# The Inversion of the Land Gradient in the Inner City of Haifa, Israel

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Abstract

While suburbanization and decentralization are familiar concepts in urban economics, there is a possibility that land gradients will not simply flatten over time, but actually invert themselves. This would mean that the traditional CBD or downtown ceases to act as the pinnacle or nucleus of the land/housing pricing function within the metropolitan area. Such a possibility has been noted in the theoretical literature and has been demonstrated empirically in a few cases. Such an urban ''inversion'' is shown to have occurred in Haifa, Israel. Beginning in the 1960s, the stock of privately-owned cars grew in Israel at one of the most rapid rates ever seen in any industrial country, with relatively little growth in transportation infrastructure.

## Introduction

Urban economic theory is largely based on the classic theory of a monocentric circular urban or metropolitan area with a single central business district (CBD), built largely on the models first developed in the research of Alonso (1964), Beckmann (1969, 1974), Mills (1972a, b), Muth (1969, 1975), Solow (1973), and others. In these models, urban land and housing are priced as a downward (usually concave; often negative exponential) function of distance from this single urban center or CBD. In other words, ''accessibility'' to the CBD is the main argument in the locational demand function by households and other land users (commercial, industrial, etc.), who bid for land and housing. This generates the ''land-rent'' gradients, which describe prices at different distances from the CBD

While later urban models recognized the roles of secondary ''centers'' in the metropolitan area, the CBD generally plays a critical role even in such polycentric models. There is debate in the literature as to what actually ''drives'' the demand for accessibility or proximity to the CBD. In the earliest papers, the CBD was envisioned as a transportation terminal, such as a railhead or water port, and real goods had to be transported either to this terminal, or from it. Thus, transportation costs would increase with distance from the terminal and consequently bids for land would decrease. Accessibility would be ''traded off'' for higher prices for land and housing.

In later versions of the classic model, the CBD is an employment and commercial district, to which people must commute in order to engage in employment and/ or shopping. The CBD could also represent the nucleus of agglomeration economies (Calem and Carlino, 1991). Once again accessibility to the CBD is the major locational pricing factor for which people are willing to pay a premium through housing prices, and so distance from the CBD is associated with diminishing land and housing gradients. The CBD remains the pinnacle or nucleus of the land pricing gradient, with the highest prices for land in the metropolitan area. The ‘‘inner city’’ is then the area in proximity to the CBD.

While the ‘‘central location’’ model of urban economics continues to dominate much of the thinking about urban structure, there has also arisen a body of literature that shows that under certain circumstances it is possible for land gradients to ‘‘invert’’ themselves, and so for housing and land prices to *increase* with distance from the ‘‘downtown’’ or CBD instead of diminishing. In many cases this is presumed to stem from neighborhood effects, such as crime or socioeconomic traits of people in ‘‘inner city’’ neighborhoods, or from aging and deterioration of the housing stock in proximity to the downtown. Among those who have investigated the possibility of land gradient ‘‘inversions’’ have been McDonald and Bowman (1979), McDonald and McMillen (1990) and McMillen (1996). Much of the empirical investigation of land gradient inversion has been for the city of Chicago, where such an inversion appears to have occurred. There have been few investigations of inversions in other places.[1]

Discovery of inversions in other places is important for a number of reasons. Inversions imply the loss of locational comparative advantage for downtown areas, implying significant changes in urban structure, including changes in the nature of the ‘‘inner cities.’’ The factors that create inversions are also of interest. Are these the same across those cities in which inversions occur? Are inversions more likely to occur due to ecological factors, socioeconomic factors, or transportation system factors? Would inversions outside the United States occur for reasons similar to those cases occurring in the U.S.?

In this article the occurrence of a land gradient inversion is documented for Haifa, Israel. The land gradient for the city appears to have been a ‘‘normal’’ one at least until the early 1970s and the ‘‘inner city’’ decidedly middle-class. But by the late 1980s the gradient appears to have inverted. The inversion occurred following a dramatic change in the transportation system and in particular a very rapid increase in private car ownership relative to road infrastructure and parking availability in traditional downtown areas. The documentation of the occurrence of an inversion outside the U.S. implies that such phenomena may not be as anomalous as has been thought.

In the popular press there has long been discussion of the ‘‘death of downtowns,’’ where central business districts are said to lose their comparative advantages altogether and ‘‘die’’ in some economic sense.[2] In most cases, these commentators presumably have in mind the deterioration of housing quality in inner cities and the ‘‘flight’’ of jobs and capital to the suburbs. It has become well-understood that the economics of metropolitan housing markets and of downtowns have been changing.

In the analytic literature, the manifestation of such ‘‘dying’’ would be primarily in the flattening of land gradients and housing pricing gradients and the emergence of new secondary CBDs or multi-centered metropolitan areas.[3] There is a growing empirical literature on the emergence of multi-centered cities. In some cases the analysis focuses on employment patterns and population density gradients within multi-centered metropolitan areas, as in Boarnet (1994a,b), Cervero (1989), Giuliano and Small (1991), Gordon, Richardson and Wong (1986) and McDonald (1987). In other studies, multiple centers or pinnacles in the land/housing pricing gradients are explored, such as Heikkila, *et al* (1989) or Richardson, *et al* (1990) for Los Angeles. Multi-centered nonresidential real estate gradients are analyzed in Peiser (1987) and Sivitanidou (1996, 1997). There has also been research on the movement over time of the location of the city’s ‘‘center,’’ as in Alperovich and Deutsch (1994), who document shifts in the location of the center of Tel Aviv using population density data.

While the emergence of multiple centers competing with *the* downtown is now a familiar idea, there is far less known about land gradient inversions, where land and housing prices increase with distance from the CBD. In an inversion, the traditional downtown of a metropolitan area suffers an economic ‘‘death’’ in the sense that the pricing function or gradient actually changes sign, not just flattening. When the sign is changed, this means that other factors overwhelm any locational comparative advantage from proximity to the traditional CBD.

When land gradients invert, apparently in most cases neighborhood or housing features in areas close to the CBD offset the positive value of this proximity to the CBD. To pinpoint causes for inversions, it is of interest to ‘‘neutralize’’ as many of the quality factors associated with housing as possible in order to isolate the ‘‘pure’’ locational factors.

In the case of an ‘‘inverted city,’’ the CBD would serve as the (local or global) trough of a land pricing gradient rather than as its nucleus or pinnacle. The ‘‘peak’’ or pinnacle of the pricing function would relocate someplace else, replacing the downtown as the center of pricing. The new ‘‘center’’ or ‘‘centers’’ of the pricing structure would emerge, presumably possessing some locational comparative advantage of their own. People would then bid more in order to establish accessibility to the new center(s). Housing, employment and commercial activity may then be restructured to reflect preferences for distance away from the old downtown and proximity to the new center(s).

In the following sections, we show that this is precisely what occurred in Haifa, Israel.

## The Haifa Metropolitan Area

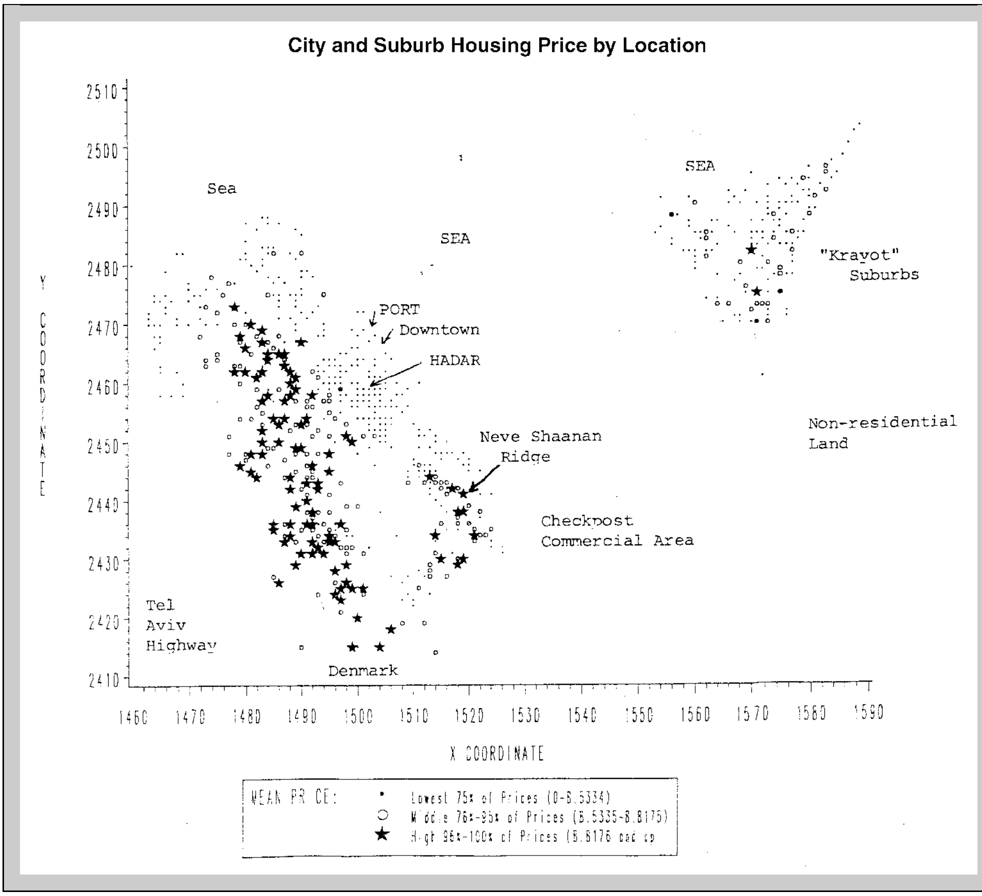
Haifa is the main urban center in northern Israel, located near the sea on the Bible's Mount Carmel. While its origins were thousands of years ago, the city began its rapid modern growth with the beginnings of the Zionist migration movement during the era of the British Mandate, where Haifa was designated to become the main seaport of a future Jewish state.[4] The growth of the port was also stimulated after World War I, when the British Mandatory government developed refineries and a petroleum port to serve as the terminus of a pipeline bringing in oil from Iraq. The CBD of the city consisted of the port area, known as "downtown," and a nearby shopping and employment center named Hadar, located a few blocks away from the port district and partly up the slope of Mount Carmel.[5]

Until the 1970s, the downtown-cum-Hadar CBD was the unambiguous economic center of the Haifa urban area. While no formal research on housing prices was performed for this early period, there is evidence suggesting that Haifa at the time had a traditional urban structure centered around the CBD. Housing density was highest there, dropping with distance from the CBD.[6] There was very little dispersal of employment and shopping, other than some neighborhood grocery stores and similar small shops. Downtown contained not only the port, but also a central train and bus terminal. Nearby Hadar was a shopping and retail center, as well as the center for public sector services (such as law courts, governmental offices and municipal services). Intracity buses virtually all terminated their routes in downtown or Hadar. The city continued to expand up the slopes of Mount Carmel, and eventually housing expanded along the ridges and on the crest of the mountain.[7] A small subway train was constructed in the 1950s, linking downtown and Hadar with some of the neighborhoods higher up the slope, feeding commuters and shoppers into the CBD.

During the 1950s and 1960s, the area northeast of the city became the location for a considerable amount of heavy industry, including petrochemicals and shipbuilding, near the "Krayot" suburbs of the city (see map in Exhibit 1). The downtown-cum-Hadar CBD continued to serve as the economic nucleus of the city at least until the 1970s (Soffer and Kipnis, 1980). It was also the highest-density center of the city's residential density function, with a second local center within the Krayot suburbs. Downtown-cum-Hadar was a major employment center, although much industrial employment decentralized to the industrial zones around the city outskirts. By 1976 the city proper contained about 228,000 people, with a total of about 367,000 in the greater metropolitan area (including the Krayot suburbs). In 1995, the official estimate for the city was 252,300, with 483,000 in the greater metropolitan area.

Beginning in the 1960s, there was a dramatic change in the nature of the city and of transportation throughout Israel. Private passenger car ownership skyrocketed, and the fleet of cars expanded rapidly. Private ownership of cars rose six-fold

**Exhibit 1** | The Layout of Greater Haifa




between 1960 and 1970, and tripled between 1970 and 1980. This was one of the most rapid rates of growth in private car ownership recorded anywhere, reflecting rapidly rising real levels of consumption in Israel.[8] By the late 1980s, Israelis were buying 100,000 new cars a year. In 1995, nearly three times as many private cars were on the road compared with 1980, 200 times the number that had been on the road in 1949.

The result of this massive accumulation of privately-owned cars altered a number of Israeli urban elements. Neighborhoods of residential housing could develop ‘‘off the tracks’’ of main bus and train lines. New suburbs and satellite towns could develop outside the main cities. Employment and shopping could decentralize and become more diffused (Kellerman, 1983). But perhaps most importantly, there was a sharp increase in urban traffic and parking congestion.

These trends were strongly felt in Haifa. Car ownership in Haifa was a mere 91.5 per 1000 inhabitants in 1965. It doubled to 181.3 per 1000 inhabitants in 1978 and then rose another 63% to 294.6 per 1000 inhabitants by 1990.[9] By 1984, there were 254,800 motor vehicles registered in Haifa, 208,400 of these were privately owned cars. Meanwhile the development of road infrastructure took place at a very slow pace. The expenditure on road infrastructure is shown in Exhibit 2. Even for a small city the size of Haifa, the amounts being spent on road building and road maintenance were quite modest. Road paving expenditures seem to have averaged about $200,000 per year (in 1987 dollars) in the 1960s, and perhaps twice that in the 1970s. Total expenditure on all road maintenance averaged around $400,000 per year (in 1987 dollars) in the 1960s, although rising sharply, and about twice that in the 1970s, but with a sharp drop in the early 1980s.

**Exhibit 2** | Real Expenditure on Haifa Road Infrastructure in 1987

| Fiscal Year | Total Road Maintenance and Paving | Paving Only |
|---|---|---|
| 87/88 | 4,392,290 | NA |
| 86/87 | NA | NA |
| 85/86 | NA | NA |
| 84/85 | 1,452,060 | NA |
| 83/84 | 3,321,252 | NA |
| 82/83 | 615,190 | NA |
| 81/82 | 606,930 | NA |
| 80/81 | 548,604 | NA |
| 79/80 | 815,281 | NA |
| 78/79 | NA | NA |
| 77/78 | 1,073,532 | NA |
| 76/77 | 1,031,482 | NA |
| 75/76 | 1,410,974 | 620,458 |
| 74/75 | 807,720 | 423,167 |
| 73/74 | 1,033,308 | 550,299 |
| 72/73 | 702,447 | 325,382 |
| 71/72 | NA | NA |
| 70/71 | 559,459 | 165,441 |
| 69/70 | 775,491 | 356,364 |
| 68/69 | 477,200 | 285,395 |
| 67/68 | 583,155 | 444,806 |
| 66/67 | 554,922 | 397,141 |
| 65/66 | 827,570 | 375,154 |
| 64/65 | 507,404 | 297,113 |
| 63/64 | 348,644 | 178,057 |
| 62/63 | 295,615 | 98,478 |
| 61/62 | 118,132 | NA |
| 60/61 | 89,977 | NA |

*Notes:* New Israeli Shekels (NIS). De Facto Expenditure: 1.6 1987 NIS = 1 1987 dollar. Source: Haifa Municipal Budget Reports, Various Issues.

Beginning in the 1970s, large commercial and shopping areas sprang up at the peripheries of the city, on the northeast side comprising the ‘‘Check Post,’’ the largest retail district in Israel, on the southwest side by a high-tech industrial park and—more recently—shopping areas near the entrance to the Tel Aviv freeway (see locations on map in Exhibit 1). At the same time, the rapid increase in car ownership created traffic congestion and parking problems throughout the city, but especially in the downtown-cum-Hadar CBD. The traditional CBD appears to have had a locational comparative advantage based on the pattern and modes of travel that existed before the 1970s, where there were few privately-owned vehicles and the bulk of travel was via public transit. In other words, a location that exhibited ‘‘comparative advantage’’ in the era before acquisition of private cars may have lost this advantage, as will be seen, once the main mode of transportation became the privately-owned car. There was enormous growth in the number of retail and service establishment in Haifa outside the CBD area (Greenberg, 1997). Even more dramatically, the downtown-cum-Hadar became the trough of an inverted housing pricing function.

## Haifa Housing Prices and Methodological Issues

Like most of the world outside North America and parts of Western Europe, data sets on housing and real estate in Israel are at a much lower level of development and there have been very few transactions-based research papers published to date using Israeli data. GIS tools in Israel are also at a much earlier level of development.[10]

In order to demonstrate the emergence of an inverted urban land pricing function, a large sample of residential real estate transactions that took place in the period 1988–96 in Haifa and the greater Haifa metropolitan area were analyzed. These consisted of nearly 6,000 transactions in the city proper, and over 11,000 in the greater metropolitan area, including the suburbs.

Data on second-hand real estate transactions for the period 1988–96 were obtained from the Israeli Ministry of Finance. The transactions in the sample are for residential housing units only.[11] The vast majority of these are in multi-family apartment buildings in which the housing units are sold as separate units, somewhat like American condominiums. Single-family houses are extremely rare in Haifa, and are largely concentrated in a single area (the ‘‘Denmark’’ neighborhood; see Exhibit 1).

The location of each transaction is given by its postal code.[12] For technical reasons related to data accessibility problems, all transactions after 1990 are in buildings for which there also occurred some transaction in the 1988–90 period. This creates an interesting advantage in the data set; each observation in the 1991–96 period is for a sort of *repeat sale* for the building (although not necessarily the same exact unit therein), that is, where all post-1990 sales are from buildings in which there already occurred a transaction. This increases the comparability and reliability of the 1991–96 subperiod with respect to the 1988–90 subperiod.[13] The prices of residential housing units are all recorded as a dollar price.[14]

## Non-Locational Factors in Haifa Residential Real Estate

As a first step towards analyzing the location structure of housing prices, the locational factors were separated from the non-locational factors affecting real estate prices. The non-locational hedonic regressions permit assessment of the locational premia and are not a complete state-of-the-arts hedonic representation of the full housing pricing function. The hedonic representation here is less sophisticated than those found in analyses of some other housing markets. The goal of this study was not to extend hedonic theory and application, but rather to extract, even if less than perfectly, the locational values in order to explore the nature of the Haifa ‘‘inner city.’’ Because the housing stock in the city is fairly homogeneous in terms of building style (multi-family apartment buildings), materials used, and so on, the damage from missing variables is reduced.

In the regressions, both non-locational variables and location dummies were run together, but the two sets of variables will be discussed separately. The analytic strategy was to regress housing prices on *all* locational and non-locational explanatory variables, where the non-locational factors are regarded as a simplified ‘‘hedonic’’ price function, and where locational factors may then be isolated and analyzed separately. Separating out the non-locational explanatory factors, leaves the ‘‘generic housing prices’’ or the underlying land price. Thus, location pricing can be addressed without confusing it with quality or housing unit differences.

The non-locational variables used are all of those that were obtainable from the data set.[15] They include the size of the housing unit measured in floor space, its number of rooms, the story, ceiling height and date of transaction. The number of stories in the entire building is known for about two-thirds of the observations. The date of construction of the unit is not known, nor information (except for a very small number of observations) on other fixtures and features, such as number of bathrooms, heating systems, number of exposures, separate entrance, and so on, and so unfortunately are not included in the analysis. Of these, perhaps the most troubling absence is the construction date; but for reasons to be discussed below, any bias introduced by this absence may actually strengthen the results below.[16] In any case, the observations regarding the nature and shape of the locational gradients are less affected by the absence of missing variables, the lower the degree to which these missing variables are themselves correlated with location. Unfortunately, usable socioeconomic indicators for locations were not available.[17]

Regressions were run for residential housing prices on the physical (non-locational) and the locational explanatory variables, while the latter were expressed as dummy variables by postal code. The two sets of explanatory variables will be discussed separately.

The basic regression equation for the case with no location indicators is:

$$\begin{aligned} \text{Res} = {} & \textit{ln Price} - \underset{(22.7)}{0.510}\ \textit{ln Square Meters} - \underset{(25.8)}{0.216}\ \textit{Rooms} \\ & - \underset{(0.59)}{0.0011}\ \textit{Floor} + \underset{(-2.64)}{0.115}\ \textit{Ceiling Height} - \underset{(45.2)}{0.010}\ \textit{Time}. \end{aligned}$$

with $R^2 = 0.57$. The numbers in parentheses are $t$-Statistics.

Here the explanatory variables shown are all the quality and non-locational variables that are usable from our data set. *Square Meters* is the floor size of the housing unit; *Rooms* is the number of rooms in the unit; *Floor* is the floor number; *Ceiling Height* is the measurement from floor to ceiling (it was expected to be a quality proxy, but may also act as an age proxy, as newer units tend to be built with somewhat lower ceilings); and *Time* is a time variable equal to 1 for the first month of 1988 and rising by 1 in each month thereafter, until December 1996. The price of the unit is the dollar price.

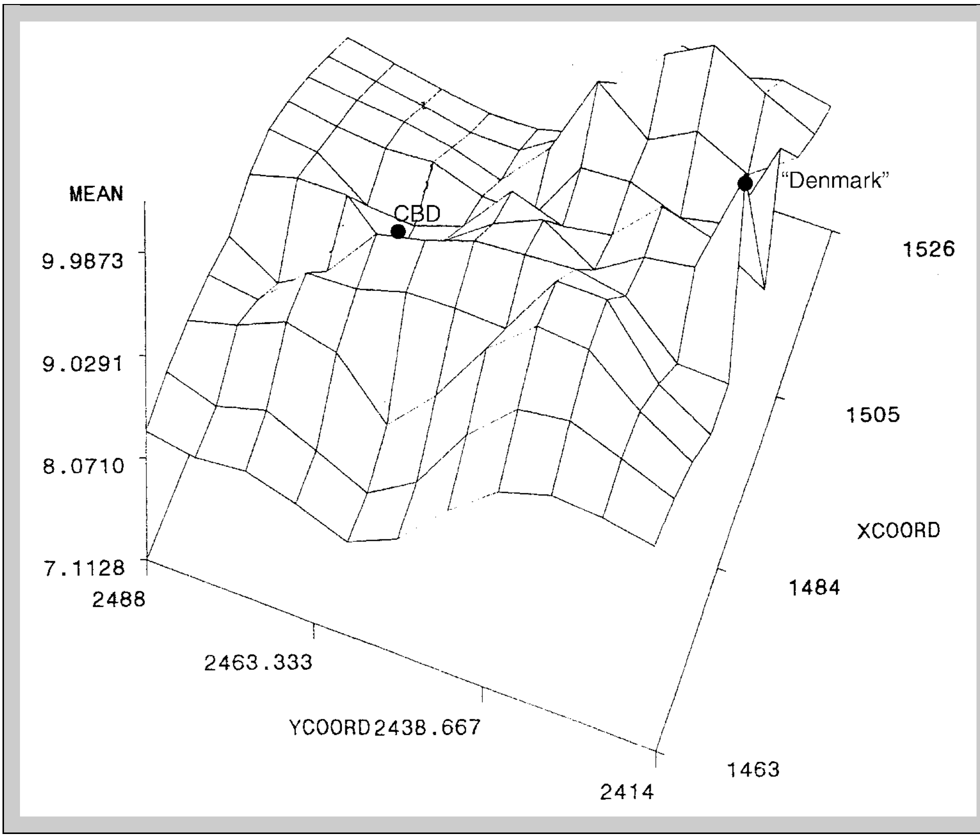
The non-locational (only) determinants of the dollar prices of Haifa residential real estate are shown in Exhibit 3 for the municipal boundaries only, and in Exhibit 4 for the greater Haifa metropolitan area (including suburbs).

In Exhibit 3, the results from regressions on residential housing transactions in municipal Haifa are shown. In these regressions, location was captured by the postal code dummy variables (not shown). A full five-digit code in Israel is generally a very small area of 1–2 city blocks. The three-digit code is approximately a complete neighborhood (in some cases a large neighborhood would spread over two or three such three-digit codes). The locational dummies are represented graphically in Exhibit 1.

Equation 1 was run with no locational variables. It can be seen that the non-locational variables explain about 57% of the variance in transaction prices in the sample. The locational variables add between another 11% and another 26% of explanatory power, where the more disaggregated are the locational variables (the postal code dummies)—the greater the explanatory power (not surprisingly).

Of the non-locational variables, it can be seen that the size of the housing unit has a coefficient in the range of 0.36–0.62, depending on the equation. This coefficient may be properly interpreted as an elasticity. Hence, for every doubling in the floor space of a housing unit, other things equal (including holding location constant), the unit's price would rise by between 36% and 62%. In all variations of the regression, this elasticity seems to have been considerably higher in the earlier 1988–90 period and to have dropped a bit thereafter. In other words, the premium commanded by greater size seems to have diminished over time, although it is unclear here whether this was a supply-side phenomenon (growth

**Exhibit 3** | Spline Mapping of Residual Land Values in Haifa—Low Smoothing

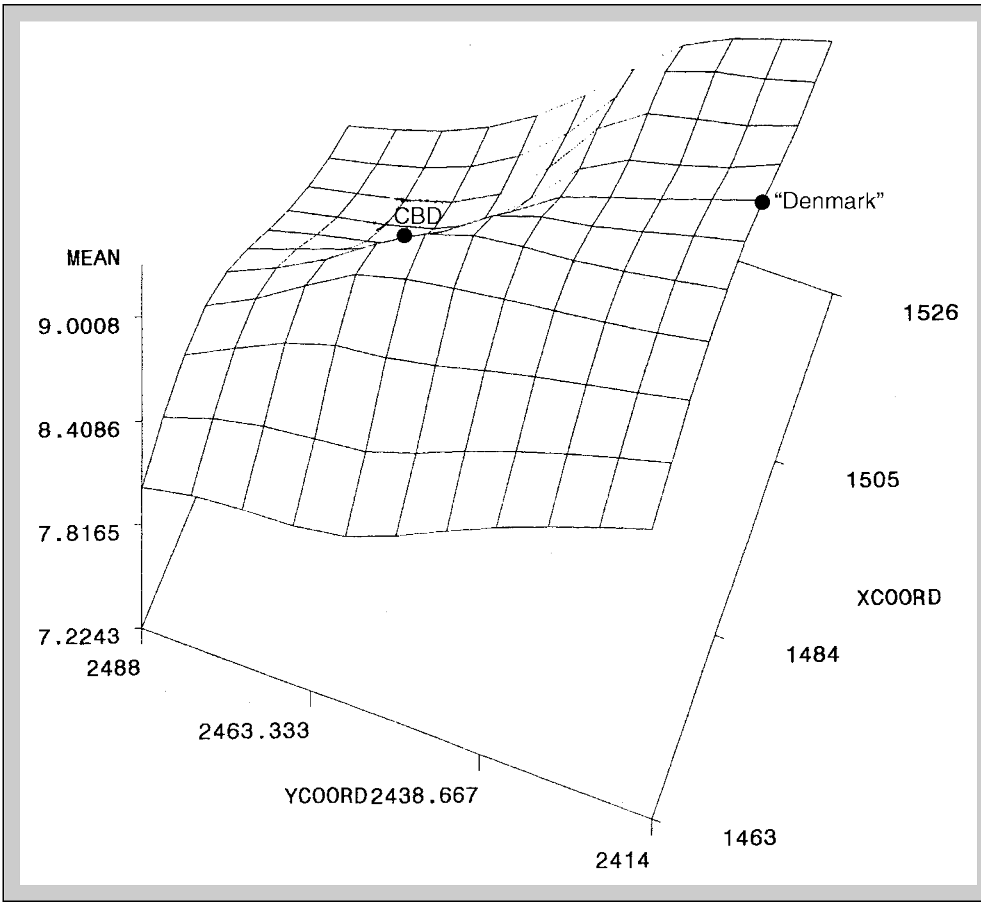



in stock of larger units available) or a demand-side phenomenon (drop in demand for larger units). The former is suspected.

The next variable is the number of rooms in the unit. Note that this variable is not a size measure as such, but rather measures the impact on price from an increase (through greater room division) in the number of rooms in a housing unit with *given* size. The coefficient here is between 10% and 20%, which is the increase in housing value from the addition of one extra room without changing total floor space. There does not appear to have been any time trend in this coefficient within the sample period.

There is a weak effect on real estate value of the number of floors within the building. Other things equal, a higher floor is associated with a slightly higher value, with prices rising by 0.1%–0.8% per floor, although in some cases this coefficient is not significant. The total number of floors in the apartment building in question was missing in many cases, but when included in the regression, also seems to be weakly (borderline significance) correlated with price.

**Exhibit 4** | Spline Mapping of Residual Land Values in Haifa—High Smoothing




The height of the ceiling was thought to be a quality surrogate, and appears significant in some of the regressions, non-significant in others. It appears with a negative coefficient in Equation 1, where no locational indicators are used, and positive everywhere else. The negative coefficient in Equation 1 is probably due to the fact that ceiling height is correlated with earlier construction and perhaps also cheaper neighborhoods in the city. The overall city trend over time seems to be toward construction with lower ceilings. The last non-locational explanatory variable is the time trend, showing an upward trend.

Similar regressions for the greater Haifa metropolitan area are shown in Exhibit 6.[18]

In Exhibit 6, regressions similar to those in Exhibit 5 appear, but where the data are taken from the greater Haifa metropolitan area. The data used here include the suburbs of Haifa, mainly the Krayot suburbs. The numbers of transactions in

**Exhibit 5** | Municipal Haifa Residential Housing Price Function

| Explanatory Variables | *N* | $R^2$ | Log of Square Meters | Number of Rooms | Floor of Unit | Number of Floors in Building | Ceiling Height | Time |
|---|---|---|---|---|---|---|---|---|
| With No Locational Variables (1988l–96) | 5914 | 0.57 | 0.510 | 0.216 | 0.001 | — | −0.115 | 0.010 |
| | | | (22.7) | (25.8) | (0.59) | | (−2.64) | (45.2) |
| With Three Digit Postal Code Locators (1988–96) | 5914 | 0.71 | 0.408 | 0.161 | 0.006 | — | 0.124 | 0.010 |
| | | | (21.5) | (22.7) | (3.50) | | (3.41) | (52.2) |
| With Three Digit Postal Code Locators (1988–96) | 3808 | 0.72 | 0.362 | 0.174 | 0.004 | 0.0031 | 0.154 | 0.009 |
| | | | (16.2) | (20.1) | (1.50) | (1.61) | (3.95) | (46.4) |
| With Three-Digit Postal Code Locators (1994–96 only) | 821 | 0.73 | 0.419 | 0.119 | 0.004 | — | −0.024 | 0.011 |
| | | | (9.30) | (7.28) | (1.21) | | (−0.42) | (14.1) |
| With Three-Digit Postal Code Locators (1988–90 only) | 4165 | 0.68 | 0.621 | 0.120 | 0.005 | — | 0.017 | 0.016 |
| | | | (23.7) | (13.3) | (2.34) | | (0.33) | (24.7) |
| With Four-Digit Postal Code Locators (1988–96) | 5889 | 0.77 | 0.356 | 0.157 | 0.008 | — | 0.109 | 0.010 |
| | | | (20.4) | (24.0) | (5.46) | | (3.33) | (58.0) |
| With Four-Digit Postal Code Locators (1988–90 only) | 4121 | 0.75 | 0.554 | 0.124 | 0.008 | — | 0.009 | 0.017 |
| | | | (22.9) | (14.8) | (3.90) | | (0.188) | (29.0) |
| With Five-Digit Postal Code Locators (1988–96) | 4794 | 0.83 | 0.371 | 0.138 | 0.007 | — | 0.148 | 0.010 |
| | | | (18.0) | (19.1) | (4.20) | | (4.48) | (59.2) |
| With Five-Digit Postal Code Locators (1988–90 only) | 2867 | 0.82 | 0.470 | 0.127 | 0.006 | — | 0.043 | 0.018 |
| | | | (16.6) | (13.5) | (2.55) | | (0.85) | (27.0) |

*Notes:* The dependent variable is Log of Price. Only the non-locational variables are shown for the explanatory variables. Numbers in parentheses are *t*-Statistics. Regression variables used but not shown in the tables include intercept and locational identifiers -postal codes. Equation 1 included intercept not shown.

**Exhibit 6** | Greater Metropolitan Haifa Residential Housing Price Function

| Explanatory Variables | *N* | $R^2$ | Log of Square Meters | Number of Rooms | Floor of Unit | Ceiling Height | Time |
|---|---|---|---|---|---|---|---|
| With No Locational Variables (1988–96) | 11487 | 0.56 | 0.365 | 0.217 | 0.001 | 0.154 | 0.009 |
| | | | (24.6) | (38.0) | (−0.99) | (4.68) | (66.0) |
| With Three-Digit Postal Code Locators (1988–96) | 11487 | 0.69 | 0.335 | 0.221 | −0.004 | 0.179 | 0.010 |
| | | | (25.6) | (45.0) | (−2.97) | (6.30) | (82.5) |
| With Three-Digit Postal Code Locators (1994–96 only) | 1880 | 0.71 | 0.412 | 0.135 | 0.001 | 0.028 | 0.011 |
| | | | (15.7) | (13.7) | (0.70) | (0.63) | (22.8) |
| With Three-Digit Postal Code Locators (1988–90 only) | 7259 | 0.64 | 0.392 | 0.222 | −0.002 | 0.058 | 0.016 |
| | | | (22.9) | (34.9) | (−1.12) | (1.38) | (34.3) |
| With Four-Digit Postal Code Locators (1988–96) | 11462 | 0.74 | 0.304 | 0.209 | −0.001 | 0.156 | 0.010 |
| | | | (24.7) | (45.0) | (−1.01) | (5.90) | (90.2) |
| With Four-Digit Postal Code Locators (1988–90 only) | 7215 | 0.70 | 0.349 | 0.215 | 0.001 | 0.047 | 0.016 |
| | | | (21.8) | (35.9) | (0.70) | (1.20) | (36.9) |
| With Four-Digit Postal Code Locators (1994–96) | 1609 | 0.76 | 0.370 | 0.129 | 0.002 | 0.002 | 0.011 |
| | | | (14.0) | (13.3) | (1.33) | (0.05) | (23.6) |
| With Five-Digit Postal Code Locators (1988–90 only) | 5607 | 0.74 | 0.283 | 0.226 | −0.001 | 0.090 | 0.017 |
| | | | (16.7) | (34.3) | (−0.36) | (2.16) | (34.4) |

*Notes:* The dependent variable is Log of Price. Only the non-locational variables are shown for the explanatory variables. Numbers in parentheses are *t*-Statistics. Regression variables used but not shown in the tables include intercept and locational identifiers -postal codes. Equation 1 included intercept not shown.

the regressions are roughly twice those for the Haifa-only regressions. The $R^2$ statistics are roughly the same. Once again, the physical traits without location explain about 56% of the variation in prices, while the locational variables explain an additional 13%–18% of variance.

In general, the coefficients are similar to those for Haifa only. The main exception is that the elasticity of floor space here is about the same as the lower range of estimates found in the Haifa-only regressions. The ‘‘rate of return on real estate’’ as measured by the time coefficient is also roughly the same as for Haifa-only.

## Locational Determinants

In order to understand the pattern of locational gradients and land prices, the location-specific premiums were extracted from the above equations. These location dummy coefficients are interpreted as observations of the ‘‘net’’ land value at the locations, identified by postal codes. These values were then cross-matched with the locational grids or coordinates on maps for each postal code. The coefficient interpreted as the land premium for location at the coordinates; in effect the location premium is the ‘‘pure’’ location price, after neutralizing as many housing unit specific features and characteristics as possible, including size of unit.

In Exhibits 1, 3 and 4, the general pattern of location-specific land prices and the general shape of the land gradient are showed for the Haifa data. In Exhibit 1, the locational prices are split into three categories, for low, medium and high prices, and different symbols show the pattern, superimposed on a map of the city. In Exhibits 3 and 4, the land gradient is drawn, using spline techniques with different degrees of smoothing.

In all cases, it is seen that the traditional downtown-cum-Hadar CBD is the trough of the land pricing function and not the nucleus or pinnacle. Indeed, the global lowest locational price in the entire sample is in the center of this CBD. The tract with the highest location in the sample located in a postal code that is one of the most distant from the CBD, in the Denmark neighborhood in which some single-family housing and duplexes are to be found. The traditional CBD appears as a trough in the pricing gradient whether or not suburban transactions are included in the analysis. If mathematical functional forms are imposed on the data to try to estimate the pricing gradient as a function of location, the traditional CBD still emerges as the trough of the function, with other areas emerging as local or global pricing pinnacles.[19] This is true even when allowing the gradient to have multiple local ‘‘centers.’’[20]

Because the global pricing pinnacle is in Central Carmel, which is not very far from the Hadar CBD and its global trough, and because the ages of housing units in those two areas are not very different, it would appear unlikely that the inversion is caused by the absence of better data on the ages of structures. One of the newest neighborhoods is in the Denmark area, where the location premia are fairly low compared with most of the rest of the Mount Carmel ridge.

Of course there is a difference between demonstrating that a price gradient inversion has occurred and diagnosing its cause. It cannot be stated in any definitive manner what the cause was, although the rapid growth in the size of the car fleet and its timing surely makes it an important contender. The timing of the Haifa inversion is certainly consistent with the change in the transportation system, that is, with traffic and parking congestion being the cause. Such transportation factors no doubt played a critical role in the emergence of new commercial districts outside the traditional CBD that are accessible by private automobile.[21] The timing is consistent with the conjecture that the comparative advantage of the Haifa CBD before the 1970s was tied to public transportation and so may have been lost when private car ownership expanded dramatically and accessibility to the CBD dropped in tandem.

However, the possibility that other factors besides the change in the transportation system played some role in the inversion are not ruled out. For example, air quality appears to be a factor in Haifa housing, although levels of pollution are actually higher in some peripheral areas (generally rising with proximity to the Check Post) and so would appear to be an unlikely cause of the inversion.

## Conclusion

This study documents an inversion in the housing price gradient for Haifa Israel. A price inversion would be said to occur whenever prices of land or housing decrease with proximity to the traditional CBD of a city, and represents an extreme version of urban decentralization. Inversions have been noted previously for other cities, mainly Chicago. The Haifa inversion appears empirically even when neutralizing several housing quality variables using the hedonic variables that were available. It may have been a product of the rapid change in the transportation system, and in particular a very rapid growth in the ownership of private cars relative to infrastructure (one of the most rapid in the world), thus leading to changes in the locational comparative advantage of the traditional CBD and several peripheral areas. Whatever its causes, this inversion in turn altered dramatically the nature and characteristics of the Haifa inner city.

If it is correct that the Haifa inversion was caused by a rapid change in the transportation system, it would be of interest to investigate whether the Haifa real estate gradient inversion is unique or whether it could indicate what the future holds in store for other inner cities, especially those whose downtown infrastructures are not automobile friendly (such as in many European cities).

In inversions of the price gradient, as discussed here, the traditional downtown becomes the pricing trough of the housing gradient in the metropolitan area, in effect losing its locational comparative advantage. If housing gradient inversion can be caused by traffic and parking congestion, inversions might be expected in some older European cities, where the downtowns were built before the age of the automobile.

While the focus here has been primarily on residential real estate values, it would be interesting to see whether commercial real estate values follow the same inversion pattern when housing prices do so, and which group of transactions leads and follows the other. The limited evidence seems to suggest that, in Haifa, commercial real estate values also followed an inversion pattern. Local real estate appraisal companies now claim that the highest commercial real estate values in the city are at great distances from the traditional downtown, either atop Mount Carmel or by the entrance to the city near the Tel Aviv highway. Both areas seem to have emerged as new ‘‘pinnacles’’ in the *commercial* land gradient and may have displaced the traditional CBD altogether.

Another intriguing idea that needs further investigation is whether residential and commercial land gradients may ‘‘diverge’’ and wrap themselves around *different* new ‘‘centers,’’ one for the residential properties and another altogether for the commercial market, as the CBD loses its comparative advantage. Could there emerge ‘‘commercial’’ and ‘‘residential’’ nuclei, but at different locations, with different comparative advantages? The limited information available suggests that this may have occurred in Haifa.

Finally, the underlying causes of urban housing price inversions require further investigation. Here the possible causes have been examined, but the proof that these or other factors produce inversions is a matter of interest for future research.

## Endnotes

[1] While ‘‘inversion’’ could be used in a number of different senses, including movement of locations of employment to the urban periphery, it will be used throughout to refer to the shape of the land gradient itself.

[2] See, for example, ‘‘Down and Out Downtown,’’ by David Broder, *Washington Post*, June 19, 1991 and ‘‘Downtown’s Empty Feeling,’’ *The New York Times*, May 9, 1993. Glaeser (1998) raises the question of cities ‘‘dying’’ in a different but related manner.

[3] Multi-centered cities have been modeled by Papageorgiou (1971), Papageorgiou and Casetti (1971), Hartwick and Hartwick (1974), Amson (1976), White (1976, 1988), Odland (1978), Ramanos (1979), Ogawa and Fujita (1980), Griffith (1981a,b), Fugita and Ogawa (1982), Wieand (1987), Sasaki (1990), Helsley and Sullivan (1991), Sasaki and Mun (1996), Yinger (1992) and Anas, Arnott and Small (1997).

[4] It was earmarked as such in the early writings by the ‘‘father of modern Zionism’’ Theodore Herzl.

[5] See Soffer and Kipnis (1980), especially pages 53, 62–65 and 72–73. The article also contains a survey of historical and geographic research on Haifa.

[6] Soffer and Kipnis (1980), pages 72–76 and 86–87.

[7] It reached its maximal limits, which are the borders of the Carmel National Park, in the 1980s.

[8] See Dargay and Gately (1997). They list Israel among the most rapid car fleet growth rates, but not the highest in their sample. We suspect that if they had looked at 1965-80 only, Israel would have held the title of fastest growth.

[9] Israel Statistical Abstract and Tel Aviv Statistical Abstract, various volumes.

[10] While the Central Bureau of Statistics in Israel has been developing some GIS tools, those in use are not usable with the sorts of data used in this study.

[11] A problem with the data set is that they were not accumulated for the specific purpose of research analysis, but rather for governmental administration purposes. As a result, the variables included in the data set are not ideal and do not include all those that we would have liked to include in the hedonic analysis. The hedonic equations must be regarded as imperfect representations of the pricing functions.

[12] Each postal code in Israel is for a very small area, approximately a block of 100 meters by 100 meters, or about one or two city blocks by American standards.

[13] Transactions under $20,000 were discarded on grounds that they were probably either misrepresented prices, ''gifts'' or intra-family transfers, or were for assets that are less than full housing units (such as a storage room) misclassified as residential housing. Transactions over $3 million were discarded on the presumption that the price was entered incorrectly in the database.

[14] This may strike non-Israelis as a bit bizarre, as the dollar is not the national currency used in Israel. In fact, the dollar is the unit of account in which virtually all real estate transactions and contracts (including rentals) are denominated in Israel, and dollar prices are even used and recorded by government offices.

[15] To date, there have been many countries for which GIS analyses and hedonic regressions have not been published because of the difficulty in obtaining data sets, and Israel is one. While the set of variables in this study is less than ideal, it is in fact one of the few analyses of such a set for non-Western countries. The comparative advantage of the set is not its completeness but rather its application to a non-Western city.

[16] In any case, the difference in average age across neighborhoods is relatively small. Most of the housing stock in the entire city was built from the 1940s onward. In the sample, there are only second-hand transactions, meaning the latest construction for any units in the sample would be the 1980s, but for most units the construction would be earlier. For example, most structures in the Hadar CBD were constructed in the 1940s and 1950s, whereas in the Central Carmel area most were constructed in the 1950s and early 1960s. The two neighborhoods are not very far away; the Hadar area turns out to be the trough of the pricing function whereas the Central Carmel area is the global pinnacle, making it doubtful that age of construction is what is behind the shape of the function.

[17] Such indicators are available at the municipal level and for fairly large census divisions, but not for the micro-locations being used. The same problem exists for indicators of school quality, although such quality is fairly homogeneous especially in the areas atop Mount Carmel. Because the pricing trend in these Mount Carmel areas appears to be for prices to drop with distance from the city's pinnacle in Central Carmel, the price trend there does not appear to be school related. In any case, inclusion of such variables in hedonic regressions raises conceptual problems because it is not clear whether the socioeconomic measures are a function of housing costs or vice versa. Analyzing the role of socioeconomic measures as the cause and effect of housing pricing is an interesting direction of research, but could not be addressed with the available variables.

[18] Because the five-digit postal code dummy set was so large, the regression software would not solve at this level for the full time period, and so the four-digit equation parameters were used to generate location variables.

[19] In Plaut and Plaut (1998), a method for inferring such locations of local and global centers of the pricing gradient was developed. In applying this method to Haifa, the traditional CBD emerges in all cases as a trough.

[20] There is not enough data to run a similar analysis on commercial real estate. However, estimates of prices and rents for commercial properties per square meter by local appraisers indicate that the Haifa CBD has ‘‘died’’ in the sense of commercial properties as well, with the highest commercial rentals in the Matam area southwest of the city center and along the ridge of Mount Carmel, with the Check Post area in between these areas and the CBD. The commercial rents may indicate some alternative center that differs from the center for the residential housing function, but it is clearly not in the traditional CBD.

[21] Alperovich and Deutsch (1994) document a similar shift in the center of Tel Aviv.

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