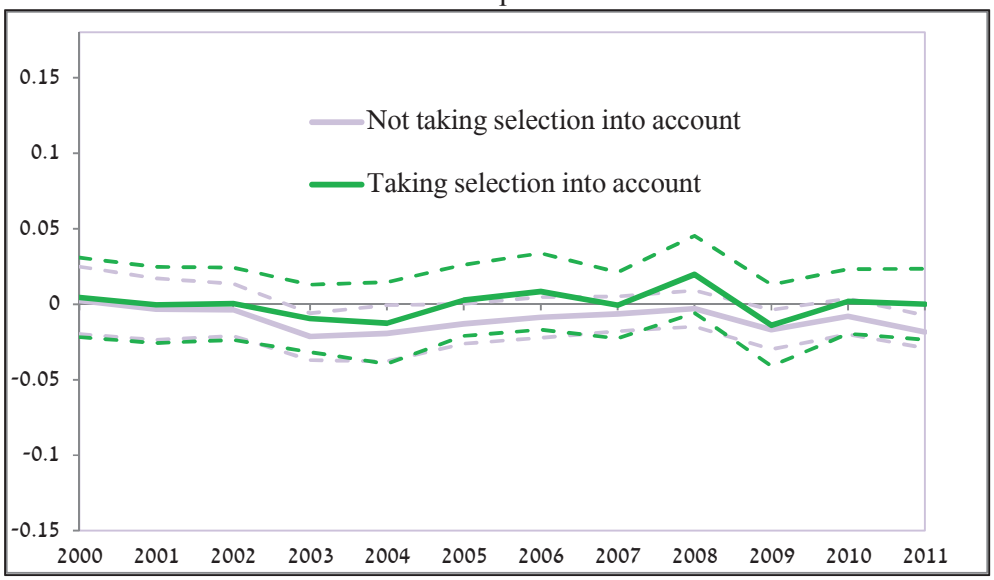
Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
Dashed lines indicate 5% confidence intervals.

Appendix Figure 3 – Annual Estimates of the Effect of the Existence of *Cellular Sites without pole* in the Proximity of Residential Units on Housing Prices

a. Cellular Sites at a Distance of up to 50 Meters from the Houses



b. Cellular Sites at a Distance of up to 100 Meters from the Houses



Source: Israel Tax Authority, Central Bureau of Statistics, Ministry of Environmental Protection, and the authors' analyses.
Dashed lines indicate 5% confidence intervals.