The University of Alberta

Department of Economics

WHO IS REALLY PAYING FOR YOUR PARKING SPACE? ESTIMATING THE MARGINAL IMPLICIT VALUE OF OFF-STREET PARKING SPACES FOR CONDOMINIUMS IN CENTRAL EDMONTON, CANADA

By

OWEN JUNG

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ABSTRACT

Many large North American cities impose minimum parking space requirements on multi-family residential developments. There is concern that the high costs to developers of providing these spaces are raising housing prices in such complexes. Because there is not a well-developed formal market for parking places, this paper attempts to estimate the implicit price of parkade-style (aboveground or underground parking garages) parking spaces for condominiums located in central Edmonton, Canada. Using two real estate data sets, this paper employs the hedonic method and tests for the presence of heteroskedasticity and spatial autocorrelation, when possible. Based on the results for one data set, the marginal effect of an additional parkade-style parking space on the predicted condominium price was statistically significant but substantially less than the typical cost of supplying that space. Using the other data set, the number of parkade-style parking spaces variable was found to be statistically insignificant, which suggests that this attribute is not an important real housing price determinant and therefore that the marginal implicit value of parkade-style parking spaces is less than the substantial costs associated with providing such spaces. Overall, the results suggest that consumers of those spaces are receiving a large discount on bundled parkade-style parking spaces, meaning that if the retail price is increased due to the inclusion of additional parking spaces, the higher price does not fully reflect the cost to the developer of providing those parking spaces. Housing affordability, nonetheless, may still be adversely affected as developers, who are likely burdened with some of this indirect parking subsidy, may ultimately provide less housing to the market, thus leading to a higher market-clearing price. Therefore, this paper provides further empirical evidence

towards the argument against the use of minimum parking requirements as they are likely to cause an oversupply of parking at multi-family residential developments.

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I. INTRODUCTION

For some years prior to the global economic downturn in the second half of 2008, housing affordability was one of the top social and economic issues across Canada as several Canadian housing markets experienced substantial price increases. In particular, the City of Edmonton in the Province of Alberta suffered rapidly deteriorating housing affordability conditions from 2006 to mid-2008 as the province, endowed with enormous oil and gas reserves, enjoyed a booming economy that attracted thousands of new migrants looking for employment. This put tremendous upward pressure on housing prices (see Figure 1). Both the Government of Alberta and the municipal government of Edmonton have responded by launching various initiatives to address housing affordability;[1] however, the consideration that minimum parking requirements as required by land use bylaws in Edmonton (and in many other cities) could have a significant negative effect on housing affordability has, until recently, been largely absent from discussions regarding housing issues.[2]

Minimum parking requirements are often incorporated in municipal land use bylaws in response to public frustration over perceived vehicular parking shortages. Introduced via zoning ordinances of North American cities in the 1930s (Shoup, 2005), minimum parking requirements are used by municipal policy makers as a supply-side

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[1] For example, in its 2007 Budget, the Government of Alberta established the Homeless and Eviction Prevention Fund, increased funding for homeless shelters, allocated funding for an Alberta Transitional Housing Initiative, and increased funding for the Rent Supplement Program (Snow 2008). The City of Edmonton launched in 2006 Cornerstones, a five-year plan to increase the supply of affordable housing (*ibid*. 2008).

[2] At a City Council meeting held on April 15, 2009, City of Edmonton mayor Stephen Mandel inquired about how parking requirements could be reduced in order to make the development of smaller bachelor units more affordable (Piroddi, 2009). Piroddi (2009) produced a list revealing that other Canadian and American cities allowed for a reduction in parking requirements if: 1) the units are considered "small" (below a certain size threshold), 2) the units are developed under an affordable housing initiative, and/or 3) the units are located near high-frequency transit routes. The report indicated that similar allowances could be considered for Edmonton.

approach to solve the parking issue, overlooking the fact that the development cost of parking spaces is often substantial.[3] If the minimum parking requirements imposed by a municipality are too generous, then an excessive amount of parking is likely to be supplied (Bunt & Associates, 2008). Indeed, a recent parking study showed evidence of an overabundance of residential parking spaces in the downtown area of Edmonton (*ibid*., 2008). If parking is oversupplied at a residential development, a large fraction, if not all, of the excess development costs could potentially be passed on to the consumers. The costs, however, may be hidden from the consumers because the parking costs are usually bundled in the final market price (Shoup, 2005). The added costs are particularly burdensome on lower-income households because this household cohort is less likely to own a vehicle (Litman, 2008), meaning that these households are more likely to end up paying for a parking space(s) they never desired in the first place. Despite the significant implications for housing affordability, there has been little research on how much of these parking costs are ultimately passed on to the consumers. The objective of this paper is to estimate the value to consumers of additional parking at multi-family residential developments. Such research will help provide insight into the impact of parking development costs on the price of this type of housing.

The paper focuses on the condominium (condo, hereafter) market in the central area of Edmonton: that is, the downtown core and adjacent neighbourhoods. The condo market was chosen for this study because the construction of parking spaces typically poses a substantially larger proportional cost burden for multi-family developments than one- or two-family dwellings (Litman, 2008); consequently, overly generous minimum

[3] See Litman (2008) for a thorough breakdown of parking development costs for different types of residential developments.

parking requirements will likely have a significantly larger impact on condo prices than on prices for detached houses. Located in the centre of the city, the downtown area of Edmonton can largely be considered a central business district (CBD); as a result, land prices are usually at a premium in the central area, thus making capital costs of parking particularly acute.

This paper uses two independent sets of real estate data. The first data set is composed of real estate transactions occurring from May 2005 to January 2006. The second data set is composed of condos listed for sale by the owners during the month of December 2008. The paper applies a hedonic model, in which the condo prices are estimated to be a function of a variety of dwelling attributes (Griliches, 1971). The hedonic method allows us to estimate the implicit prices of a dwelling's characteristics. The paper will target the implicit price of off-street parking spaces; it is this estimated price that will help reveal the underlying preference for such parking spaces.

Despite the widespread use of hedonic models among researchers in the study of residential land values,[4] this approach has not often been applied to the investigation of off-street parking provision. A study by Jia and Wachs (1998) found that the availability of off-street parking was a statistically significant housing attribute that raised both the prices of houses and condos in San Francisco by a substantial margin.

The remainder of the paper is structured as follows. In Section Two, Edmonton's history of minimum parking requirements is discussed. A review of existing literature is presented in Section Three. In Section Four, the two data sets employed in this paper are described, followed by a presentation of the hedonic method in Section Five. The

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[4] For example, see Andersson (2000), Boxall *et al*. (2005), Can and Megbolugbe (1997), Debrezion *et* al. (2006), Gawande and Jenkins-Smith (2001), Habib and Miller (2008), Kockelman (1997), Leggett and Bockstael (2000), and Poor *et al*. (2007).

empirical results and analysis for our two data sets appear in Section Six. In Section Seven, policy implications of the study findings are discussed. Finally, a summary and conclusions are presented in Section Eight.

II. A HISTORY OF EDMONTON'S MINIMUM PARKING REQUIREMENTS

The City of Edmonton first incorporated minimum off-street parking requirements in October 1961. In zoning bylaw 2135, a list of minimum parking requirements was established for different types of development, including residential categories.[5] For single- or multi-family dwellings, the minimum number of parking or garage spaces was one space per dwelling unit; this parking requirement applied to any new development or any existing development that underwent a substantial expansion in capacity.

In May 1973, in response to public concerns over the perceived lack of available parking in the growing city, the Planning Department of the City of Edmonton completed a study that reviewed the existing parking requirements, which were at the time largely unaltered since 1961 (Low, 1973). The study (which is discussed in greater detail below) concluded that the parking requirements at that time were inadequate, especially for multi-family residences, and therefore proposed a new set of parking standards with substantially higher parking requirements (Low, 1973). In July 1980, the City of Edmonton introduced land use bylaw 5996, which adopted in large part the recommendations outlined in Low (1973). Among the notable changes brought about in

[5] Historical records of City of Edmonton bylaws can be found at the Planning and Development Department library located in downtown Edmonton.

this bylaw was the distinction between one- and two-family housing, and multi-family dwellings with regards to parking standards. These standards are outlined in Table 1.

In an effort to rejuvenate the downtown core, which as a whole suffered due to years of economic decline prior to the late 1990s, Edmonton City Council approved the "Capital City Downtown Plan" in 1997. The plan included a revitalization strategy that led, among other things, to a relaxation of minimum parking requirements for the downtown area (Bunt & Associates, 2008). In June 2001, the City of Edmonton introduced zoning bylaw 12800, which was in effect at the time of writing. This bylaw maintains the two sets of minimum parking requirements: one set for developments occurring within the boundaries of the "Downtown Area Redevelopment Plan" (a 160-hectare designated area in central Edmonton; see Figure 2), and a more demanding set of parking standards for the rest of the city. The two sets of minimum parking requirements are outlined in Table 2. Note that the more demanding set of parking standards is identical to the standards as required by the previous bylaw (Table 1).

In 2008, the City of Edmonton publicly released a draft version of "Edmonton's New Downtown Plan", which, if approved, is intended to replace the 1997 downtown plan.[6] Under the proposed plan, the downtown district would have a new zoning classification system, which would consist of seven zones based on land use and intensity (City of Edmonton, 2008). Each zone would have its own set of minimum parking requirements, but each set would also have some form of *maximum* parking limits. Five zones would be granted a further relaxation of parking requirements on top of the

[6] The final version of "Edmonton's New Downtown Plan" is scheduled to be submitted to City Council in the fall of 2009.

reduction approved in 1997,[7] while the other two zones would be granted a provision to allow parking requirements to be lowered if the residential development is within 200m of a light-rail transit (LRT) station. The new plan also calls for an adjustment to the Downtown Plan boundaries to increase the designated area from 160 hectares to 251 hectares (*ibid*., 2008).

Since Low's 1973 parking study became the foundation of Edmonton's current parking standards, it is worthwhile to take a closer look at his findings and analysis. Low concluded that the parking standards at the time were inadequate not only for residential development, but also for commercial, industrial, and other types of development. Low found that parking requirements for residential development in particular were insufficient, largely because they neglected parking provision for visitors and the storage of recreation vehicles, and did not differentiate among types of residential developments. While parking standards for one- and two- family dwellings at the time were generally viewed as passable,[8] Low concluded that such was not the case for multi-family dwellings. External parking studies cited by Low suggested that minimum parking requirements should increase with the number of bedrooms in a unit.[9] The survey of parking studies convinced Low that parking standards for multi-family dwellings would be improved if they were sensitive to the number of bedrooms. Using 1972 Civic Census data, Low showed that the average number of bedrooms per dwelling increased with distance from the city core. Low also noticed that average car ownership followed a

[7] For example, instead of 0.5 parking space currently required, a bachelor suite would no longer require a parking space.
[8] Residential areas occupied by one- or two-family dwellings were typically of low-density development, meaning that there was usually ample private space for the owner to store additional vehicles, including recreational vehicles. In addition, there was usually a healthy amount of on-street parking available for visitors.
[9] For example, the United States Highway Research Board recommended 1 space for each efficiency suite, 1.5 spaces per 1 or 2 bedroom suite, and 2 spaces per 3 or more bedroom suite (Low, 1973).

similar spatial pattern.[10] The evidence led Low to conclude that "a logical solution to ascribing a parking standard would be to require parking in relation to the location and to the number of bedrooms" (Low, 1973, p. 13).

Nevertheless, Low surmised that a parking standard that considered *both* the type of development and location would involve a complicated parking system that Low predicted would have very high administrative costs. Low suggested that a parking standard that looked only at the type of development – and not location – would suffice since the average number of bedrooms, and thus the total minimum number of parking spaces required for the building, increased with distance from the city core anyway. Consequently, Low recommended that one parking standard for one type of dwelling unit should be applied to *all* areas of the city.

To establish parking requirements for multi-family dwellings, Low focused on one economic indicator: average car ownership according to type of dwelling. Using the 1972 Civic Census data, Low calculated these values for bachelor suites, 1 bedroom suites, 2 bedroom suites, and 3 or more bedroom suites. To allow for visitor and recreational vehicle parking, Low then inflated the average car ownership rates in a somewhat arbitrary fraction, such that the final numbers would conveniently be multiples of 0.5. Low acknowledged that by using average values to formulate the parking standards, there would be areas in the city that would face parking requirements that were higher than the actual ownership rate, especially in the downtown core, where there was a higher concentration of bachelor-type suites than elsewhere. To compensate, Low intentionally made the allowance for visitor/recreational vehicle parking a smaller

[10] In addition, Low recognized that factors such as the quality of public transit, rent, and household income affected the parking demand directly or indirectly.

fraction of the total amount of parking required for bachelor suites compared to the other types of dwelling units.[11, 12]

III. LITERATURE REVIEW

Depending on the cost of land and the type of parking structure provided, the development cost of a single parking space can be startlingly large. According to RSMeans (2006), the median construction cost for an aboveground parking garage developed in the U.S. in 2007 was $13,650 per space, and the 75th percentile cost was $23,400 per space.[13] Based on typical values found across major cities in the U.S., Litman (2008) estimates that for aboveground parking structures developed in a CBD area the construction cost is on average approximately $15,000 per space (in 2005 dollars).[14] These figures, however, exclude land costs, which can be substantially larger than the actual construction costs. For example, when land cost is included, the cost of an aboveground parking garage in San Jose, California, in 2002 was about $57,000 per space (Folmar, 2003). Consequently, in the case of off-street surface parking, which requires no structure, capital cost can still be significant. Litman (2008) claims that the land cost alone for off-street surface parking in a typical urban setting in the U.S. is over

[11] Using the same logic, the share of the total parking amount required represented by the allowance for visitor/recreational vehicle parking was largest for the 3 or more bedrooms suites.

[12] Noteworthy among the report's recommendations was the inclusion of a clause for government-sponsored housing projects to apply for an exemption to the parking requirements. Low recognized that such housing projects were typically large in terms of number of bedrooms, but were catered towards low-income households, who tended to have lower rates of car ownership. Low therefore anticipated that less parking would be required for such residential development. Regardless, no exemption clause for government-sponsored housing projects was adopted in the subsequent zoning bylaw in 1980.

[13] A typical off-street parking space requires about 300 square feet, including access lanes for vehicles to navigate around the parking lot (Litman, 2008; Shoup, 2005).

[14] Note that a number of factors can substantially increase the construction cost of parking structures. These factors include shape irregularity of the lot, complexity of the structure design, and problematic topography at the site (Victoria Transport Policy Institute, 2009).

$2,000 (2005 dollars) per space. Indeed, assuming a unit price of $15 per square foot,[15] the land cost for an off-street surface parking space in Edmonton would be about $4,500 (2009 dollars). These costs exclude paving and annual operating and maintenance costs, which are not trivial (Litman, 2008). For a city like Edmonton, it is fair to assume that the land cost will be significantly higher in the downtown area.

When it comes to underground parking garages built underneath the building, the purchase of additional land is not necessary; nevertheless, the construction costs for such garages can be substantial. To develop an underground parking garage in a CBD area in the U.S., Litman (2008) estimates the typical construction cost would be $25,000 per space (in 2005 dollars). According to Block-Schachter and Attanucci (2008), the capital cost of building underground parking at the Massachusetts Institute of Technology was estimated to range from $100,000 to $125,000 per space, while at Harvard University the cost was an astounding $200,000 per space. In downtown Amsterdam, the cost of an underground parking garage ranged from 50,000 to 80,000 Euros per space (Wentink, 2009).

Overall, regardless of the type of parking being constructed, the capital cost of each off-street parking space developed in the Edmonton downtown area is more than likely to be significant. Therefore, if a residential development produces a surplus of parking, the total cost of the excess parking spaces could be substantial.

A recent parking inventory study by Bunt & Associates (2008) provides evidence that there is indeed an oversupply of parking spaces in the Edmonton downtown area. In 2006, Bunt & Associates conducted parking utilization surveys during the morning,

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[15] A typical price for an area zoned for industrial use well outside the Edmonton downtown area (see Colliers International, 2009).

afternoon, and early evening throughout the Edmonton downtown area. Even at peak usage, which occurred at the earliest surveyed hour (i.e., 9:00am), only 50% of residential-only stalls were being occupied by vehicles (*ibid*., 2008).[16] Moreover, in a list of 44 CBDs throughout the world, Edmonton was ranked 12th in terms of parking per hectare (i.e., 126 spaces per hectare), well ahead of other Canadian cities (Shoup, 2005).[17,18] The high density of parking in the Edmonton downtown area may be a result of the urban renewal schemes that occurred in the 1960s, during which a number of abandoned or derelict buildings were demolished (City of Edmonton, 2008). Instead of being redeveloped, many of the lots, for a variety of reasons, were simply converted into surface parking lots (*ibid*., 2008).

In addition to Edmonton, there is evidence that excess residential parking is a problem elsewhere in Canada. For example, a parking study specifically targeting condo apartment buildings in Mississauga (a major suburb of Toronto, Ontario) found that the parking standards existing at the time were 35% higher than the residents' vehicle ownership rate. As a result, a less demanding set of parking standards for condos was adopted in 1994 (Litman, 2008).[19] There is reason to believe that many of the minimum parking requirements adopted in North American cities are excessive. Based on five surveys conducted since 1964, the Planning Advisory Service (PAS) concluded in its latest survey in 2002 that "[m]any communities have created parking standards that require developments to build parking spaces far in excess of demand" (Shoup, 2005, p.

[16] On the other hand, since many people in Edmonton start their commute to work before 9:00am, the surveys may have underestimated actual parking utilization.
[17] These cities were Winnipeg (21st, 85 spaces per hectare), Ottawa (23rd, 84 spaces per hectare), and Montreal (26th, 77 spaces per hectare).
[18] The original data were derived from Jeffrey Kenworthy and Felix Laube's 1999 book, *An International Sourcebook of Automobile Dependence in Cities, 1960-1990*, Boulder, University Press of Colorado.
[19] At the time the city zoning code, adopted in 1979, specified that 2.0 parking spaces must be built for each condo unit.

27). PAS also found that cities would often develop their parking requirements by simply copying requirements set in other cities. However, for the cities that developed their own parking requirements, PAS discovered that the parking standards were based on little, if any, empirical evidence (*ibid*., 2005). Consequently, Shoup (2005) believes that most parking requirements are simply a "collective hunch". Combining the above findings and the methodology employed in Low (1973), it is highly plausible that Edmonton's parking standards are excessive. Therefore, if Edmonton's minimum parking requirements are overly generous, and if the capital costs of parking, regardless of type, in the downtown area are substantial, then a question that should subsequently be asked is: *who* ultimately ends up paying for the cost, and *by how much*?

There are a number of stakeholders in the housing market who would be affected by minimum parking requirements. This paper focuses on the three stakeholder groups who are most likely to be negatively impacted by the excess economic costs: the consumers, the developers, and the original (pre-development) land owners. The consumers are potentially impacted as the costs associated with excessive parking provisions could be incorporated in the market price of the dwelling, but since the price attributed to parking features is not normally explicitly stated (i.e., consumers generally see only the total housing price), this upward pressure on prices is essentially hidden from consumers. The developers would be negatively affected if they cannot pass the costs completely on to the consumers. In this case, the developers would have to absorb some of the costs, leading to a reduction in economic rents (profits) for the developers. The erosion in economic rents would therefore make land purchases for development less financially attractive. As a result, the land values of pre-developed land may drop, reducing economic rents for the original land owners. Although this paper concentrates on the effect on the consumers, the adverse impacts on the other stakeholder groups also have significant implications on housing affordability (explained later on in this paper).

One study that attempted to measure the cost effects from the introduction of a residential parking requirement in a zoning code was conducted for the city of Oakland, California. Prior to June 1961, Oakland did not have any form of off-street parking requirements in its zoning ordinances as on-street parking was assumed to be sufficient to satisfy parking needs. However, in response to the traffic congestion occurring in medium- and high-density areas, the city changed its zoning code such that new apartment buildings were required to build one off-street parking space per dwelling unit (Bertha, 1964). While the city's Planning Commission did not anticipate any effect on land use or land value from the parking requirement, market analysts in Oakland were certain that land value would be adversely affected.

In response, Bertha collected data on apartment buildings constructed between June 1957 and November 1963. Of these buildings, 45 properties were developed before the zoning change, while 19 properties were developed afterward. Among his results, Bertha observed that the median construction cost per dwelling unit was 18% higher among the properties built after the zoning change compared to the properties developed before. Bertha's findings revealed that since the parking requirement was independent of dwelling size, developers viewed the parking construction cost as an expensive, but fixed, cost. Thus, the larger the total construction cost per dwelling, the smaller the parking construction cost would proportionally represent. As a result, it was more cost-effective to build fewer but larger dwelling units. This led to a decrease in housing density in terms of both median number of units per acre (-30%) and median number of units per development (-36%).

To receive compensation for the higher overall construction cost per dwelling unit, developers touted the larger dwelling size as a selling strategy to pass some of the increased construction costs to the tenants in the form of higher rents. Bertha did not, however, collect data on the rent structure for the sampled buildings, so an empirical rent structure comparison was not possible. On the other hand, Bertha found that the profit margin for the developers was significantly smaller on the properties developed after the zoning change,[20] meaning that, despite the higher rents being charged, the developers had to absorb some of the increased construction costs.[21] Bertha also attempted to measure the effect of the minimum parking requirement on pre-development land values in terms of price per square foot. While he found some evidence that land value may have increased slightly after the zoning change, Bertha admitted that he could not truly disentangle the effect of the parking requirement on land value from other influential factors in the complex real estate market. In other words, evidence regarding whether or not land owners benefited from the minimum parking requirement was inconclusive.

Bertha (1964) revealed that both the developers (decrease in profits) and the consumers (higher rents) were burdened with paying for some of the increased

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[20] Bertha (1964) measured profitability as a ratio of the developer's profit (i.e., gross sales price minus total development costs and pre-development costs) to the pre-development land costs. According to this measure, median profitability dropped by 52.2% after the parking requirement was imposed.

[21] Interestingly, Bertha viewed this effect as a *positive* impact because prior to the zoning change there were a number of inferior developers constructing marginal buildings because it was profitable to do so. Since the parking requirement reduced the profit margin, Bertha surmised that the zoning change effectively priced the inferior developers out of the housing market. Bertha's conclusion, however, does not take into account the fact that profit margin erosion was not discriminatory: the parking requirement likely reduced the welfare of *both* proficient and inferior developers. To mitigate the construction of marginal buildings, other strategies, such as improvement or better enforcement of building codes, would have likely been a more effective and efficient method.

construction cost brought about by the parking requirement. Bertha did not, however, empirically measure the adverse effect on the consumers. Using real estate transaction data and census data, Jia and Wachs (1998) attempted to quantitatively measure the impact of off-street parking availability on housing prices in San Francisco, California. In the mid-1950s, San Francisco introduced in its planning code a parking standard that demanded at least one off-street parking space for every bedroom in new apartment housing (Klipp, 2005). During this time, few residential buildings had off-street parking spaces. In 1975, the city relaxed its parking requirement to a 1:1 parking rule, meaning a parking space was required for each new single unit of housing, independent of unit size.

Collecting data on 232 dwelling units sold in 1996 in six San Francisco neighbourhoods, Jia and Wachs (1998) matched each sampled real estate transaction with neighbourhood-level characteristics using 1990 census data. In their hedonic model, the housing characteristics employed were: unit size, number of bathrooms, off-street parking availability, unit age, and architectural style.[22] The neighbourhood attributes selected were: median household income and ethnic composition.[23] Jia and Wachs estimated separate models for single-family dwellings and condos. In their analysis, Jia and Wachs found that the availability of off-street parking was statistically significant in both models. For single-family dwellings, off-street parking availability was found to increase the price by about 12%, or $46,000, while for condos the price increase was about 13%, or $39,000 (both in 1996 US dollars).

Based on their results, they concluded that if dwellings were built without off-street parking, 16,600 additional households would be able to afford a single-family unit,

[22] The architectural styles selected in the study were: contemporary style, cottage, custom, Edwardian, Spanish, rustic, and traditional.
[23] The ethnic groups selected were: Caucasian, Asian, African-American, and Hispanic.

while 26,800 additional households could afford a condo.[24] Jia and Wachs also found that it took on average 41 days longer to sell a condo with parking than a condo without the feature. This finding ran contrary to the popular belief that condos without parking provision were more difficult to sell on the housing market (Klipp, 2005)

Some caution, however, should be exercised when interpreting the results in Jia and Wachs (1998). Jia and Wachs interpreted their estimated coefficient for the availability of off-street parking as the marginal value of this housing attribute. In other words, they viewed the coefficient estimate as representative as the true willingness to pay to have an off-street parking space. McMillan *et al*. (1980), however, showed that this scenario would be true only under highly restrictive conditions.[25] To properly estimate actual household demand for attributes, Rosen (1974) suggested a second-stage regression using the implicit prices provided by the hedonic price function in addition to other information (e.g., household income).[26]

In Jia and Wachs (1998), no explicit test was performed to select the most appropriate hedonic price functional form for their data; thus, it is possible that misspecification of the functional form may be problematic in their study. Jia and Wachs also do not indicate whether or not they checked for the presence of heteroskedasticity in the error term. If present and not dealt with, apparent statistical significance of coefficients could be misleading (Leggett and Bockstael, 2000). In her hedonic study of land values in San Francisco, Kockelman (1997) found evidence of heteroskedasticity in

[24] Assuming a 30-year mortgage with a prevailing rate of 7.5% and a 10% down payment.
[25] The conditions are as follow: consumers have equal incomes, identical preferences and reside in small open areas (McMillan *et al*., 1980).
[26] On the other hand, if it could be assumed that households have similar preferences (tastes) for housing attributes, then the implicit prices derived from the hedonic regression may not be too far from the true willingness to pay schedule (McMillan *et al*.., 1980).

the error term, and modified her models, accordingly. In Boxall *et al*. (2005), which looked at the impact of oil and natural gas facilities on rural residential property values, evidence of heteroskedasticity was found in the error term derived from their baseline model (i.e., non-industrial property attributes only).

Another econometric concern regarding hedonic specification is spatial autocorrelation of error terms (Goodman, 1989). Similar to heteroskedasticity, spatial autocorrelation biases Ordinary Least Squares (OLS)-derived standard error estimates, leading to inaccurate hypothesis tests (Leggett and Bockstael, 2000). Evidence of spatial autocorrelation was found in other hedonic studies, such as Gawande and Jenkins-Smith (2001).[27] Gawande and Jenkins-Smith employed a hedonic model to show evidence that the proximity to nuclear waste transport adversely affected residential prices in populous urban areas. Spatial autocorrelation is further discussed later in this paper.

Although Jia and Wachs (1998) was the only study found that explicitly focused on the impact of off-street parking on property prices in a North American city that enforces a minimum parking requirement, the implicit marginal value of an off-street garage has been estimated in other hedonic studies. For example, in Boxall *et al*. (2005), the marginal impact on rural residential property price in Alberta from a unit change in garage space was estimated to be about $7,300 (in constant 2000 $CDN). McMillan *et al.* (1980), who estimated the value of quiet in the residential areas surrounding an Edmonton airport, found that the marginal effect on property price from the presence of a garage was estimated to be about $5,600 (in $CDN, based on sales occurring in 1975 or

[27] Other examples include Boxall *et al*. (2005), Leggett and Bockstael (2000), and Can and Megbolugbe (1997).

1976). In both Boxall *et al.* (2005) and McMillan *et al.* (1980), the presence of a garage was highly statistically significant.

In another hedonic study, Macdonald and Veeman (1996) employed a random sample of 60 single family homes sold in Edmonton in March 1993 to conduct a hedonic price analysis. Macdonald and Veeman found that the coefficient associated with the presence of a garage (separate or attached) was statistically significant. The marginal implicit value of a garage was estimated to be $7,386 (in 1993 $CDN), which is comparable to the results found in Boxall *et al*. (2005) and McMillan *et al*. (1980).

Caution should be exercised in comparing the results of the three Canadian studies with the results of Jia and Wachs (1998) as they are not estimating the same housing attribute. Since space is generally not an issue in rural or urban Alberta, the three Canadian studies are measuring the marginal implicit value of the structure itself (i.e., garage), whereas Jia and Wachs (1998) are measuring the implicit price of having off-street parking, regardless of type and the number of spaces included.

Another hedonic study of parking space can be found in Wentink (2009), who estimated housing prices in Amsterdam. Wentink found that the marginal implicit value of an off-street parking space was 42,336 Euros.[28] In Amsterdam, less than 10% of houses have off-street parking (*ibid*., 2009). In addition, since paid-parking is in effect for most of the city, vehicle-owning residents without access to off-street parking often have to apply for a parking permit. Without a permit, these residents would have to pay the much higher hourly parking rates normally charged to visitors in order to park their vehicles. Since the marginal implicit value estimated is comparable to the capital costs associated with underground parking garages, Wentink provides empirical support for the

[28] This value is based on average hourly on-street parking rate and average waiting list for a parking permit.

construction of such garages in Amsterdam, especially in areas where waiting lists for a parking permit are very long.

A direct comparison between Wentink (2009) and the above three Canadian studies, however, would not be appropriate as the residential parking situation in Amsterdam is very different from the parking circumstances in rural and urban Alberta. In Edmonton, off-street residential parking is widely available, and usually no permit is necessary to park on-street as free parking is prevalent throughout the city.[29] Consequently, it should not be surprising that the marginal implicit value of off-street parking would be significantly lower in Edmonton than in Amsterdam.

Notwithstanding the sharp contrast in parking circumstances between Edmonton and Amsterdam, the studies collectively suggest that the presence of off-street parking can impact property values by non-trivial amounts. The results also imply that it would be worthwhile to conduct additional hedonic studies for different types of real estate markets in various geographical locations to improve the understanding of the relationship between off-street parking and housing prices and, by extension, housing affordability.

This paper attempts to expand the hedonic literature on housing affordability by investigating the implicit price of off-street parking at condos in the downtown area of Edmonton. The results of the model in this paper will undergo a number of hypothesis tests to examine the robustness of the findings.

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[29] Even in areas where on-street parking meters are present, parking rates are often in effect only during normal business hours on weekdays and Saturday.

IV. SOURCE and DESCRIPTION of DATA

In this paper, two sets of real estate data are utilized. The first data set originates from the Multiple Listing Service (MLS) records of the Edmonton Real Estate Board. The MLS sample contains real estate transaction data for 500 condos sales occurring over a nine-month period from May 2005 to January 2006. Each sale took place either in the Edmonton downtown area or in the neighbourhood of Oliver, a major residential area directly adjacent to the downtown area. Information in the MLS data set includes the final selling price of the unit, major housing characteristics (including type and number of off-street parking spaces), number of days on the market, various amenities available in the condo complex, physical neighbourhood attributes, the monthly condo fee, services included in the condo fee, and the property tax assessed for the unit. According to Boxall *et al*. (2005), local government taxes can affect property values. Tax information is missing for 28 observations. Crucial parking information is also missing for some observations. There are 465 observations left in the final data set.

A special note should be made here regarding the parking information included in the data set. In general, there are three types of off-street parking: surface, aboveground multi-level, and underground.[30] For the latter two categories, the associated parking structure is often called a parkade rather than a parking garage. In the MLS data set, the term parkade is used as a descriptor and is sometimes accompanied with another code to indicate the parking is underground; however, since the data set is a collection of input from numerous realtors, some realtors may describe an underground parking space by simply using the parkade term only. Consequently, to avoid ambiguity, all parking

[30] There is of course some heterogeneity in each category. For example, a surface parking stall could have a gravel surface, an asphalt surface, a protective canopy, an electrical outlet, etc.

spaces described with the term "parkade" are combined into one category; thus, aboveground and underground parking spaces are collectively referred to as parkade-style spaces, hereafter.[31]

Building amenities, neighbourhood attributes, and services included with the condo fee are measured solely by their presence. Consequently, many of the regressors in the model based on the MLS data set are dummy variables. As the MLS sample is a collection of data from numerous real estate agents, many of the characteristics, especially at neighbourhood-level, were likely evaluated using different criteria. For example, a golf course (variable DGOLF) located one kilometre away from a dwelling could be considered as "nearby" by one real estate agent but another agent may think otherwise.

Overall, a total of 125 unique features are identified in the MLS sample. Many of these features, however, are similar in nature and can therefore be grouped together.[32] In addition, some features are dropped because their frequencies are very high (i.e., present in almost every observation) or very low. Regardless, even after the groupings, the total number of attributes is still quite large: that is, 57 available explanatory variables. A glossary of the variables, along with associated summary statistics, is available in Table 3.

Note that the prevalence of off-street parking is clearly evident in the sample set as majority of the condos has at least one off-street parking space of some type. On the other hand, there is a small subset of observations that has no off-street parking included

[31] Such grouping was considered reasonable as the construction costs of aboveground and underground parking spaces are generally similar and often considerably higher than surface parking spaces (Litman, 2008).

[32] For example, there were three types of building security features, four types of air-conditioning, seven types of aesthetically pleasing views from the condo (e.g., lake view, ravine view, river valley view), etc.

with the dwelling;[33] consequently, a dummy variable (DNOPARK) is created to account for these observations.

The lack of locational information, however, is a serious shortcoming of the MLS data sample. For privacy reasons, neither the address nor the postal code of any dwelling unit was provided. As a result, it is not possible to supplement each observation with neighbourhood-level socio-economic information by matching real estate transactions with census information from Statistics Canada. It is also not possible to test for the presence of spatial autocorrelation in the data (explained in the next section).

This inability to test for the presence of spatial autocorrelation is the main impetus behind finding another source of real estate data. ComFree Private Sales (ComFree) is a real estate company that assists home owners to privately sell their properties without the intermediary assistance of a real estate agent. Primarily through the website, www.ComFree.ca, for-sale-by-owner sellers advertise their properties with a sample of pictures and a brief description of the property. In addition to major housing attributes, each advertisement discloses the asking price for the dwelling unit and, important for this study, the address of the property.

On ComFree's website, properties for sale can be sorted according to municipality, property type, and residential area. A December 2008 search of the site for condos selling in the central area of Edmonton produced 84 results. A map displaying the locations of all 84 units is provided in Figure 3. From each advertisement, the

[33] Although no explicit explanation is given, there are a number of possible reasons why no parking space is bundled with the dwelling. The MLS data set includes observations that were developed before 1961, when minimum parking requirements were first introduced in Edmonton, so parking provision would not have been mandatory at the time of construction. In addition, at some condo complexes, parking spaces are sold separately from the dwellings (i.e., *unbundled* parking spaces), meaning that some tenants could have more than one parking space, while other tenants may have none.

following housing attributes are tabulated: address, asking price, the year the condo was built, floor area, the number of bedrooms, the number of full bathrooms, the number of half bathrooms, the monthly condo fee, the number of parkade-style spaces, the number of surface parking spaces,[34] building type,[35] the presence of a balcony, the presence of air-conditioning, the presence of in-suite laundry, the presence of a fireplace, and if heating is included with the condo fee.

Utilizing the address information, each observation is supplemented with neighbourhood-level data originating from Statistics Canada's 2006 census, the most recent year available. Census information is available in various degrees of data aggregation; the least aggregated data publicly available are at the dissemination area (DA) level, which is a small area with a population of 400 to 700 persons.[36] DA information is considered the closest approximation to neighbourhood-level data. To match the appropriate DA data set to each property, the postal code for each property has to be acquired. This is accomplished using Canada Post's online conversion tool.[37] The following census information is then acquired: the percentage of the population in the DA who are 65 years or older, the percentage individuals of Aboriginal ancestry, the percentage of individuals belonging to a visible minority,[38] the percentage with completed post-secondary education, and median household after-tax household income.

[34] Property tax information was also usually disclosed, but a number of properties did not have any tax data. In light of the small size of the ComFree sample, property tax was excluded from the list of variables rather than removing observations from the sample.
[35] Each condo complex was designated as either a low-rise building or a high-rise building. A high-rise building was a complex having five or more stories.
[36] As defined in Statistics Canada's 2006 Census dictionary, available at: http://www12.statcan.gc.ca/english/census06/reference/dictionary/index.cfm
[37] At the time of writing, this conversion tool was available at: http://www.canadapost.ca/cpotools/apps/fpc/personal/findByCity?execution=e1s1
[38] Based on the Employment Equity Act, which is Canadian federal legislation, visible minorities are defined as "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour".

Gawande and Jenkins-Smith (2001) found in their baseline models that most of the racial-based, education-based, and income-based neighbourhood characteristics applied in their study were statistically significant at the 1% level; Jia and Wachs (1998) had similar results in their study.

To conduct hypothesis tests for the presence of spatial autocorrelation in the error term, the relative Euclidean distances between all of the condo complexes in the sample are measured in a two-step procedure. First, the latitude and longitude coordinates (lats-longs) of the properties are derived from street addresses (a process called geocoding) using the GPS Visualizer website,[39] where geocoding applications developed by Yahoo! or Google can be accessed. Using digital property maps available on the City of Edmonton website as a guide,[40] the approximate centre of a condo complex is used as the designated point of reference. In addition to the condo complexes, the lats-longs of every LRT station in downtown, two major educational institutions,[41] a shopping mall,[42] a downtown-adjacent golf course,[43] the Province of Alberta legislature building,[44] and the City Hall are determined. Close proximity to any of these locations could be considered an attractive feature for prospective buyers, thereby increasing the market value of the property. In the second step, the lats-longs are processed using ArcView, a geographic information system (GIS) software, which calculated the desired Euclidean distances.

[39] http://www.gpsvisualizer.com/geocoding.html
[40] http://www.edmonton.ca/for_residents/assessment-maps-property-value.aspx
[41] The two institutes chosen here were the University of Alberta (main campus) and Grant MacEwan College (city centre campus).
[42] Located close to the downtown area, Kingsway Garden Mall is a popular shopping mall that is also adjacent to a major technical college (i.e., Northern Alberta Institute of Technology). This college could have also been identified as another place-of-interest, but since the shopping mall and the college are located so close to each other, the variables associated with these two locations would have been highly correlated to each other.
[43] The Victoria Golf Course is a popular public golf course that also has a driving range. The golf course's club house was chosen as the geographic reference point.
[44] Edmonton is the capital of the Province of Alberta.

The distance to the nearest LRT station for each condo complex is subsequently identified.

A list summarizing the ComFree data variables, including abbreviations and summary statistics, is provided in Table 4. Although the ComFree sample provides some advantages over the MLS sample, the ComFree data set suffers from serious shortcomings that prevent its exclusive use in the study. Not only is the ComFree sample substantially smaller than the MLS sample, but the property price provided for each observation is the asking price, not the final market price. Consequently, since the asking price is typically higher than the final market price,[45] there will likely be an upward bias on the dependent variable. Also, unlike the MLS sample, in which observations occurred over a nine-month time-period, the ComFree sample is a "snapshot" of the Edmonton downtown condo market. Consequently, the results based on the ComFree sample will likely be highly affected by seasonal or idiosyncratic market conditions during December 2008.

In short, two sets of real estate data are gathered for this study. The MLS-based data set has a relatively large number of observations occurring over a nine-month period, but lacks critical locational information. The ComFree-based data set provides locational information, thereby allowing for the inclusion of census-based neighbourhood characteristics and the testing for spatial autocorrelation. It also has the disadvantage of having a small "snapshot" number of observations, and likely suffers from upward bias on property prices. In spite of the limitations of both data sets, a comparative analysis of

[45] If the local economy enjoys an economic boom, then a bidding war may drive up the final market price above the initial asking price; however, this would probably be a temporary phenomenon as news of bidding wars will likely induce property sellers to quickly escalate asking prices. Such a scenario is highly unlikely for the ComFree observations as average condo prices in Edmonton dropped significantly from the third quarter to the fourth quarter of 2008.

the results from the two sets may nevertheless provide substantive and insightful findings on the impact of off-street parking on property prices.

V. THE HEDONIC MODEL

Residential dwelling units can largely be considered as bundles of attributes that cannot easily be repackaged to suit individual preferences; consumers, therefore, choose from a finite number of multi-attribute bundles in the housing market (Andersson, 2000). The hedonic method is often employed in housing price studies because it is a computationally simple approach to separate the various attributes from one another, allowing the estimation of an implicit price of each individual attribute. Since the objective here is to isolate the impact of off-street parking on housing prices, the use of the hedonic method is appropriate for this study.

A technique belonging to a class of "indirect" valuation approaches (Boxall *et al.*, 2005), the hedonic model interprets the property price as the consumer's appraisal of the property's attributes (Taylor, 2003). As a result, the hedonic model relies on observable market transactions; however, if transaction prices are not available, then price estimates by property owners may be an adequate proxy (Can and Megbolugbe, 1997). The attributes typically evaluated by buyers (or property owners) in the housing market include not only structural characteristics (S) of the properties, but also neighbourhood attributes (N) linked to the properties. Neighbourhood attributes may include physical characteristics of the neighbourhood, the socio-economic characteristics of the local residents, public service provisions, and environmental amenities. The general form of a hedonic property price function is as follows:

$$y = f(S\beta, N\gamma) + \varepsilon \qquad (1)$$

where y is a vector of observations on the dependent variable, S is a matrix of structural attributes, N is a matrix of neighbourhood attributes, β and γ are vectors of regression coefficients, and ε is a vector of random-error terms. In the first-stage hedonic analysis, the price function in equation (1) is estimated, thereby revealing the estimated implicit prices of the attributes. From this analysis, information on the underlying preferences for these attributes is revealed.[46]

There are two basic issues that are common to all hedonic price analyses: functional form and model specification (Boxall *et al*., 2005). The former refers to the ascertainment of the appropriate hedonic price function specification, while the latter refers to the determination of the hedonic model specification. Regarding the first concern, selection of an inappropriate functional form will impact the error term in (1) (Can and Megbolugbe, 1997); therefore, the choice of functional form is an important step in hedonic analysis. In some hedonic studies regression procedures suggested by Box and Cox (1964) have been followed to select the appropriate functional form (e.g., Boxall *et al*., 2005; Elad *et al*., 1994). This study uses Box-Cox procedures to ascertain appropriate functional forms for both the MLS and ComFree data sets.

Regarding the second concern, proper specification of hedonic models is a common concern for researchers chiefly because of the lack of theoretical arguments that call for a specific set of independent variables (Andersson, 2000). As a consequence, unlike many economic models, in which the independent variables are derived from

[46] As noted in Section Three, to estimate actual household demand for these attributes, some researchers have followed a suggestion from Rosen (1974) to use the estimated implicit prices and supplemental household characteristics as inputs in a second-stage regression analysis (McMillan *et al*., 1980); however, the second-stage process has so far proven to be a formidable challenge for economists (Boxall *et al*., 2005).

economic theory, the selection of partial price determinants in many previous hedonic studies have been rather arbitrary (*ibid*., 2000). While there is no established rule against the use of all available variables in hedonic analysis, the inclusion of numerous independent variables in the model bring about concerns regarding multicollinearity (Leggett and Bockstael, 2000) and overfitting (Greene, 2003). Additionally, in a hedonic price study that estimated the condo market in Singapore, Andersson (2000) found that the addition of variables with less credibility as real price determinants added very little explanatory value.[47] On the other hand, the exclusion of a significant variable from the model (i.e., omitted variable bias) represents a considerably more serious problem for the model than the inclusion of superfluous variables (Greene, 2003). Thus, appropriate specification of the hedonic model represents a considerable challenge for the researcher.

As aforementioned, the lack of locational information in the MLS data set was a serious deficiency as it renders the data set inadequate in resolving another basic issue regarding the construction of a hedonic price model: model misspecification due to the presence of spatial autocorrelation (also known as spatial dependence) (Goodman, 1989). Loosely speaking, spatial autocorrelation is present when a random variable tends to exhibit similar values (high or low) in a given cluster of space (Anselin and Bera, 1998).[48] In more formal terms, spatial autocorrelation is present when the following moment condition is observed:

$$Cov(\varepsilon_i, \varepsilon_j) = E(\varepsilon_i \varepsilon_j) - E(\varepsilon_i) \cdot E(\varepsilon_j) \neq 0 \qquad \text{for } i \neq j$$

[47] Variables found to provide little additional explanatory value in Andersson (2000) include a swimming pool dummy, a squash court dummy, and the ln(x) of the percentage of residents over the age of 60.
[48] Technically speaking, the type of spatial autocorrelation described here is called positive spatial autocorrelation (Anselin and Bera, 1998). There is also negative spatial autocorrelation, in which the values of a random variable tend to be dissimilar to the values exhibited in neighbouring areas. This type of spatial autocorrelation, however, is far less intuitive than its counterpart and less likely to reveal any informative insight during the analysis (*ibid*., 1998). Hereafter, spatial autocorrelation will refer to only positive spatial autocorrelation in this paper.

where ε_i, and ε_j are observations on a random variable at locations *i* and *j* in space, and *i* and *j* can be points or areal units (*ibid*., 1998). A violation of one of the classical assumptions, the nonzero covariance above implies that a sample will contain less information compared to a duplicate data set with no spatial autocorrelation. Consequently, without accounting for this loss of information in estimation and diagnostics tests, statistical inference cannot be properly carried out.

As shown by Anselin and Bera (1998), there are two major ways to incorporate spatial autocorrelation in a regression model: expressing a functional relationship between a variable and a spatially lagged dependent variable (i.e., spatial lag model),[49] or expressing a functional relationship between the error term and a spatially lagged error term (i.e., spatial error model). Note that it is possible for both forms of spatial autocorrelation to be present in a sample; fortunately, Anselin and Florax (1995) describe simple Lagrange Multiplier (LM) tests to help a researcher select the most appropriate model.[50] In either form, a critical issue in the definition of spatial autocorrelation is the ascertainment of "neighbours", i.e., the locations for which the values of the random variable are correlated (Anselin and Bera, 1998). Locations considered "neighbours" will have a spatial relationship that can be interpreted through some explicit form of spatial structure, spatial interaction or spatial arrangement. Mathematically, the spatial relationships among all observed locations are expressed by a spatial weights matrix, which is described later in this section. Accounting for spatial autocorrelation in this

[49] Note that the term "lag" here should not be interpreted in the temporal sense: that is, an exogenous time shift (or lag) to express "neighbouring" observations (Anselin and Bera, 1998). Unless all the observations are located in a predictable grid pattern, then developing an equivalent *spatial* shift operator would be unmanageable. Instead, the spatial lag operator utilized in spatial dependence analysis consists of a weighted average of the values at neighbouring locations (*ibid*., 1998).
[50] These tests are described in the following section. Boxall *et al*. (2005) also followed this method.

fashion effectively mimics the "comparable-sales" approach used in residential real estate appraisals (Can and Megbolugbe, 1997). Often employed by agents in the housing market, including sellers, the "comparable-sales" approach considers the price history of recently sold properties in a given geographical area to estimate the market value of a property in the same area.

Technically referred to as a mixed regressive-spatial autoregressive model, the spatial lag model (Anselin, 1988) for our application can be expressed as follows:

$$y = \rho Wy + S\beta + N\gamma + \varepsilon \qquad (2)$$

where y is the dependent variable, Wy is the corresponding spatially lagged dependent variable for spatial weights matrix W, S and N are the structural and neighbourhood attributes, respectively, ε is the error term, ρ is the spatial autoregressive parameter for Wy, and β represents the regression coefficients associated with the explanatory variables. In this model, X may include both continuously measured attributes and dummy variables.

As described in Anselin (1988), the spatial error model for our application can be expressed as follows:

$$y = S\beta + N\gamma + \varepsilon \qquad (3)$$

$$\varepsilon = \lambda W\varepsilon + \upsilon, \quad \upsilon \sim N(0, \Omega) \qquad (4)$$

where $W\varepsilon$ is the spatially lagged error term, λ is the spatial autoregressive parameter for $W\varepsilon$, and υ is an uncorrelated and homoskedastic error term. In the presence of a spatial lag term, OLS estimates are inconsistent for a spatial lag model, and are unbiased but inefficient for a spatial error model.[51] In lieu of OLS method, the most popular approach

[51] For a thorough mathematical explanation, see Anselin (1988) or Anselin and Bera (1998).

to estimate the two models is to use the maximum likelihood method (Anselin *et al*., 1993).

The spatial weights matrix, *W*, is a *n* x *n* positive and symmetric matrix, where *n* is the number of observations, and the diagonal elements are set to zero. A spatial arrangement is expressed for observations considered "neighbours", while non-"neighbours" are given a designated value of zero. *W* is often row-standardized such that the elements of a row sum to one, ensuring that all weights are between 0 and 1. Beyond these guidelines, however, there is no generally accepted rule on what defines a "neighbour" or how the strength of the association should be described (Anselin *et al*., 1993). Two types of the spatial weights matrix have been used in previous spatial hedonic analyses: the so-called binary contiguity matrix and the so-called general spatial weights matrix (*ibid*., 1993). In the former, observations considered "neighbours" are given a designated non-zero value (e.g., 1), while in the latter the strength of association between "neighbours" is based on the distance between the observations. As for determining which observations constitute neighbours it is usually considered the researcher's responsibility to ascertain the appropriate specification of *W* using economic intuition and comparative analysis. For example, Boxall *et al*. (2005) employed different mathematical expressions and different radii of influence to strengthen the robustness of their results. Therefore, in light of the arbitrariness of *W*, this study will construct several versions of the spatial weights matrix.

Employing the locational information in the ComFree data set and the various spatial weights matrices, the presence of spatial autocorrelation will be tested and, if present, the most appropriate spatial autoregressive model will be selected.

VI. EMPIRICAL RESULTS

In this section the empirical tests and the parameter estimates of the hedonic models are presented. As there are two distinct sets of data utilized in this study, this section is split into two parts. In the first subsection, the results derived from the MLS data set are outlined. In the second subsection, results derived from the ComFree data set are summarized, including tests to check for the presence of spatial autocorrelation.

VI.a. Results Derived From the MLS Data Set

Given the large number of possible explanatory variables available, previous hedonic housing studies were used as a guide to select a starting set of variables in order to conduct preliminary Box-Cox tests.[52] Variables found to be statistically significant or frequently employed in the hedonic studies scanned were favoured during the selection. Based on the log-likelihood values produced in the preliminary Box-Cox tests, the null hypotheses of log-log form and linear form were rejected, but the null hypothesis of log-linear form on the other hand could not be rejected. Thus, the log-linear form was chosen for the MLS data set. Considering that the log-linear form is most common functional form employed in hedonic studies (Wentink, 2009), the use of this form is further supported. In mathematical terms, the log-linear model is as follows:

$$\ln P = S\beta + N\gamma + \varepsilon \qquad (5)$$

where P represents the property prices (the other terms are as defined in equation (1)).

[52] Previous hedonic studies used as a guide include Jia and Wachs (1998), Gawande and Jenkins-Smith (2001), Andersson (2000), Boxall *et al*. (2005), and McMillan *et al*. (1980)

With the functional form chosen, the set of explanatory variables to be used in the final form of the model had to be identified. The available MLS variables were sorted into four groups: structural attributes, seasonal factors, neighbourhood attributes, and condo fee attributes.[53] Based on *t*-test results, statistically insignificant variables in each group (except for seasonal factors) are identified as candidates for deletion from the model. Subsequent *F*-tests by group are then conducted to verify joint insignificance. (Both *t*-tests and *F*-tests are based on heteroskedasticity-consistent standard errors as heteroskedasticity is present in the error term.). Some variables, however, such as the number of full bathrooms (NFBATH), despite their statistical insignificance, are not dropped from the model because they are regarded as important variables for the model to consider. As a result, the final results include several variables that are found to be insignificant.

The high prevalence of off-street parking among the observations meant that the number of surface parking spaces (NSPARK) and the number of parkade-style spaces (NPPARK) are highly negatively correlated (-0.75), since a typical dwelling would include either one surface parking space or one parkade-style space. Since NPPARK would provide a more interesting result due to the considerably higher development cost, NSPARK is dropped from the model.[54] Therefore, the exclusion of NSPARK, combined with the dummy variables DNOPARK (observations with no bundled parking spaces) and D2SURF (observations with two surface parking spaces),[55] meant that the intercept

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[53] The last category describes the amenities included in the condo's monthly fee.

[54] Admittedly, dropping NSPARK complicates the interpretation of the results due to omitted variable bias, so further research that does not involve dropping NSPARK from the model is recommended.

[55] One observation had two surface parking spaces included with the dwelling. Since NSPARK was dropped from the model, the dummy variable D2SURF was created to accommodate this observation.

would correspond to observations with one surface parking space.[56] (See Table 5 for a distribution of MLS observations based on off-street parking attribute.)

Table 6 presents the OLS parameter estimates for the variables chosen for the final form of the model. Another Box-Cox test is performed using these variables and based on the Likelihood Ratio test results, the appropriateness of the log-linear functional form is confirmed. Both preliminary and final Box-Cox test results are provided in Table 6.

To test for the presence of heteroskedasticity, a number of Breusch-Pagan (BP) tests are conducted. The Koenker variation of the BP test indicates the presence of heteroskedasticity. Consequently, *t*-ratios are calculated using White's heteroskedasticity-consistent standard errors.

Based on these *t*-ratios, the variables found to be statistically significant at a 5% level are age of dwelling (AGE), the square of age of dwelling (AGE2), area of dwelling (AREA), the number of bedrooms (NBED), the number of half bathrooms (NFBATH), the presence of in-suite storage and/or storage locker room (DSTORA), the number of parkade-style spaces (NPPARK), the presence of visitor parking (DPRKVI), the monthly condo fee (CONFEE), the property tax most recently assessed (TAX), the presence of air conditioning (DAIR), a dummy variable to indicate a high-rise building (DHRISE), the presence of a social or recreational room (DSOCIA), the presence of a golf facility nearby (DGOLF), the presence of public transportation nearby (DPUBTR), the presence of an aesthetically pleasing view from the dwelling (DVIEW), and a dummy variable to indicate that the monthly condo fee includes parking fees (DCPARK).

[56] Thus, in this case, NPPARK=0, DNOPARK=0, and D2SURF=0.

The high adjusted-R^2 value (i.e., 0.8824) is a favourable result for the model. For the majority of the variables, the signs of the parameters are as expected. The signs on the coefficients for AGE and AGE2 equate to a flattening effect of the age of the dwelling on the selling price, which is an expected result since a dwelling will generally undergo some form of renovation over time to maintain the functionality of the dwelling. There was no expectation on the sign for the impact of DHRISE because it was uncertain how this variable would affect the predicted price *a priori*. The sign on the coefficient for DHRISE is negative. One explanation could be that high-rise buildings have more adjacent neighbours, so privacy (or building noise) could be negatively (positively) affected. Another possible explanation is that the inconvenience of sharing and/or waiting for elevators is viewed as an unpleasant attribute of high-rise condo buildings.

In contrast to most of the variables, the signs on the coefficients for DSTORA, DPUBTR, and TAX are contrary to what was expected. The negative sign on the coefficient for DSTORA might suggest that, given a fixed area of the dwelling, consumers would prefer the area allotted for storage space to be used for another purpose; however, this would not explain the cases where the storage space is located outside of the dwelling (e.g., in the basement or parkade). Perhaps DSTORA is capturing some unknown housing characteristic that is not measured by the other variables.

Contrary to expectations, the sign on the coefficient for DPUBTR is negative. One possible explanation is that public transit is typically located on major arterial roads, and dwellings located in close proximity to public transit are exposed to high traffic noise and possibly a higher incidence of crime. The positive sign on the coefficient for TAX, however, is the most interesting result among the three variables. Assuming that capitalization theory applies to the MLS data set, the provision of local public services would have a positive effect on dwelling prices, but municipal taxes would have a negative effect (Chaudry-Shah, 1988). Thus, the positive sign on the coefficient for TAX is rather puzzling. In Edmonton, property taxes are based on property value, which is calculated using the market value assessment method (MVA).[57] MVA considers many of the same explanatory variables used in this study, but it also includes some additional variables, such as building condition and exterior finish. Thus, a higher property tax may partially be attributed to an improved level of an omitted desired attribute among consumers.

In Table 7, the marginal impacts of the variables on price in terms of CDN dollars and percentage of selling price are summarized. The marginal impacts are ascertained by calculating the difference in the predicted price of a "typical" condo dwelling due to a unit change of a variable.[58] The magnitudes of these marginal impacts appear to be generally reasonable, although the impacts associated with NFBATH are considerably smaller than NHBATH and NBED, likely due to the limited number of observations with half bathrooms or three bedrooms. Of particular interest for this study are the marginal impacts associated with NPPARK. Based on the MLS data set, the marginal price effects of NPPARK are -$4,112 if a dwelling's parkade-style parking space is *downgraded* to a surface parking space (since the baseline model includes one surface parking space), and

[57] See City of Edmonton website: http://www.edmonton.ca/for_residents/residential_property_taxes /market-value-assessment-method.aspx

[58] The attributes of a "typical" condo are based on the means or modes of the variables. In this case, the "typical" condo had the following characteristics: AGE=24 yrs (AGE2=576), AREA=950 ft^2, NBED=2, NFBATH=1, NHBATH=0, DOM=44, NPPARK=1, CONFEE=$314, TAX=$1261, DNOPARK=0, D2SURF=0, DOLIVE=1, DHRISE=1, DAIR=0, DSOCIA=0, DCWASH=0, DPRKVI=0, DSTORA=0, DGOLF=0, DPUBTR=1, DVIEW=1, DCPARK=1, DSPR=0, and DSUMM=0. The predicted price of the "typical" condo is $139,399.

+$4,237 if a dwelling has an *additional* (i.e., a second) parkade-style parking space.[59] Note that neither number represents the price effect of the inclusion of one parkade-style parking space on a dwelling *without any* off-street parking, so a direct comparison cannot be made with Jia and Wachs (1998). This is an unfortunate by-product of dropping NSPARK from the model, but the properties of the data largely dictated such action. Nonetheless, the price impacts of NPPARK still merit further discussion.

Another interesting result generated here is the statistical significance of the coefficient associated with DCPARK (i.e., parking fees included in monthly condo fee). Accurate interpretation of this result is difficult due to the ambiguity of what constitutes a "parking fee". This fee may mean the monthly rental fee charged to use a parking space, or a fee to pay for regular maintenance of the parking spaces. If it is the former, then the value of having the rental charge already included in the condo fee should be capitalized in the housing price; however, the average condo fee among observations with parking fees included in the condo fee was only slightly higher than observations that excluded parking fees in the condo fee ($322 versus $298). On the other hand, the marginal price effect associated with DCPARK was not trivial (i.e., a decrease of $3,817 in predicted price if parking fees were not included in the condo fee). Thus, it is too difficult at this point to surmise exactly what DCPARK is measuring with much confidence. Further investigation should be conducted to ascertain what DCPARK is truly indicating in future

[59]The same estimated coefficient associated with NPPARK was used to calculate the marginal price effect from the downgrade of a parkade-style space to a surface parking space and marginal price impact from the addition of a second parkade-style space. Admittedly, use of the same estimated coefficient may not be appropriate in this case as the variable increments are generally not comparable. Modification of the model, such as the addition of a dummy variable to express the second parkade-style space, should be considered in future research.

research. The possibility that realtors are using different criteria to measure DCPARK further complicates the matter.

Based on the results, the marginal willingness to pay to upgrade from a surface parking space to a parkade-style parking space is approximately $4,000. Naturally, this value would then be compared to the cost differential between a surface parking space and a parkade-style one. Unfortunately, the cost of a surface parking space is principally dependent on land cost, which, in a CBD, could be so large that it is possible that the *total* average cost of a surface parking space is similar to the *total* average cost of a parkade-style space (Litman, 2008). Due to the large uncertainty over land costs, it is too difficult to say if the marginal willingness to pay for this parking upgrade is more, less, or equal to the cost differential.

On the other hand, it is possible to use the marginal willingness to pay for an additional parkade-style parking space for comparative purposes as the cost of such parking can be conservatively estimated. According to Litman (2008), the typical construction cost *alone* of a 4-level parking structure in an American CBD area is $15,000 per space, while for underground parking the figure is $25,000 per space (both in 2005 dollars). Using these conservative estimates, the $4,237 consumers were willing to pay for another parkade-style space as implied by the data is significantly less than the average cost of building such parking spaces. If accurate, this result suggests that the customer is not paying for the full cost of the additional parking space, meaning that the rest of the cost is being passed onto other agents in the condo market. Based on Bertha (1964), the condo developers may be burdened with a large portion of the remaining cost. According to the above results, the developers could be facing at least a $10,000 cost burden that cannot be passed on to the consumers for the second parkade-style space included in the dwelling.

VI.b. Results Derived From the ComFree Data Set

As was the case for the MLS data set, the appropriate functional form is ascertained through the Box-Cox test using a preliminary set of variables and re-verified for the final model. The initial Box-Cox test results suggest that either log-linear form or the log-log form would be appropriate for the ComFree data set. Given the choice, the log-linear form is selected since the same form was employed for the MLS data set.

As in the MLS data set, there are a large number of variables that could be used in the hedonic model. To select the variables to be used in the final form of the model, the available variables were sorted into three groups: structural attributes, census-based neighbourhood attributes, and places-of-interest variables. Based on *t*-test results, statistically insignificant variables in each group are first identified as candidates for deletion from the model. Afterward, *F*-tests by group are conducted to verify joint insignificance of the identified variables. As with the MLS data set, variables considered important are kept in the model regardless if they are found insignificant (e.g., the number of full bathrooms (NFBATH), the number of half bathrooms (NHBATH), etc.). As for the third group of variables, it was found that the variables are highly correlated to each other, so in response the variables NLRT (distance from dwelling's building to the nearest light rail public transit station), UOFA (distance to the main administration building of University of Alberta), CITYH (distance to City of Edmonton's city hall), and KINGSW (distance to Kingsway Garden shopping mall) are kept in the model while the others are dropped. Regarding the latter three variables, they are selected principally because the associated places are located in sharply different directions relative to majority of the ComFree observations (i.e., University of Alberta is located to the south, Kingsway Garden Mall is to north, and City Hall is centrally located).

Table 8 lists the OLS parameter estimates for the variables chosen for the final form of the model. No heteroskedasticity is found with this data set. At a 5% level, the variables having significant coefficients are age of dwelling (AGE), the square of age of dwelling (AGE2), area of dwelling (AREA), the floor of building where dwelling is located (FLOOR), the presence of a balcony at dwelling (DBALCO), a dummy variable to indicate the dwelling is located in a high-rise building (DHRISE), the percentage of the DA population who were aged 65 years or older (PSENR), and UOFA. All the signs for the significant coefficients are as expected. Unfortunately, one of the variables whose impact is found to be insignificant is the number of parkade-style spaces (NPPARK).

Statistical tests are conducted to check for the presence of spatial autocorrelation in the ComFree data set. One of the main approaches to test for spatial autocorrelation is based on the extension of Moran's *I*-test (Anselin *et al.*, 1993); however, this test is not overly powerful since it is usually used as a general test of model misspecification when spatial autocorrelation is a concern (Boxall *et al.*, 2005). Inference for the Moran's *I*-test is conducted on the basis of an asymptotically normal standardized z-value, but it should be noted that there is no direct correspondence with a particular alternative hypothesis (Anselin and Florax, 1995). Moran's *I* statistic is calculated as follows:

$$I = e'W_r e \ / \ e'e \qquad (6)$$

where e is the residual in (5) and W_r is a row-standardized spatial weights matrix (*ibid*., 1995).[60]

Another popular approach to test for spatial autocorrelation is based on the LM principle (Anselin and Florax, 1995). Unlike Moran's *I*-test, LM tests can be used to check for the presence of spatial lag ($\rho \neq 0$ in (2)) or spatial error ($\lambda \neq 0$ in (4)). When testing for spatial lag dependence, the test is defined as:

$$\text{LM-LAG} = (e'W_r y/s^2)^2 / (RJ_{\rho\text{-}ß}) \quad (7)$$

where: $$s^2 = e'e / n \quad (8)$$

$$RJ_{\rho\text{-}ß} = T + (W_r Xß)'M(W_r Xß) / s^2 \quad (9)$$

$$T = \text{trace}(W_r'W_r + W_r^2) \quad (10)$$

$$M = I_d - X(X'X)^{-1}X' \quad (11)$$

In (7), y represents the dependent variable, which in this case is ln *P*. In (8), n is the number of observations. In (9), the term $W_r Xß$ is a spatial lag of the predicted values from the OLS regression of (5). In (11), I_d is the identity matrix. LM-LAG is distributed as χ^2 with one degree of freedom.

When testing for spatial error dependence, the LM test is defined as:

$$\text{LM-ERR} = (e'W_r e/s^2)^2 / T$$

with the same notation as for the previous test. Like LM-LAG, LM-ERR is distributed as χ^2 with one degree of freedom.

Bera and Yoon (1993) suggested adjusted LM tests that are robust to local misspecification in the form of other types of spatial autocorrelation. To check for spatial lag dependence, the robust LM test is as follows:

$$\text{LM-LE} = (e'W_r y/s^2 - e'W_r e/s^2)^2 / (RJ_{\rho\text{-}ß} - T) \quad (12)$$

[60] In a row-standardized matrix, the sum of each row is equal to one.

The spatial error dependence-equivalent of the robust LM test is defined as:

$$LM\text{-}EL = [e'W_r e/s^2 - T(RJ_{\rho\text{-}\beta})^{-1}(e'W_r y/s^2)]^2 / [T - T^2(RJ_{\rho\text{-}\beta})^{-1}] \qquad (13)$$

Both LM-LE and LM-EL are distributed as χ^2 with one degree of freedom.[61] The notable advantage of the above statistical tests is that they require only the results from the OLS estimation of (5). On the other hand, the tests are highly sensitive to the choice of the spatial weights matrix. As a result, various specifications of this matrix are employed to provide a check for robustness. Tests are first performed using a general spatial matrix in which the weights are the inverse of the distances between "neighbours". Such a matrix is as follows (figure taken from Boxall *et al.*, 2005):

$$W = \begin{bmatrix} 0 & & & & \\ \frac{1}{d_{1,2}} & 0 & & & \\ \frac{1}{d_{1,3}} & \frac{1}{d_{2,3}} & \ddots & & \\ \vdots & \ddots & \ddots & 0 & \\ \frac{1}{d_{1,N}} & \cdots & \cdots & \frac{1}{d_{N-1,N}} & 0 \end{bmatrix}$$

As in Boxall *et al*. (2005), different cut-off distances are used to ascertain "neighbours". In this study, cut-off distances of 2km, 3km, and 4km are employed.[62] In addition, matrices using the forms $(1/d)^2$ and $(1/d)^{1/2}$ are subsequently considered. Note that no relative distance information was available for observations located in the same condo complex; thus, such observations are given a small constant (i.e., 1m) for a distance. Using such a small constant, however, causes a concern that same-building "neighbours"

[61] Another popular test used to check for spatial autocorrelation is based on the work from Kelejian and Robinson (K-R) (1992). The main advantage of the K-R test over the other tests is that it does not require the model to be linear or the error term to be normally distributed (Anselin and Bera, 1998). On the other hand, the K-R test is a large sample test. Anselin and Florax (1995) demonstrated that the K-R test performed very poorly on small sample sets; consequently, the K-R test was not performed here.
[62] Observations located outside of these cut-off distances were considered non-"neighbours" and were therefore given a zero spatial weight.

would be given too large of a spatial weight compared to other "neighbours".[63] In response, a matrix somewhat similar to a binary contiguity matrix is employed, in which "neighbours" are given a "ranking" (see Table 9 for ranking criteria). The corresponding spatial weight would be the inverse of the designated ranking, or (1/R). Afterward, another spatial weight matrix is developed but using the form $(1/R)^{1/2}$.

Tables 10a – 10k summarize all the test results associated with spatial autocorrelation. As can be seen from these tables, there is no evidence that spatial autocorrelation is present, regardless of the spatial weight matrix employed. A reasonable explanation for this outcome is that the neighbourhood attributes chosen in the model captured enough information to prevent spatial autocorrelation from becoming a significant factor.

In light of the lack of evidence of the presence of either heteroskedasticity or spatial autocorrelation, the OLS results presented in Table 8 are considered to be suitable for the ComFree data set. Using these results, marginal impacts are ascertained by calculating the difference in the predicted price of a "typical" condo dwelling due to a unit change of a variable (see Table 11).[64] When compared to the results associated with the MLS data set, the marginal impacts associated with the ComFree data set are considerably larger in magnitude. Considering that the average housing price in the ComFree data set is almost double compared to its MLS counterpart – largely due to the

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[63] For example, using $(1/d)^2$, a same-building neighbour would be given a spatial weight a million times larger than neighbour 1000m away.

[64] As in the case for the MLS data set, the attributes of a "typical" condo were based on the means or modes of the variables. In this case, the "typical" condo had the following characteristics: FLOOR=5th floor, AGE=15 yrs (AGE2=225), AREA=1013 ft^2, NBED=2, NFBATH=1, NHBATH=0, NPPARK=1, CONFEE=$320, DHRISE=1, DBALCO=1, PSENR=14%, PHOUSE=6%, PPUBTR=21%, PUNIV=37%, PABOR=7%, MATHHIN=$38,605, NLRT=959m, CITYH=1850m, KINGSW=2282m, UOFA=2915m, DDOWN=0, DOLIVE=0, DNOPARK=0, D2SURF=0. The predicted price of the "typical" condo is $299,542.

fact that the ComFree data were collected *after* Edmonton's housing market experienced a rapid rise in prices – larger marginal impacts were not unexpected. On the other hand, when comparing marginal impacts in terms of percentage of predicted price, the two sets of results are quite similar to each other. With this in mind, the marginal effects in Table 11 are generally reasonable, although the effects associated with DDOWN, DBALCO, and DHRISE still seem rather large.[65]

The main focus of this study is the marginal effects associated with parking spaces. Table 12 displays the distribution of ComFree observations based on off-street parking attributes. As was in the case for the MLS data set, the "loss" of a parkade-style space is really a downgrade to a surface parking space, while a "gain" is an additional space in a parkade. For the same reasons explained above, the focus will be on the price impact due to a second parkade-style space. Unfortunately, the fact that NPPARK is found to be statistically insignificant puts into the question the value of thorough analysis of its marginal impact. If anything, the results suggest that parkade-style spaces, at the margin, may not play a significant role as a real price determinant, thus implying that the actual marginal willingness to pay for such a parking space may be well below its cost of supplying it. This finding has significant parking policy implications, which will be discussed in the following section.

Note that in both the MLS and ComFree models no interaction terms were incorporated. The implicit assumption therefore applied in both cases is that the values of structural characteristics and amenities are independent of sub-neighbourhood characteristics. While this assumption may be reasonable, both Kockelman (1997) and

[65] Also note that for the ComFree data set, DHRISE is a favourable attribute, sharply contrasting with the results from the MLS data set.

Wentink (2009) showed that the addition of interaction terms can produce useful and insightful results. The employment of interaction terms was initially considered in this paper, but the empirical results for both the MLS and ComFree cases above revealed considerable correlation between key structural attributes. In addition, there was a noticeable lack of variation among several important housing characteristics.[66]

VII. POLICY IMPLICATIONS/FURTHER RESEARCH

The findings based on both the MLS and ComFree data sets provide some evidence that the consumer's marginal willingness to pay for an additional parkade-style space may be substantially less than the cost of that space, at least for the case of condos in central Edmonton. Thus, at first glance, the concern that the bundling of parking spaces in dwellings is negatively affecting housing affordability may be misdirected as, from the typical consumer's perspective, buyers are getting the parking spaces at a discount, meaning that someone else is subsidizing them. Based on the findings in Bertha (1964), developers are the likely group of stakeholders who would be burdened with a significant portion of that subsidy, although landowners may be bearing some of the costs, as well.[67] Therefore, the mandatory provision of parking spaces via minimum parking requirements may appear to be beneficial to consumers, especially those owning a vehicle(s).

On the other hand, as explained by Shoup (2005), placing a financial burden on developers will ultimately adversely impact housing affordability in that the burden will

[66] Note, for example, the rather small variances associated with the number of bedrooms (NBED) and the number of full bathrooms (NFBATH). Since the degree of heterogeneity among condos is limited compared to single-family dwellings, the employment of large data samples would be advisable for models that include interaction terms.
[67] Bertha (1964) found inconclusive evidence of the welfare impacts on landowners.

suppress housing supply in the condo market. This will put upward pressure on prices, provided that market demand is unaffected. Formally, assuming a competitive market, the costs associated with parking will shift the market's supply curve upward, leading to a market equilibrium where less housing is sold at a higher market price. Figure 4 helps illustrate the effects of minimum parking requirements on the price of housing and the associated welfare-distributional effects. In this figure, consumers are assumed to differ in their willingness to pay for housing, but they value off-street parking identically.[68] It is also assumed here that without minimum parking requirements, no off-street parking is provided. In the figure, D_N represents the demand curve, while S_N is the supply curve. At the intersection of these two curves is point E_N, where the market price is p_N^* and the number of housing units sold is Q_N.

If minimum parking requirements are introduced, the supply curve will shift up by the cost of an off-street parking spot, C. The supply curve now becomes S_P. In response, the demand curve shifts up by the value that consumers place on off-street parking, V. The demand curve now becomes D_P. For this example, $V < C$ (i.e., the value of the off-street parking is less than its cost); as a result, the new equilibrium occurs at point E_P, where the market price is p_P^*, which is higher than p_N^*, but the number of housing units sold drops to Q_P from Q_N. In this case, the effect of the minimum parking requirements is analogous to a tax of $C - V$, where consumers bear a share $p_B - p_N^*$ of the burden, while developers and landowners bear a share $p_N^* - p_A$. The fraction of the burden borne by each party, and the drop in housing units sold at equilibrium, are

[68] The assumptions made here are, admittedly, highly restrictive in order to simplify the figure. Nonetheless, the point being made by the graph remains valid.

determined by the relative slopes of the demand and supply curves. If the supply curve is more inelastic relative to the demand curve, then the developers will bear a larger share of the burden than the consumers, and vice versa. A formal analysis of the effect on housing prices due to a constraint on housing supply indirectly caused by the overprovision of parking spaces is beyond the scope of this paper.

As described in Shoup (2005), if minimum parking requirements force developers to supply the amount of parking beyond what the market is willing to pay for, then profit-maximizing developers will try to mitigate the negative effect from parking provisions on profits by constructing larger dwellings and/or build them with fewer bedrooms since the parking requirements for multi-family dwellings are usually determined based on the number of bedrooms, not on dwelling size. This way, since the cost of constructing a parking space can be considered fixed, the developers can sell these larger, higher-end dwellings at a higher price for a potentially greater profit. However, this behaviour from the developers results in fewer dwellings and/or fewer bedrooms per unit area, thus limiting urban density. This behaviour encourages urban sprawl and increases automobile dependency, which is associated with pollution, traffic congestion, and accidents (Litman, 2008). In addition, if consumers are getting these parkade-style spaces at a bargain, then there is a greater incentive to own a vehicle (or own more vehicles); Litman (2008) argues that the greater availability of parking induces higher automobile ownership, which in turn increases automobile dependency.

If developers are indeed burdened with paying for much of the costs of supplying parkade-style spaces, then one question that can reasonably be asked is: Why has there not been a more salient opposition to minimum parking requirements from developers themselves? One possibility, of course, is that they may not in fact be faced with much of a financial burden. On the other hand, according to Bunt & Associates (2008), Forinash *et al*. (2004) and Klipp (2005), developers may actually elect to oversupply parking spaces because of a perceived risk among financiers/lending institutions that a scarcity of parking will significantly lower the marketability of the dwellings. Lenders are typically risk-averse, and thus will usually expect developers to comply with local minimum parking requirements as a condition of the loan, regardless of how generous the parking ordinances actually are. In other words, developers may view the overprovision of parking as a cost of doing business.

Accordingly, if parking provision is such an important consideration among lenders and, by extension, developers, then it begs the question: Are minimum parking requirements even required? If the goal of minimum parking requirements is to ensure accessible parking for residents, then developers will likely have the incentive to provide an adequate amount of parking to ensure the attractiveness of their products. If, however, the goal is to prevent parking spillover and traffic congestion associated with cruising for on-street parking in adjacent neighbourhoods, there is ample evidence to suggest that minimum parking requirements are an overly blunt and highly inefficient form of parking management. Shoup (2005), Arnott *et al*. (2005), and several others have strongly suggested that a form of parking pricing that accounts for social externalities such as traffic congestion is a far superior parking management strategy. In fact, Arnott *et al*. (2005) found that an efficient on-street parking pricing scheme has the potential to produce a *triple* dividend: 1) raised government revenue from parking could be used to reduce revenue raised through distortionary taxation, 2) travel time savings from the reduction in traffic congestion, and 3) travel time savings from the reduction in wasteful cruising-for-parking activity.

Moreover, the demand for parking is complex and dependent on numerous socio-economic, temporal, and spatial factors. Therefore, the use of a blanket requirement based solely on the number of bedrooms seems clearly inappropriate. Since it is in their best interests to be informed of market conditions potentially affecting a residential development, it is reasonable to assume that the developers will have a significantly better idea of the amount of parking likely to be demanded for a particular development than a municipal bylaw. Minimum parking requirements, however, force developers to allocate a certain amount of scarce resources to provide a good that, from a developer's point of view, may be excessive. The sizeable mismatch between the costs of parkade-style spaces and the marginal willingness to pay for such spaces suggests that too many resources are being allocated towards the construction of parking spaces. This misallocation of scarce resources, primarily land, may be causing unnecessary upward pressure on condo prices, thus adversely affecting housing affordability.

On the other hand, the existence of a secondary market where consumers or developers can sell or rent out surplus parking spaces would increase the value of the parking spaces and therefore reduce the welfare costs associated with minimum parking requirements. The presence of a secondary market for off-street parking was indicated for a few of the data observations,[69] but it was difficult to accurately measure the prevalence of such a market among the observations as second-hand market activity may be conducted informally or infrequently (e.g., parking spaces advertised on a local

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[69] For example, in one ComFree observation, consumers had the option to purchase an additional underground parking space at a price of $25,000.

bulletin board). Such a secondary market can play a useful role, but there are significant shortcomings that could limit the effectiveness of this market. First of all, walking distance from a parking space to the intended destination is often a key determinant in the market value of that space (Shoup, 2005). If a residential development is located a considerable walking distance from major places of employment, then few non-tenants would be interested in buying or renting a parking space (although there may still be interest among non-tenants living nearby). Second, if there is plentiful cheap or free on-street parking nearby, then the value of an off-street parking space will likely be low. Thirdly, access to a building's surplus parking spaces may be restricted (especially if parking is underground), so potential buyers may be limited to only tenants. If tenants already have their own parking spaces, then, assuming diminishing marginal value, the market value of surplus parking spaces may be depressed. Lastly, sellers may have to bear the burden of advertising their parking spaces, an inconvenience which may also involve payment of fees.

Based on the results derived from the MLS data set, the large discrepancy between the estimated implicit price of a parkade-style space and its typical construction cost provides evidence against the use of minimum parking requirements. This signals that a significant revamping of such municipal bylaws, including the one currently imposed in Edmonton, should be considered. On the other hand, data problems encountered during the research introduce some uncertainty in the accuracy of the results. First of all, the size of the data sets is particularly worrisome. Although considerably larger than the ComFree sample, the MLS data set would still be considered small compared to those used in other housing pricing studies.[70] (Access to MLS data is restricted and normally involves a sizeable payment to acquire such data. For this paper, however, the 500 MLS observations were generously donated by the Edmonton Real Estate Board.)

Not only is the number of observations in each set a concern, but the time periods covered by the data sets are very short. Consequently, the results derived from each data set will most likely be highly sensitive to market behaviour during those time periods. Estimating a similar model but with a significantly expanded data set would provide valuable information regarding the robustness of the results. Further research using alternative models or estimation approaches may also help verify the paper's empirical results. Alternative methods include the multinomial logit model (discrete choice approach), which was employed in Cropper *et al*. (1993), and the decision tree approach, which was used in Fan *et al*. (2006).

Second, the prevalence of included parking spaces among the observations in both data sets prevented the calculation of the marginal effect of the *first* and often *only* parking space, either surface or parkade-style, since the "typical" dwelling had to include some type of parking space. Such a prevalence of bundled off-street parking spaces among condos may not exist in other cities that are significantly older and/or face more significant geographic constraints to expand (e.g., coastal cities). If so, observations with no bundled off-street parking should be more abundant in such cities. Therefore, conducting a similar study for such a city will hopefully shed more light on the marginal willingness to pay for bundled off-street parking.

[70] For example, Wentink (2009) utilizied a sample of almost 25,000 observations.

Lastly, this research focused only on condos located in central Edmonton, but condo buyers willing to move to (or continue to stay in) this area may be attracted to its greater accessibility (e.g., closer to the workplace, school, etc.) and therefore may exhibit less value of owning a vehicle. Therefore, the marginal willingness to pay for a parking space may be considerably lower than in other, more suburban parts of the city. Since land costs are likely less expensive in such areas, it is possible that the implicit price of an off-street parking space might match, or even surpass, the cost of that space. Even if that were the case, however, the outcome still would not provide satisfactory defence of the use of minimum parking requirements because in this case developers likely have no incentive to provide insufficient off-street parking when the housing market is willing to support more parking.

VIII. SUMMARY AND CONCLUSION

The potential costs of supplying off-street parking spaces for multi-family dwellings such as condos have been identified by previous parking literature as substantial, especially if land is sold at a premium. Despite the significant costs, minimum parking requirements enforced by local governments may cause an oversupply of parking spaces in some residential developments if the parking ordinances are overly generous. Ultimately, there was a concern among some parking researchers such as Shoup (2005) and Litman (2008) that housing affordability may be adversely affected by excessive parking if the associated costs are passed on to the consumers in the form of higher overall housing prices; however, there is only very limited literature that provides empirical evidence to suggest that this is indeed the case.

In response, this paper attempts to shed light on how much consumers are actually paying for off-street parking spaces. As identified by Bunt & Associates (2008), there is indeed evidence that parking is oversupplied in residential developments in central Edmonton, Canada. The implicit price of a parkade-style space is estimated using the hedonic method with the application of two data sets covering condos located in central Edmonton. The first data set contained structural and neighbourhood information for 465 condos that were sold during a nine-month period in 2005-06. The hedonic model estimated for this data set provided generally satisfactory results in terms of signs, significance of coefficients and the explanatory power of the regression. In particular, the coefficient for the number of parkade-style spaces included with the condos was found statistically significant at a 5% level. The calculated marginal impact on the predicted price due to a second parkade-style space was $4,237, which, when compared to conservative construction estimates in Litman (2008), is substantially lower than the cost of providing that space. On the other hand, the lack of address information in the data set posed a serious deficiency for the model as statistical tests to check for the presence of spatial autocorrelation could not be conducted. If present, not accounting for spatial autocorrelation would make the parameter estimates inefficient. On the other hand, since evidence of spatial autocorrelation was not found in the results using the second data set, perhaps the data deficiency in this case may not be an overly harmful shortcoming.

The second data set contained information pertaining to 84 condos that were listed for sale during the month of December in 2008. Although a much smaller sample than the first data set, the advantage of this data set is that address information was available, thus tests associated with spatial autocorrelation were feasible. Using this data set, the estimated model produced generally reasonable results regarding signs, significance of coefficients and explanatory power of the regression. The calculated marginal effects of the explanatory variables were overall considerably higher in magnitude than for the first data set, but when compared in terms of percentage of predicted price, the marginal impacts were generally similar. The most notable result from this model is that the coefficient for the number of parkade-style spaces was found to be statistically insignificant, suggesting that this variable may not be an important real price determinant, which is in conflict with the significant costs likely involved to provide the spaces.

At first glance, the paper's results suggest that condo consumers may actually be getting a bargain when acquiring included off-street parking spaces (at least parkade-style spaces); however, if consumers are getting a large discount on these spaces, then that implies that some other group of stakeholders is subsidizing these parking spaces. One group likely to bear a significant portion of the subsidy burden is the developers, although it is possible that landowners may ultimately end up bearing much of the costs. As explained by Shoup (2005), this burden's negative effect on profits likely induces developers to build larger and fewer condos per unit area and/or build them with fewer bedrooms. Such construction behaviour may ultimately act as a constraint on housing supply and therefore, assuming demand is unaffected, lead to a higher market-clearing price. Thus, the "bargain" on off-street parking spaces may in fact be an illusion since consumers may in the end face higher overall housing prices due to the oversupply of parking spaces. In other words, the misallocation of scarce resources (i.e., too much parking) will likely affect housing affordability in an adverse manner, whether directly or indirectly.

Admittedly, the data sets employed in this paper suffer from serious deficiencies, thus interpretation of the results should be taken with some caution. Conducting a similar study using a higher quality data set will certainly help introduce more certainty in the overall analysis. Further research using alternative models or estimation approaches may also help strengthen confidence in the paper's results. Notwithstanding the noted shortcomings, the results generated by this paper could potentially provide additional evidence in the argument against the use of minimum parking requirements as a form of parking management. The new downtown development strategy currently being proposed in Edmonton calls for further relaxation of parking standards, but this change would be in effect – pending approval from City Council – for the designated Downtown Plan area only. Assuming the proposed expansion of the area is approved, the size of this area is still only 251 hectares, a very small fraction of the city's total area of 70,000 hectares (City of Edmonton, 2008). In addition, this area excludes major residential neighbourhoods that are directly adjacent to the downtown core. The adverse effects on housing affordability caused by overly generous minimum parking requirements likely go beyond the boundaries of the main downtown district. Consequently, a comprehensive re-evaluation of minimum parking requirements for the entire city, not just for the main downtown area, should be considered.

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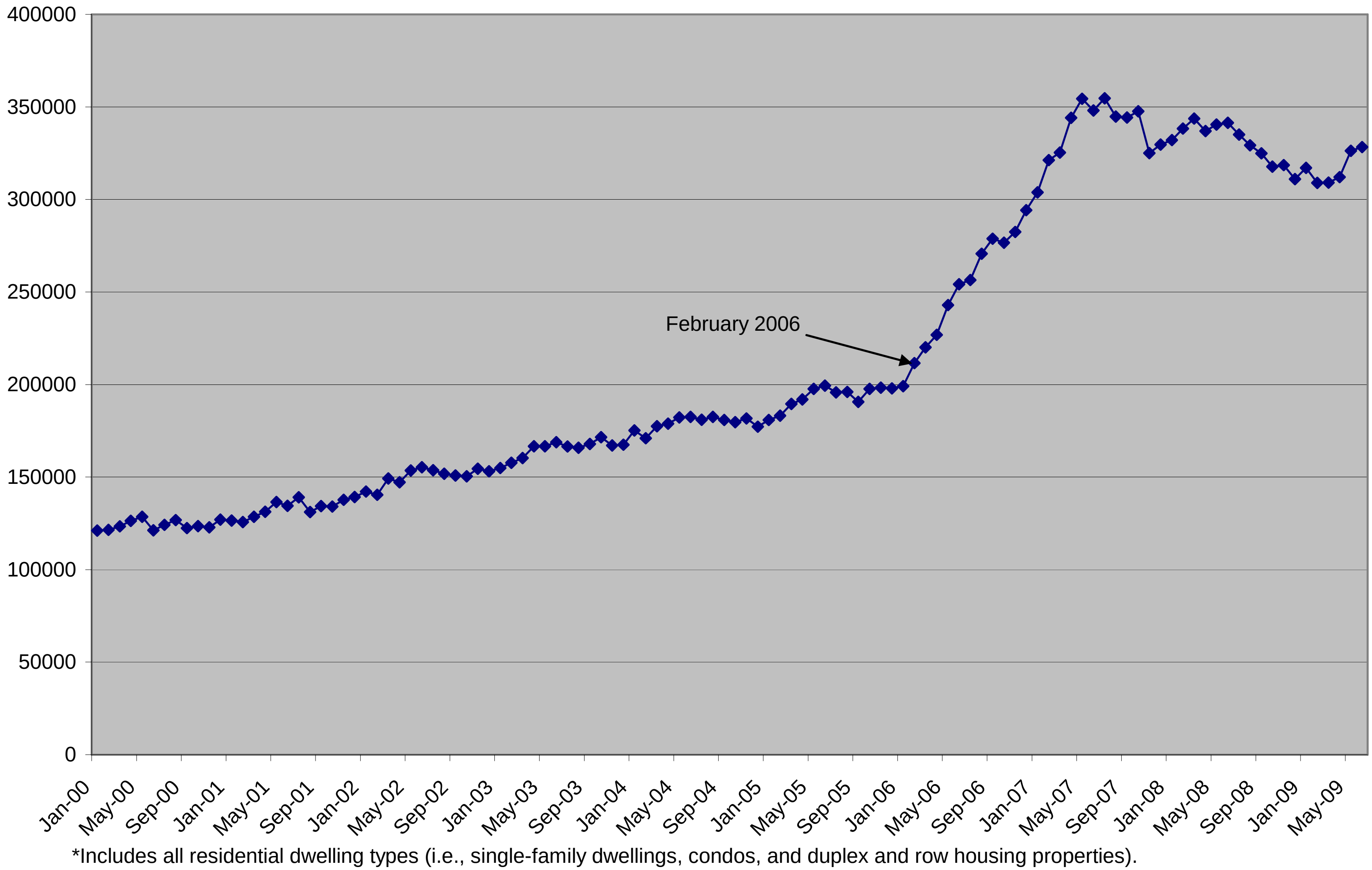
Figure 1: Average Monthly Residential Prices* in Edmonton (nominal dollars)

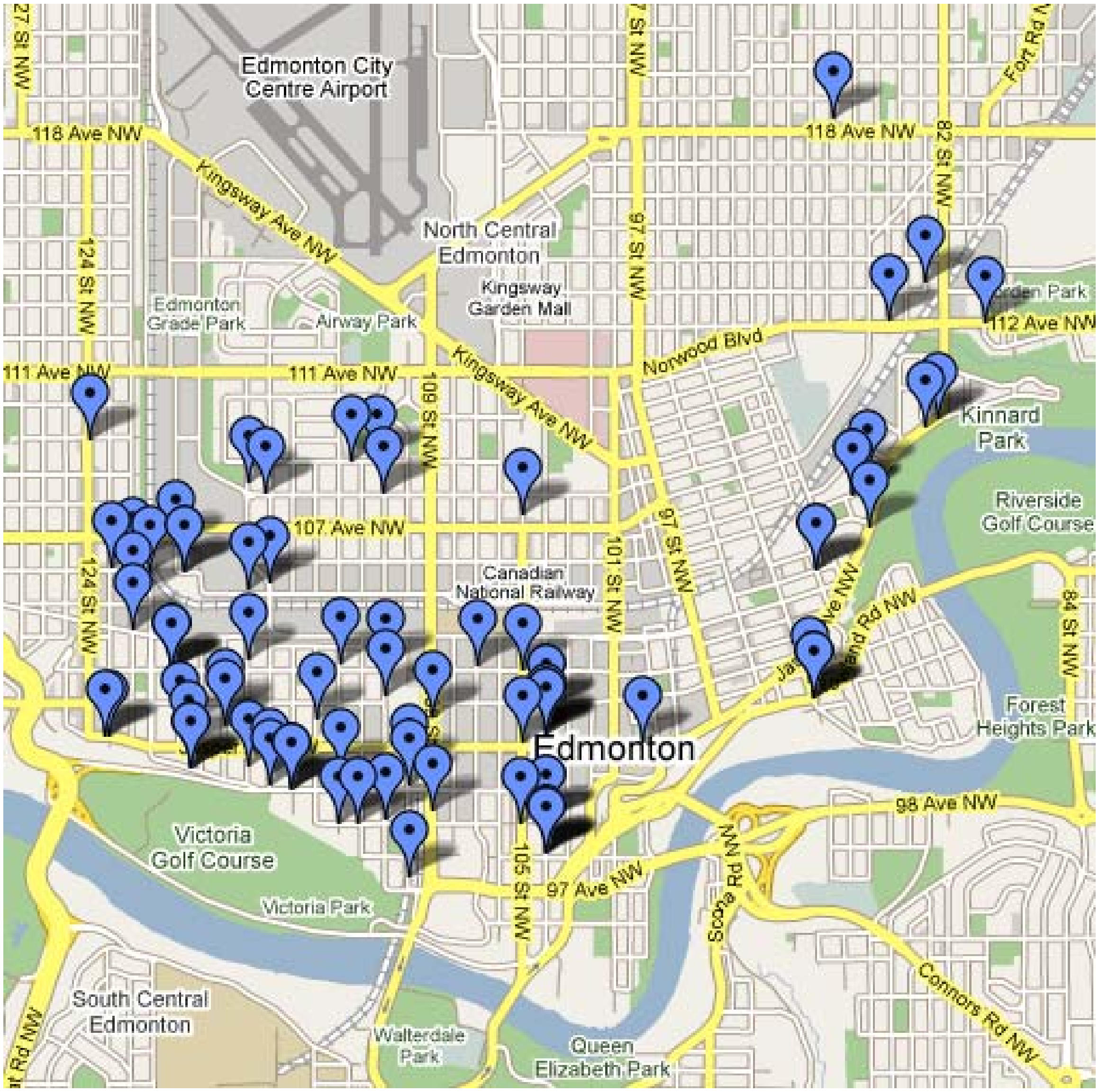


*Includes all residential dwelling types (i.e., single-family dwellings, condos, and duplex and row housing properties).
Source: Realtors Association of Edmonton

Figure 2: Map of the "Downtown Area Redevelopment Plan" in Edmonton

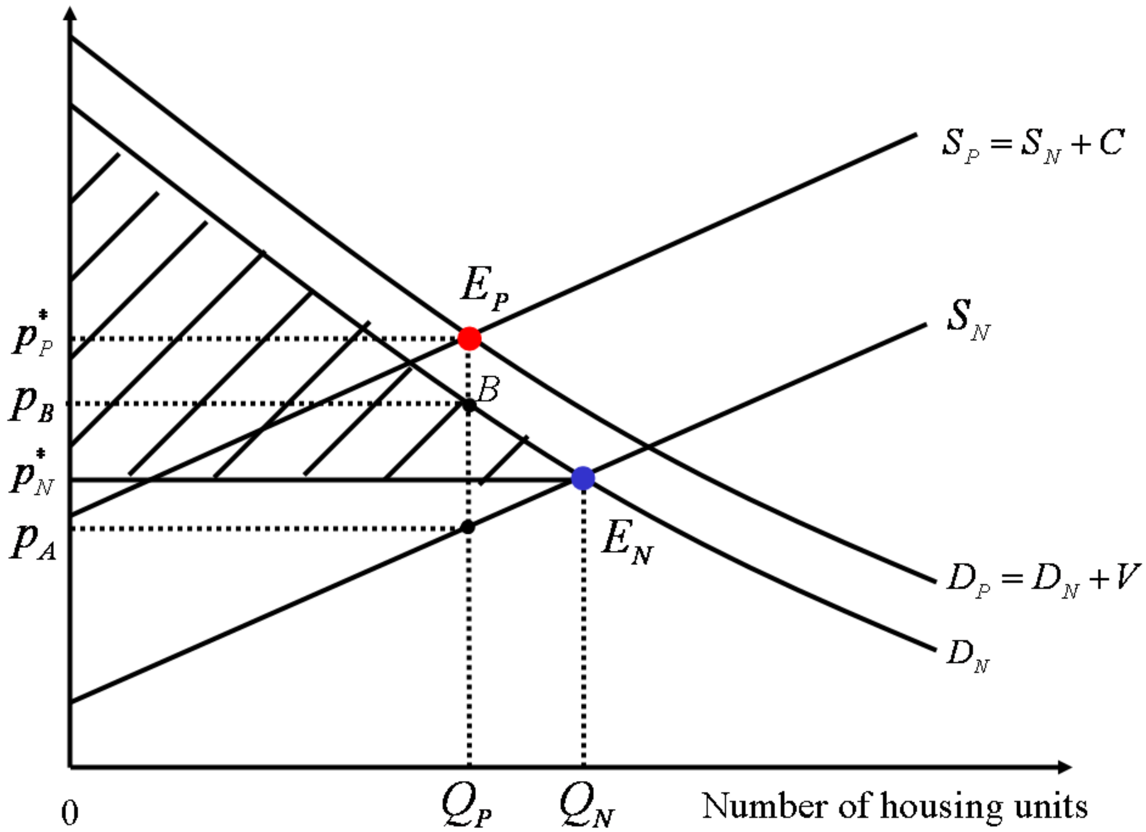
Source: City of Edmonton, Planning and Development, 2008

Figure 3: Location of Condos in the ComFree Data Set



Note: Map created using Google Maps.

Figure 4: The Effects of Minimum Parking Requirements on the Price of Housing and the Associated Welfare-Distributional Effects.



Note: Figure courteously provided by Professor Robin Lindsey, University of Alberta.

Table 1: Minimum Parking Requirements for Multi-Family Dwellings* in Edmonton Specified by Land Use 5996, effective from 1980 to 1997.

Residential Type	Minimum Number of Parking Spaces or Garage Spaces
Bachelor Suite and Bed Sitting Room	1 parking space
1 Bedroom Dwelling	1 parking space
2 Bedroom Dwelling	1.5 parking spaces
3 or more Bedroom Dwelling	1.75 parking spaces
Visitor Parking (mandatory)	1 per 7 dwellings

*Defined as apartment housing, row housing, and stacked row housing

Table 2: Current Minimum Parking Requirements for Multi-Family Dwellings* in Edmonton as Specified in Zoning Bylaw 12800.

Minimum Number of Parking Spaces or Garage Spaces Required Per	Outside the Boundaries of the "Downtown Area Redevelopment Plan"	Within the Boundaries of the "Downtown Area Redevelopment Plan"
Bachelor Suite and Bed Sitting Room	1 parking space	0.5 parking space
1 Bedroom Dwelling	1 parking space	0.75 parking space
2 Bedroom Dwelling	1.5 parking spaces	1 parking space
3 or more Bedroom Dwelling	1.75 parking spaces	1 parking space
Visitor Parking (mandatory)	1 per 7 dwellings	1 per 7 dwellings

*Defined as apartment housing, row housing, and stacked row housing

Table 3: Glossary and Summary Statistics (MLS Variables)

	Variable Name	Description of Variable	Mean	Standard Deviation	Variance	Max	Min
	MPRICE	Market price of the dwelling (2005 or 2006 $CDN)	155063	74702	5.58E9	735000	60000
Structural Attributes	AGE	Age of dwelling (years)	24.15	17.33	300.15	105	0
	AGE2	Square of AGE (years^2)	882.75	1365.9	1.87E6	11025	0
	AREA	Area of the dwelling (ft^2)	950.08	322.34	103903	2691	344.45
	NBED	Number of bedrooms	1.51	0.57	0.32	3	0
	NFBATH	Number of full bathrooms	1.32	0.48	0.23	3	0
	NHBATH	Number of half bathrooms	0.11	0.31	0.09	1	0
	DAPPIN	Appliances are included (dummy variable, DV)	0.48	0.50	0.25	1	0
	DBALCO	Deck or balcony present (DV)	0.38	0.48	0.24	1	0
	DFAIR	Dwelling is heated via forced air (DV)	0.11	0.32	0.10	1	0
	DFIREP	Fireplace is present (DV)	0.08	0.27	0.07	1	0
	DLAUND	In-suite laundry is present (DV)	0.54	0.50	0.25	1	0
	DSTORA	In-suite storage and/or storage locker room is present (DV)	0.34	0.47	0.23	1	0
	CONFEE	Monthly condo fee (nominal $CDN)	313.79	135.62	18392	993	90
	DOM	Number of days on the market	44.25	38.40	1474.18	319	0
	TAX	Property tax most recently assessed for the property prior to sale	1261.35	564.69	318872	4306	162

	Variable Name	Description of Variable	Mean	Standard Deviation	Variance	Max	Min
Structural Attributes (continued)	NPPARK	Number of included parkade/underground parking spaces	0.87	0.54	0.29	2	0
	NSPARK	Number of included surface parking spaces	0.18	0.39	0.15	2	0
	D2SURF	Dwelling includes two surface parking spaces (DV)	0.0022	0.0464	0.0022	1	0
	DNOPARK	No off-street parking is available (DV)	0.0409	0.1982	0.0393	1	0
	DPRKEX	Extra parking available for rent/purchase (DV)	0.05	0.22	0.05	1	0
	DPRKVI	Visitor parking is available (DV)	0.33	0.47	0.22	1	0
	DAIR	Dwelling's building contains one or more of the following: central air conditioning, full air conditioned, partial air conditioned, or window air conditioned (DV)	0.21	0.41	0.17	1	0
	DCWASH	Dwelling's building contains a car wash facility (DV)	0.06	0.24	0.06	1	0
	DGUEST	Guest suite is present (DV)	0.08	0.28	0.08	1	0
	DHANDI	Dwelling's building has handicap access and/or handicap interior accessories (DV)	0.38	0.49	0.24	1	0
	DHRISE	Dwelling is located in a high-rise building (DV)	0.65	0.48	0.23	1	0
	DINTER	Intercom is present (DV)	0.29	0.45	0.21	1	0
	DOLIVE	Located in the neighbourhood of Oliver (DV)	0.60	0.49	0.24	1	0

	Variable Name	Description of Variable	Mean	Standard Deviation	Variance	Max	Min
Structural Attributes (continued)	DSECUR	Dwelling's building contains one or more of the following: security door, secured parking, or security personnel (DV)	0.64	0.48	0.23	1	0
	DSOCIA	Dwelling's building contains one or more of the following: clubhouse, gazebo, partyroom, picnic area, recreation room, or social rooms (DV)	0.26	0.44	0.19	1	0
	DWATER	Dwelling's building contains one or more of the following: indoor pool, outdoor pool, sauna, swirlpool/jacuzzi, or steamroom (DV)	0.32	0.47	0.22	1	0
Seasonal Factors	DOTHER	Dwelling sold in October, November, December 2005, or January 2006 (DV)	0.25	0.43	0.19	1	0
	DSPR	Dwelling sold in May or June 2005 (DV)	0.28	0.45	0.20	1	0
	DSUMM	Dwelling sold in July, August or September 2005 (DV)	0.47	0.50	0.25	1	0
Neighbourhood Attributes	DCORNR	Dwelling's building is located on a corner of a city block (DV)	0.12	0.32	0.10	1	0
	DGOLF	Golf facility is nearby (DV)	0.34	0.48	0.23	1	0
	DPRKRE	Natural park or reserve nearby (DV)	0.14	0.34	0.12	1	0

	Variable Name	Description of Variable	Mean	Standard Deviation	Variance	Max	Min
Neighbourhood Attributes (continued)	DLANE	Back lane or paved lane is present at dwelling's building (DV)	0.25	0.43	0.19	1	0
	DLDSCP	Dwelling's building is landscaped or has low-maintenance landscape features (DV)	0.27	0.44	0.20	1	0
	DPLAYG	Playground nearby (DV)	0.20	0.40	0.16	1	0
	DPUBPL	Public swimming pool nearby (DV)	0.11	0.31	0.09	1	0
	DPUBTR	Public transportation nearby (DV)	0.80	0.40	0.16	1	0
	DSCHLS	Schools nearby (DV)	0.30	0.46	0.21	1	0
	DSHOP	Shopping nearby (DV)	0.81	0.39	0.15	1	0
	DVIEW	Aesthetically pleasing view from dwelling is present[1] (DV)	0.53	0.50	0.25	1	0
Condo Fee Attributes	DCAMEN	Monthly condo fee includes amenities (DV)	0.32	0.47	0.22	1	0
	DCCARE	Monthly condo fee includes caretaker services (DV)	0.49	0.50	0.25	1	0
	DCHEAT	Monthly condo fee includes heat (DV)	0.91	0.29	0.09	1	0
	DCINSR	Monthly condo fee includes insurance (DV)	0.88	0.32	0.10	1	0
	DCLNSN	Monthly condo fee includes landscape services and snow removal (DV)	0.82	0.38	0.15	1	0
	DCMGMT	Monthly condo fee includes professional management (DV)	0.83	0.37	0.14	1	0

	Variable Name	Description of Variable	Mean	Standard Deviation	Variance	Max	Min
Condo Fee Attributes (continued)	DCPARK	Monthly condo fee includes parking fees (DV)	0.66	0.48	0.23	1	0
	DCRECF	Monthly condo fee includes recreation facility maintenance (DV)	0.31	0.46	0.22	1	0
	DCRSRV	Monthly condo fee includes reserve fund contributions (DV)	0.85	0.35	0.13	1	0
	DCSECR	Monthly condo fee includes full-time or part-time security personnel services (DV)	0.07	0.26	0.07	1	0
	DCWTSW	Monthly condo fee includes water/sewer fees (DV)	0.85	0.36	0.13	1	0
	DCXTMT	Monthly condo fee includes exterior maintenance services (DV)	0.83	0.37	0.14	1	0

[1]Aesthetically pleasing views include views of downtown, city landscape, a river valley, a lake, etc.

Table 4: Glossary and Summary Statistics (ComFree Variables)

	Variable Name	Description of Variable	Mean	Std. Dev.	Variance	Max	Min
	APRICE	Asking price of the dwelling (2008 $CDN)	301023	114454	1.31E10	779000	139900
Structural Attributes	AGE	Age of dwelling (years)	15.417	16.514	272.73	81.0	0
	AGE2	Square of AGE (years^2)	507.15	880.52	775310	6561	0
	AREA	Area of the dwelling (ft^2)	1012.66	305.34	93235.2	2340	445
	FLOOR	Floor of building where dwelling is located	4.65	4.13	17.07	17	1
	NBED	Number of bedrooms	1.69	0.56	0.31	3	0
	NFBATH	Number of full bathrooms	1.48	0.50	0.25	2	1
	NHBATH	Number of half bathrooms	0.11	0.31	0.10	1	0
	DAIR	Air conditioning is present (dummy variable, DV)	0.25	0.44	0.19	1	0
	DAPPIN	Appliances are included (DV)	0.99	0.11	0.01	1	0
	DBALCO	Deck or balcony is present (DV)	0.88	0.33	0.11	1	0
	DFAIR	Dwelling is heated via forced air (DV)	0.35	0.48	0.23	1	0
	DFIREP	Fireplace is present (DV)	0.30	0.46	0.21	1	0
	DLAUND	In-suite laundry is present (DV)	0.79	0.41	0.17	1	0
	CONFEE	Monthly condo fee (2008 $CDN)	319.74	162.20	26309.7	1061	106.7
	NSPARK	Number of included surface parking spaces	0.35	0.50	0.25	2	0
	NPPARK	Number of included parkade/underground parking spaces	0.77	0.65	0.42	2	0

	Variable Name	Description of Variable	Mean	Std. Dev.	Variance	Max	Min
Structural Attributes (continued)	D2SURF	Dwelling includes two surface parking spaces (DV)	0.0119	0.1091	0.0119	1	0
	DNOPARK	No off-street parking is available (DV)	0.0119	0.1091	0.0119	1	0
	DCHEAT	Monthly condo fee includes heat (DV)	0.81	0.40	0.16	1	0
	DDOWN	Located in the downtown area (DV)	0.26	0.44	0.20	1	0
	DOLIVE	Located in the neighbourhood of Oliver (DV)	0.37	0.49	0.24	1	0
	DHRISE	Dwelling is located in a high-rise building (DV)	0.55	0.50	0.25	1	0
Census-based Attributes	MATHHIN	Median after-tax household income in dissemination area (DA) as determined in Statistics Canada's 2006 Census (2008 $CDN)	38604	7714.7	5.95E7	56387	17493
	PEMP15	Percentage of population aged 15 years or older in DA who were employed	94.4	2.5	6.4	100.0	88.0
	PABOR	Percentage of population in DA who were of Aboriginal ancestry	7.24	5.14	26.43	29.35	0.0
	PVISM	Percentage of population in DA who were considered visible minority[1]	21.5	13.8	191.4	61.5	4.5

	Variable Name	Description of Variable	Mean	Std. Dev.	Variance	Max	Min
Census-based Attributes (continued)	PSENR	Percentage of population in DA who were aged 65 years or older	13.9	11.0	121.3	61.3	3.6
	PUNIV	Percentage of population aged 25 to 64 in DA who earned a university certificate, diploma, or degree	36.9	12.3	152.2	71.8	9.1
	PBIKE	Percentage of employed labor force in DA who biked[2] to their workplace	1.94	1.81	3.26	6.98	0.0
	PDRIVE	Percentage of employed labor force in DA who drove a car, truck, or van to their workplace	52.2	10.8	117.2	73.7	21.6
	PPUBTR	Percentage of employed labour force in DA who used public transit to commute to their workplace	20.9	7.4	55.1	38.3	8.1
	PWALK	Percentage of employed labour force in DA who walked to their workplace	17.4	9.5	89.5	44.2	0.0
	PHOUSE	Percentage of occupied private dwellings in DA that were single-detached houses	5.8	10.9	118.6	56.9	0.0
	POWN	Percentage of occupied private dwellings in DA that was owned	42.8	23.9	569.4	89.7	0.0

	Variable Name	Description of Variable	Mean	Std. Dev.	Variance	Max	Min
Places-of-Interest	ABLEG	Distance from dwelling's building to Government of Alberta's legislature building (m)	1957.4	1024.9	1.05E6	4651.3	289.7
	CITYH	Distance from dwelling's building to City of Edmonton's city hall (m)	1849.5	678.5	460304	3168.4	475.5
	KINGSW	Distance from dwelling's building to Kingsway Garden shopping mall (m)	2282.1	464.2	215446	3048.6	930.5
	MACEWAN	Distance from dwelling's building to Grant MacEwan community college, downtown campus (m)	1486.2	682.8	466243	3289.4	189.4
	NLRT	Distance from dwelling's building to nearest light rail public transit station (m)	959.0	609.2	371106	2588.0	65.4
	UOFA	Distance from dwelling's building to main administration building of University of Alberta (m)	2914.8	1208.0	1.46E6	6052.0	1403.8
	VICGOLF	Distance from dwelling's building to clubhouse of Victoria public golf course (m)	1932.4	1344.0	1.81E6	4988.0	153.3

[1]According to Statistics Canada, visible minorities are non-Caucasian in race or non-white in colour, excluding Aboriginal peoples.
[2]Non-motorized bicycles.

Table 5: Distribution of Observations based on Parking Attribute (MLS data)

Parking Attribute	Associated Variable	Number of Observations
No off-street parking	DNOPARK	19
1 surface parking space	NSPARK	82
2 surface parking spaces	D2SURF	1
1 parkade-style space	NPPARK	322
2 parkade-style spaces	NPPARK	41
Parking fees included in condo fee	DCPARK	307 (68% of observations with off-street parking)

Table 6: Regression Results for the Hedonic Model, MLS Data [dependent variable: ln(MPRICE)]*

Variable	Description of Variable	OLS (*t*-ratio**)
INTERCEPT	-	**11.105 (258.5)**
AGE	Age of dwelling	**-0.0105 (-7.43)**
AGE2	Square of AGE	**1.189E-4 (8.022)**
AREA	Area of the dwelling	**4.902E-4 (7.291)**
NBED	Number of bedrooms	**0.0750 (4.816)**
NFBATH	Number of full bathrooms	0.0140 (0.6913)
NHBATH	Number of half bathrooms	**0.0869 (3.328)**
DSTORA	In-suite storage and/or storage locker room is present (dummy variable, DV)	**-0.0399 (-3.056)**
NPPARK	Number of included parkade/underground parking spaces	**0.0299 (1.997)**
D2SURF	Dwelling includes two surface parking spaces (DV)	-0.0568 (-1.641)
DNOPARK	No off-street parking is available (DV)	0.0199 (0.6632)
DPRKVI	Visitor parking is available (DV)	**0.0260 (1.96)**
CONFEE	Monthly condo fee	**-2.995E-4 (-2.757)**
DOM	Number of days on the market	-2.585E-4 (-1.628)
TAX	Property tax most recently assessed for the property prior to sale	**2.703E-4 (7.981)**
DAIR	Air conditioning is present (DV)	**0.0504 (3.109)**
DCWASH	Dwelling's building contains a car wash facility (DV)	0.0492 (1.839)
DHRISE	Dwelling is located in a high-rise building (DV)	**-0.0475 (-2.658)**
DOLIVE	Located in the neighbourhood of Oliver (DV)	0.0244 (1.751)
DSOCIA	Dwelling's building contains one or more of the following: clubhouse, gazebo, partyroom, picnic area, recreation room, or social rooms (DV)	**0.0475 (3.009)**
DSPR	Dwelling sold in May or June 2005 (DV)	-0.0182 (-0.9473)
DSUMM	Dwelling sold in July, August or September 2005 (DV)	0.0099 (0.6483)
DGOLF	Golf facility is nearby (DV)	**0.0553 (3.726)**
DPUBTR	Public transportation nearby (DV)	**-0.0321 (-1.915)**
DVIEW	Aesthetically pleasing view from dwelling is present (DV)	**0.0573 (4.079)**
DCPARK	Monthly condo fee includes parking fees (DV)	**0.0278 (2.111)**
Box-Cox (log-lin)	*p*-value: 0.40959 (preliminary), 0.40959 (final)	
Breusch-Pagan Test	*p*-value: 0.00478 (based on explanatory variables)	
Adjusted R^2	0.8824	

*Parameter estimates in bold indicate significance at a 5% level for a two-tailed test.
**Heteroskedasticity-consistent standard errors used.

Table 7: Marginal Price Effects of the Property Attributes in CDN Dollars (% of Selling Price), MLS Data [dependent variable: ln(MPRICE)]*

Variable	(-) Unit Change	(+) Unit Change
AGE	**693 (0.50%)**	**-656 (-0.47%)**
AREA**	**-682 (-0.49%)**	**685 (0.49%)**
NBED	**-10073 (-7.2%)**	**10857 (7.8%)**
NFBATH	-1939 (-1.4%)	1967 (1.4%)
NHBATH	**-**	**12650 (9.1%)**
DSTORA	**-**	**-5448 (-3.9%)**
NPPARK	**-4112 (-3.0%)**	**4237 (3.0%)**
D2SURF	-	-7697 (-5.5%)
DNOPARK	-	2798 (2.0%)
DPRKVI	**-**	**3673 (2.6%)**
CONFEE	**42 (0.03%)**	**-42 (-0.03%)**
DOM	36 (0.03%)	-36 (-0.03%)
TAX	**-38 (-0.03%)**	**38 (0.03%)**
DAIR	**-**	**7204 (5.2%)**
DCWASH	-	7037 (5.1%)
DHRISE	**6779 (4.9%)**	**-**
DOLIVE	-3362 (-2.4%)	-
DSOCIA	**-**	**6778 (4.9%)**
DSPR	-	-2518 (-1.8%)
DSUMM	-	1389 (1.0%)
DGOLF	**-**	**7919 (5.7%)**
DPUBTR	**4545 (3.3%)**	**-**
DVIEW	**-7759 (-5.6%)**	**-**
DCPARK	**-3817 (-2.7%)**	**-**

*Price effects in bold were derived from coefficients significant at a 5% level
**Unit change: $10ft^2$

Table 8: Regression Results for the Hedonic Model, ComFree Data [dependent variable: ln(APRICE)]*

Variable	Description of Variable	OLS (*t*-ratio)
INTERCEPT	-	**11.675 (55.68)**
AGE	Age of dwelling	**-0.01784 (-6.615)**
AGE2	Square of AGE	**2.614E-4 (6.317)**
AREA	Area of the dwelling	**7.010E-4 (7.986)**
FLOOR	Floor of building where dwelling is located	**0.00885 (2.392)**
NBED	Number of bedrooms	0.0464 (1.615)
NFBATH	Number of full bathrooms	-0.0352 (-0.9632)
NHBATH	Number of half bathrooms	-0.0168 (-0.3344)
DBALCO	Deck or balcony is present (dummy variable, DV)	**0.1107 (2.45)**
NPPARK	Number of included parkade-style parking spaces	0.0432 (1.567)
D2SURF	Dwelling includes two surface parking spaces (DV)	-0.0198 (-0.166)
DNOPARK	No off-street parking is available (DV)	-0.0241 (-0.1785)
CONFEE	Monthly condo fee	4.715E-5 (0.2961)
DDOWN	Located in the downtown area (DV)	-0.0835 (-1.678)
DHRISE	Dwelling is located in a high-rise building (DV)	**0.0839 (2.191)**
DOLIVE	Located in the neighbourhood of Oliver (DV)	-0.0139 (-0.2984)
MATHHIN	Median after-tax household income in dissemination area (DA), Statistics Canada's 2006 Census	2.067E-6 (0.7046)
PABOR	Percentage of population in DA who were of Aboriginal ancestry	-1.092E-4 (0.0035)
PHOUSE	Percentage of occupied private dwellings in DA that were single-detached houses	-0.00229 (-1.269)
PPUBTR	Percentage of employed labour force in DA who used public transit to commute to their workplace	0.00429 (1.56)
PSENR	Percentage of population in DA who were aged 65 years or older	**0.00455 (3.07)**
PUNIV	Percentage of population aged 25 to 64 in DA who earned a university certificate, diploma, or degree	4.371E-4 (0.2523)
CITYH	Distance from dwelling's building to City of Edmonton's city hall	-7.157E-5 (-1.848)
KINGSW	Distance from dwelling's building to Kingsway Garden shopping mall	5.237E-5 (1.338)
NLRT	Distance from dwelling's building to nearest light rail public transit station	2.622E-5 (0.6821)
UOFA	Distance from dwelling's building to main administration building of University of Alberta	**-5.789E-5 (-2.583)**
Box-Cox (log-lin)	*p*-value: 0.87190 (preliminary), 0.99999 (final)	
Breusch-Pagan Test	*p*-value: 0.89945 (based on explanatory variables)	
Adjusted R^2	0.9096	

*Parameter estimates in bold indicate significance at a 5% level for a two-tailed test.

Table 9: Ranking Criteria Used to Form One of the Spatial Weights Matrix

Distance Between "Neighbours"	Ranking (R)
1m	1
2 to 250m	2
251 to 500m	3
501 to 1000m	4
1001 to 2000m	5
2001 to 4000m	6
>4000m	none

Table 10a: Tests for Spatial Autocorrelation (Form: 1/d, Cut-off Distance: 2000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07418	0.2850
LM-ERR	0.22565	0.6348
LM-LAG	0.01941	0.8892
LM-EL	0.22707	0.6337
LM-LE	0.02083	0.8852

Table 10b: Tests for Spatial Autocorrelation (Form: 1/d, Cut-off Distance: 3000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07377	0.2850
LM-ERR	0.22314	0.6367
LM-LAG	0.01894	0.8905
LM-EL	0.22454	0.6356
LM-LE	0.02034	0.8866

Table 10c: Tests for Spatial Autocorrelation (Form: 1/d, Cut-off Distance: 4000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07345	0.28489
LM-ERR	0.22121	0.63812
LM-LAG	0.01893	0.89058
LM-EL	0.22260	0.63706
LM-LE	0.02031	0.88666

Table 10d: Tests for Spatial Autocorrelation (Form: $(1/d)^2$, Cut-off Distance: 2000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07534	0.28533
LM-ERR	0.23283	0.62943
LM-LAG	0.02646	0.87078
LM-EL	0.23451	0.62820
LM-LE	0.02814	0.86678

Table 10e: Tests for Spatial Autocorrelation (Form: $(1/d)^2$, Cut-off Distance: 3000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07534	0.28533
LM-ERR	0.23283	0.62943
LM-LAG	0.02646	0.87078
LM-EL	0.23451	0.62820
LM-LE	0.02814	0.86678

Table 10f: Tests for Spatial Autocorrelation (Form: $(1/d)^2$, Cut-off Distance: 4000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.07534	0.28533
LM-ERR	0.23283	0.62943
LM-LAG	0.02646	0.87078
LM-EL	0.23451	0.62820
LM-LE	0.02814	0.86678

Table 10g: Tests for Spatial Autocorrelation (Form: $(1/d)^{1/2}$, Cut-off Distance: 2000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.05039	0.29270
LM-ERR	0.09732	0.75507
LM-LAG	0.02161	0.88312
LM-EL	0.09839	0.75377
LM-LE	0.02269	0.88028

Table 10h: Tests for Spatial Autocorrelation (Form: $(1/d)^{1/2}$, Cut-off Distance: 3000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.04528	0.29669
LM-ERR	0.07820	0.77975
LM-LAG	0.00362	0.95200
LM-EL	0.07860	0.77920
LM-LE	0.00403	0.94940

Table 10i: Tests for Spatial Autocorrelation (Form: $(1/d)^{1/2}$, Cut-off Distance: 4000m)

Test	Calculated Value	*p*-value
Moran's *I*	-0.04094	0.28771
LM-ERR	0.06368	0.80078
LM-LAG	0.00358	0.95230
LM-EL	0.06403	0.80024
LM-LE	0.00393	0.95001

Table 10j: Tests for Spatial Autocorrelation (Form: 1/R, see Table 9)

Test	Calculated Value	*p*-value
Moran's *I*	-0.02204	0.32450
LM-ERR	0.00435	0.94743
LM-LAG	0.00070	0.97892
LM-EL	0.00443	0.94691
LM-LE	0.00078	0.97766

Table 10k: Tests for Spatial Autocorrelation (Form: $(1/R)^{1/2}$, see Table 9)

Test	Calculated Value	*p*-value
Moran's *I*	-0.01611	0.28289
LM-ERR	0.00064	0.97983
LM-LAG	0.00358	0.95233
LM-EL	0.00075	0.97815
LM-LE	0.00369	0.95159

Table 11: Marginal Price Effects of the Property Attributes in CDN Dollars (% of Asking Price), ComFree Data [dependent variable: ln(APRICE)]*

Variable	(-) Unit Change	(+) Unit Change
AGE	**3090 (1.0%)**	**-2903 (-1.0%)**
AREA**	**-2092 (-0.70%)**	**2107 (0.70%)**
FLOOR	**-2638 (-0.88%)**	**2662 (0.89%)**
NBED	-13569 (-4.5%)	14213 (4.7%)
NFBATH	10724 (3.6%)	-10353 (-3.5%)
NHBATH	-	-4999 (-1.7%)
DBALCO	**-31376 (-10.5%)**	**-**
NPPARK	-12677 (-4.2%)	13238 (4.4%)
D2SURF	-	-5882 (-2.0%)
DNOPARK	-	-7123 (-2.4%)
CONFEE	-14 (-0.005%)	14 (0.005%)
DHRISE	**-24092 (-8.0%)**	**-**
DDOWN	-	-23999 (-8.0%)
DOLIVE	-	-4126 (-1.4%)
MATHHIN***	-62 (-0.02%)	62 (0.02%)
PABOR	33 (0.01%)	-33 (0.01%)
PHOUSE	687 (0.23%)	-685 (-0.23%)
PPUBTR	-1281 (-0.43%)	1286 (0.43%)
PSENR	**-1361 (-0.45%)**	**1367 (0.46%)**
PUNIV	-131 (-0.04%)	131 (0.04%)
CITYH****	214 (0.07%)	-214 (-0.07%)
KINGSW****	-157 (-0.05%)	157 (0.05%)
NLRT****	-79 (-0.03%)	79 (0.03%)
UOFA****	**173 (0.06%)**	**-173 (-0.06%)**

*Price effects in bold were derived from coefficients significant at a 5% level
**Unit change: 10ft^2
***Unit change: $100
****Unit change: 10m

Table 12: Distribution of Observations based on Parking Attribute (ComFree data)

Parking Attribute	Associated Variable	Number of Observations
No off-street parking	DNOPARK	1
1 surface parking space	NSPARK	27
2 surface parking spaces	D2SURF	1
1 parkade-style space	NPPARK	45
2 parkade-style spaces	NPPARK	10