DETERMINANTS OF URBAN PRICE LEVELS IN CANADA: A TEST OF TWO THEORIES*

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Introduction

The empirical literature on urban price determination is quite new. This literature, so far, has debated the usefulness of two quite separate theories explaining city commodity prices. *Rent theory* states that any pressures that make a city grow will bid up the price of land, houses, non-residential structures, and, therefore, all final demand prices in that locality. *Agglomeration/congestion theory* states that city-specific firm size, the structure of localized urban markets, and urban economies (associated with city size) determine prices in an urban area. The crucial variable is urban size. Urban rent theory says that city prices will vary directly with urban size; agglomeration/congestion theory posits that city prices will vary inversely with the size of the city.

This paper tests the competing theories of urban price differentials for three consumer spending components. By postulating different ordinary least squares models, *both* theories can explain price variations for two of the inter-city price components. Consequently, model selection tests are used, and these results suggest that elements of both theories may be at work, and that one or the other may dominate, depending on the price componenet assessed. What is needed, ultimately, is a more careful modellng (and a more detailed data set) of urban prices and costs.

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In the next section, the two theories of inter-city price determination are outlined. The third section briefly reviews the empirical literature. The following section first tests the models from the recent literature on Canadian city price data, and then tests for the "best" theory using alternative specifications.

Theories of Urban Price Differentials

Two main lines of theoretical thought have appeared in the literature to explain price determination in cities: urban rent theory and agglomeration/congestion theory. Each theory will be discussed in turn.

Rent Theory

Standard urban rent theory, from the work of von Thunen, Alonso, Wingo, and others, posits an equilibrium land gradient determined by competitive pricing. Consumers balance transportation costs, urban amenities and externalities against increased (or decreased) housing prices at the margin. Landowners rent land, as an input into housing, to the highest bidder. The resulting land gradient can be upward-sloping or downward-sloping.

As population increases the city must expand. This expansion typically takes up agricultural land (or other types of land) as the residential centre bcomes congested to the point at which no further useful capacity can be found. The further from the city centre the new residential parcels lie, the greater the transport costs and so the greater the bidding for the more centrally located plots of land. As population increases, through either natural causes or in-migration, so too will the land prices in any location of the city [9]. The greater the proportion of rental payments of land to the total production value of a good, the more responsive is that good's price to changes in population size.

Agglomeration/Congestion Theory

The local economy of a given city entails a large set of agglomeration economies. If such economies were not present, the population and economic activity would disperse. Agglomeration economies may be subdivided into three types: internal economies of scale, localization economies, and urbanization economies.

Internal economies of scale are economies of large-scale production. If a firm is engaged in production of a commodity that requires a large threshold of population, then the firm will be able to offer the product at a cheaper price in that (larger)threshold city than comparative prices

charged by firms exporting to (smaller) non-threshold cities. The latter cities pay higher associated transportation costs.

Locational economies, also known as transport economies, take place if a firm can locate close enough to customers or intermediate suppliers so that the firm's transport costs are reduced. Cities, because they offer large centrally located populations, can attract firms to locate close by in order to take advantage of the market. There will also exist a large market for intermediate goods leading to final-demand goods provision. This intermediate goods market attracts other producers who receive similar locational advantages.

Urbanization economies take place when similar or competing firms locate in clusters in order to take advantage of technical and/or social infrastructure economies. Information, skilled labour, government services, and related firms offer intrinsic advantages to the locating enterprise. In a large city, these economies could lower output costs to that firm.

A Brief Survey of Recent U.S. Empirical Findings

The empirical literature investigating cost-of-living differences among urban areas is rather new. Contributions have been made by Haworth and Rasmussen [3], Cebula [1;2], Hogan [5], and Langston, Rasmussen and Simmons [6]. The focus of the literature so far has tended to support one theory against the other. The empirical results from Haworth and Rasmussen and Langston, Rasmussen and Simmons indicate that the "land rent" theory holds; the work by Cebula shows some evidence that the "agglomeration theory" dominates.

Haworth and Rasmussen, using 1970 data from thirty-eight standard metropolitan statistical areas (SMSAs), regressed a total urban price index against urban population, a topographical and physical constraint dummy, and a regional dummy to account for the generally lower price levels in the southern United States. The authors also experimented with a change in population variable and a variable proxying climatic conditions. Their model was tested for three different budget groups: high, moderate, and low. Their results lend support to the land rent hypothesis. The sign for the population size variable was positive and significant for high-income families, positive and marginally significant for the middle-income group, but insignificant for low-income households. The topographical variable could proxy congestion, and it had a (significant) positive coefficient in all equations. The regional dummy had the expected sign, but its inclusion added little in the way of theoretical explanation. The population change and climatic variables did little to improve the statistical results.

Cebula ran an aggregate, inter-city price index against total population, population density, per capita income, per capita property taxes, and a right-to-work dummy variable. In his 1980 article, he ran the model using data for thirty-seven SMSAs for the 1975 benchmark year. In his 1984 paper,[1] he dropped the property tax variable and ran the truncated model three times, on 1972, 1975, and 1977 data. Cebula posits his model as an "agglomeration/congestion" model: the expected sign of population is negative and that of density is positive ("congestion" is seen to push up unit-costs), and his estimated results are all significant and have the hypothesized signs. But clearly Cebula's results show a mixture of both land-rent and agglomeration theories. The inclusion of income, density, and taxes can very well be explained by the land-rent hypothesis. Income differences among cities form a standard part of the land-rent model. Density also is explained by land rent theory: the higher is density, the higher will be land (and housing) prices. Property taxes are part of shelter costs, and may be positively correlated with aggregate inter-city price indexes on that account alone.

Langston, Rasmussen and Simmons, using 1980 price index information for sixty-one counties in Florida, regressed both the total price index and five major sub-components of the index on the following variables: the number of housing units squared, expected growth for each county, and a topographical (dummy) variable. By estimating separate equations for the price-index sub-components in addition to estimating the aggregate index, the authors allow for the possibility that either theory could explain inter-county differences for a given component. Since the number of housing units typically moves closely with total population, the interpretation of its estimated coefficient (whether positive or negative) is the same as that for total population. Congestion can be proxied by the number of housing units squared, and is expected to be positive. Expected growth is a declining weighted average of past increases in housing units and is included to measure the effect of disequilibrium pressures on urban prices. The topographical dummy is again employed to measure congestion. Their results show that rent theory explains three of the five cost components: house prices, monthly rent spending, and locally produced services.[2]

[1]Cebula's 1984 paper [2]) was a reply to a critical note by Hogan [5]. Hogan suggested that Cebula's aggregate inter-urban price index should first be disaggregated and each component index then run on Cebula's set of explanatory variables. Hogan reported this experiment in his note, and found that only the shelter price indexes had a significantly negative population coefficient (and with a satisfactorily high corrected multiple correlation coefficient).

[2]The "number of housing units squared" was dropped from these equations because it appeared insignificant in previous runs.

Agglomeration/congestion theory works for supermarket prices. Langston, Rasmussen and Simmons had also estimated Cebula's model (without per-capita taxes) for the aggregate Florida price index, and found a positive coefficient for total population and an insignificant coefficient for population density. Given that result, and the results of their own specified model on the total price index, they conclude that rent theory is the best model.

Empirical Testing of Price Models With Canadian City Price Data

The previous empirical literature, so far, has portrayed the two urban price theories as competing. But modern urban economic theory suggests that the two theories are in fact complementary. The optimum size of a given city is determined by the balancing of urbanizational economies (the agglomeration economies) against locational economies (high land rents).[3] Consequently, prices play a fundamental role in determining costs faced by, and benefits accruing to, consumers and firms locating into a given city (see [4] for a good summary).

But in the recent empirical work, the authors appear to deem one or the other theories to be "correct" given the result of the estimated sign of the city variable used. Part of the disagreement stems from (i) the use of an aggregate price index by some of the studies; and (ii) the specification of different variables and use of different data bases in the research. Clearly, disaggregated price modelling is necessary. Each price component should be estimated individually to see if one or the other price effect dominates for that commodity group under consideration. The value of "rent" as an input and the effects of agglomeration in the production of a good can differ across commodities within a city. If the aggregate index is tested, one or the other theory may dominate. But that result (if undertaken without the disaggregation) could mask the key relationships between the individual price component and the crucial variable, city size. Moreover, the literature so far has not compared alternative empirical specifications on an identical disaggregated inter-city price base. Part of the disagreement in the literature could be spurious, in the sense that different data bases were used. What is needed then is to apply the competing models to the same data base, on a component-by-component basis, and to assess the results.

Each of the three models surveyed in the previous section were tested on Canadian inter-city price data and compared against each

[3]The authors are indebted to two anonymous referees for emphasizing this fundamental point.

other. In addition, further experiments were carried out to see if other variables, not used in the literature so far, could prove useful to explain (i) either of the two theories, or (ii) other institutional cause-and-effect relationships. A "best equation" was decided upon, given the additional experiments. To judge among the four models tested, formal nested model experiments were carried out. But before a discussion of the models can be undertaken, the Canadian inter-city price data should be examined.

Description of Canadian Price Data

Statistics Canada publishes comprehensive urban price data in time-series index form, but much less in the way of comparative, inter-city data. The time series indexes, shown for fifteen Canadian cities in Statistics Canada's *The Consumer Price Index*, is useful for showing movements on household consumer prices over time, but it is not useful at all for comparing levels of prices among urban areas. No fully comprehensive data base has been constructed that does compare inter-city cost of living, as is the case for the United States.

However, for Canadian cities three inter-urban prices can be found: average monthly rent paid by households for rented accommodation; average monthly house payments made by owner-occupiers for shelter; and individual weekly food prices. The data for the two shelter components can be obtained straightforwardly from Statistics Canada's 1981 census. An aggregate food price index, however, had to be constructed from individual price components.

The food price data for twenty-one Canadian cities,[4] for forty-four different food items,[5] was gathered from the April-June, 1981, and the October-December, 1981, issues of Statistics Canada's *Consumer Prices and Price Index*. The data were then averaged to get a single price for each food item in the city. The national food commodity weights[6] used

[4]The twenty-one cities used in our study (for all three price indexes) are: Trois Rivières, Saint John, Thunder Bay, Chicoutimi, Sudbury, Saskatoon, St. John's, Regina, Hull, Victoria, Halifax, London, Hamilton, Ottawa, Quebec, Winnipeg, Calgary, Edmonton, Vancouver, Montreal, and Toronto.

[5]Statistics Canada publishes inter-city price information for sixty individual food items, foods that are limited to widely available manufacturers' brands. The number of food items was cut down to forty-four because of data unavailability for certain items in certain cities. The forty-four items cover about 30 per cent of the consumer food budget.

[6]An aggregate price index of food may be estimated by using one of two weighting techniques. The first is to determine weights for each of the food groups unique to each of the urban centres of the study; the second is to use a single weight per food group within the selected basket of food goods. For either of the two approaches, each food is then multiplied by the appropriate weight. The results are then summed to obtain an aggregate food index. Of the two methods, the first is the more preferable as it allows the comparison of the "cost of living" of different locations. With an index based on unique weights it is possible to measure the pure cost of living disparities, as baskets particular to the style and standard of living for each centre are being compared. Unfortunately, due to the data problems and time requirements attached to estimating the weights of goods in the shopping basket it was necessary to adopt the second approach and use a single weight per item for each city. We must thus make a rather strong assumption that individuals relocating from one urban centre to another will keep the same consumption pattern as the Canadian average.

for each city came from Statistics Canada's *Family Food Expenditure in Canada: 1982* (Cat. No. 62-554). The weights represented quantities of food purchased for a reference week. Each food weight was then multiplied by the appropriate city price (after adjusting for some differing quantity measures used by the two publications) to obtain a weekly cost of food. The result was then scaled by a factor of fifty-two twelfths to arrive at an average monthly food price.

The econometric results for each of the three Canadian inter-city price indexes will be discussed in turn.

Average Monthly House Payments

For city monthly house payments, the results of the three models are shown in Table 1. The main result is that land theory appears to be verified by the models, whereas agglomeration theory is rejected. The estimated coefficient for city size (either total population in the Haworth/Rasmussen model, or the number of housing units in the Langston *et al.* model) supports the land rent theory hypothesis. The estimated coefficient for total population in the Cebula model comes in not significantly different from zero. But the estimated parameter for density in Cebula's model does lend support for cost-push congestion pressures.[7]

For the other variables shown in Table 1 the results were mixed. The positive coefficient on net in-migration supports the contention that with large levels of in-migration the housing market will be in a state of short-run excess demand. Housing costs increase as a result. Average income came out significant with the correct sign. But the remaining variables, barriers to expansion, climate, region, property taxes, all registered insignificant coefficients.

Various ordinary least squares experiments conducted by the authors yielded a somewhat improved version of the Cebula agglomeration model. The major difference between this and Cebula's model is that, whereas Cebula uses a general "average income" mea-

[7]It should be noted, however, that the interpretation of the density variable is somewhat ambiguous. A positive (and significant) estimated coefficient for the density variable does lend support for the land rent theory (see [9]).

Table 1

EXPLAINING CANADIAN MONTHLY HOUSE PAYMENTS USING MODELS FROM PREVIOUS LITERATURE*

Coefficient	Haworth & Rasmussen	Cebula	Langston *et al.*
INTERCEPT	450.9 (10.1)	-14.8 (.2)	380.8 (25.1)
TOTAL POPULATION	.00005 (4.4)	-.000002 (.2)	—
BARRIERS TO EXPANSION	-3.31 (1.4)	—	-1.19 (.6)
NET MIGRATION	.001 (3.0)	—	.001 (3.9)
CLIMATE	-.92 (1.1)	—	—
REGION	-20.71 (-1.3)	—	—
DENSITY	—	.05 (2.3)	—
AVERAGE INCOME	—	.02 (5.9)	—
PROPERTY TAXES	—	.01 (.4)	—
NO. OF OCCUPIED DWELLINGS	—	—	.0003 (2.4)
NO. OF OCCUPIED DWELLINGS^2	—	—	-1.2 E-10 (1.1)
$\bar{R}^2$	.64	.72	.64
F	8.2	14.3	9.9

* Figures in parentheses are t-statistics.

sure, in the new model a more specific income variable is substituted: average income of households in rented accommodation. Its inclusion is based indirectly on opportunity cost; higher rent payments bring additional indirect pressure on land and house prices, key component parts of overall monthly house payments. The final equation is:

$$HSEPAY = A1 + A2^* TOTPOP + A3^* DENSITY + A4^* INCOME + A5^* PROPTAXS \quad (1)$$

where:

HSEPAY = average monthly house payments,
TOTPOP = total population of urban area,
DENSITY = population per sq. kilometre,
INCOME = average rental income,
PROPTAXS = average property taxes paid per household.

All statistical results are improved (see column 1 in Table 4 below). Most important, the total population variable now comes in negative and is statistically significant. But this last estimated equation yields a striking result: if the model specifications of the literature reviewed in the previous section are to be taken at face value, then the findings of the land rent models shown in Table 1 and the results of this last equation suggest that each theory appears to be confirmed by the same set of data. The ordinary least squares results, taken by themselves, indicate that both hypotheses hold. The results indicate that both types of price effects may be at work to influence inter-city house payments.

Average Rent Payments

The estimated results of the three models in the literature for average monthly rent payments made by households is shown in Table 2. Again, the main findings are striking. The estimated parameters for the city size variables (total population and the number of occupied dwellings) all come in significant with the correct hypothesized sign, and thus lend support to both inter-city price theories. Cebula's density variable also comes in significant with the correct sign. Moreover, other variables, migration, climate, barriers to expansion, income, all come in significant with the appropriate sign in one or more of the models shown.

Experimentation with other possible explanatory variables suggested that "rental unit attributes" might prove useful in explaining rent expenditures. The attribute variables correct for possible quality differences of apartment dwellings across urban areas. The following model was estimated:

$$RENT = B1 + B2^*TOTPOP + B3^*RENTEDHS + B4^*RENTREPA + B5^*PRWARRENT + B6^*NETMIG \quad (2)$$

where:

RENT = average rental payments,
RENTEDHS = number of rented dwellings,

RENTREPA = number of rented dwellings that needed serious repairs,
PRWARENT = number of rented dwellings that were built before World War II,
NETMIG = net migration into urban area in last five years.

Table 2

EXPLAINING CANADIAN MONTHLY RENT PAYMENTS USING MODELS FROM PREVIOUS LITERATURE*

Coefficient	Haworth & Rasmussen	Cebula	Langston *et al.*
INTERCEPT	427.3 (12.9)	-150.8 (2.0)	295.6
TOTAL POPULATION	.00003 (3.7)	-.00002 (1.7)	—
BARRIERS TO EXPANSION	03.8 (2.1)	—	-.097 (.05)
NET MIGRATION	.001 (3.7)	—	.001 (4.7)
REGION	026.2 (2.2)	—	—
CLIMATE	-2.0 (3.1)	—	—
DENSITY	—	.040 (2.0)	—
PROPERTY TAXES	—	.014 (.5)	—
AVERAGE INCOME	— —	.018 (6.8)	—
NO. OF OCCUPIED DWELLINGS	—	—	.0003 (2.7)
NO. OF OCCUPIED DWELLINGS^2	—	—	-1.7 E-10 (1.6)
$\overline{R}^2$	.80	.73	.68
F	16.7	14.3	11.7

* Figures in parentheses are t-statistics.

The result for total population lends support to Cebula's agglomeration hypothesis (see Table 4). Both this variable and net in-migration came in very significant. The RENTREPA, PRWARENT variables are housing quality variables and are shown to be significant with the correct sign. The total number of units rented, RENTEDHS, is used in the model as a correction factor, since the quality variables are specified in absolute terms.[8]

Again, for the rent payments variable, the results of all of the models shown lend supporting evidence to both the land rent and agglomeration theories.

Average Monthly Food Payments

For the third variable, average spending for food consumed at home, the results for the three models taken from the previous literature are shown in Table 3. As can be seen from the table, the results are generally poor. None of the critical city size variables came in significantly different from zero. Density came in significant but negative. Property taxes had a negative and significant sign. Both of these findings will be discussed below. Of the other institutional variables, only barriers to expansion came in significant. Further ordinary least squares experiments suggested the following model:

$$\begin{aligned} \text{FOODPRIC} = {} & \text{C1} + \text{C2* TOTPOP} + \text{C3* DENSITY} \\ & + \text{C4* INCOME} + \text{C5* PROPTAXS} \\ & + \text{C6* MAPDUMMY} + \text{C7* REGION} \end{aligned} \quad (3)$$

where:

FOODPRIC = composite inter-city food price index,
INCOME = average familiy income in urban area,
MAPDUMMY = dummy: barriers to expansion,
REGION = dummy: 1 if city in central Canada, 0 if not.

This model is an amalgam of both rent and agglomeration/congestion theory. The results are shown in the third column of Table 4. The negative and significant density variable indicates reducing food costs as crowding increases. As the population density increases further, other large retailers are encouraged into the city. With an increasing number of retailers, competition increases. The significantly positive population variable supports land rent theory. Larger populations bid up the costs for retail outlet space, and prices are pushed up. The result for the family income variable suggests that higher income is associated with higher quality (and higher priced) foodstuffs. The negative property tax finding can be explained as follows. As property taxes increase (and as local government spending decreases) net migra-

[8]That is, divide through equation (2) by RENTEDHS, and the two housing quality variables RENTREPA and PRWARENT are then expressed as a proportion of the total number of units rented.

tion will capitalize local prices (see [7]); that is, migrants will seek higher wages and net fiscal benefits. But migration equilibrium will bid up land prices and local commodity prices. Thus, lower property taxes can be correlated with higher food prices. Of the final two institutional variables in the equation, MIDREGN, a locational variable, had a significantly negative sign, whereas MAPDUMMY was not significant. The variable MIDREGN indicates that food prices are lower the closer to the source that they are purchased; that is, food prices are lower in the central provinces, *ceteris paribus.*

Table 3

EXPLAINING CANADIAN FOOD PRICES WITH MODELS FROM THE PREVIOUS LITERATURE*

Coefficient	Haworth & Rasmussen	Cebula	Langston *et al.*
INTERCEPT	111.8 (33.3)	115.1 (13.4)	108.5 (82.8)
TOTAL POPULATION	-.0000005 (.6)	.000002 (1.3)	—
BARRIERS TO EXPANSION	.513 (2.9)	—	.67 (3.7)
NET MIGRATION	.000009 (.3)	—	.00002 (.6)
REGION	-3.38 (2.9)	—	—
CLIMATE	.0009 (.0)	—	—
DENSITY	—	-.004 (2.0)	—
AVERAGE INCOME	—	.0029 (.9)	—
PROPERTY TAXES	—	-.007 (2.4)	—
NO. OF OCCUPIED DWELLINGS	—	—	.00001 (1.1)
NO. OF OCCUPIED DWELLINGS^2	—	—	-1.3 E-11 (1.3)
$\overline{R}^2$	.53	.21	.38
F	5.5	2.3	4.1

* Figures in parentheses are t-statistics.

Table 4

EXPLAINING INTER-CITY PRICE DIFFERENCES: ADDITIONAL SPECIFICATIONS BY THE AUTHOURS*

Endogenous Variable Coefficient	House Payments	Rent Payments	Food Prices
INTERCEPT	-.75.2 (1.5)	317.3 (39.5)	117.5 (29.6)
TOTAL POPULATION	-.0002 (2.5)	-.0003 (3.2)	.000002 (2.0)
DENSITY	.053 (4.2)	—	-.006 (3.9)
AVERAGE INCOME	.026 (10.5)	—	.0001 (1.3)
PROPERTY TAXES	.023 (1.4)	—	-.005 (2.3)
RENTAL DWELLINGS	—	.003 (3.9)	—
DWELLINGS NEEDING REPAIR	—	-.014 (2.0)	—
DWELLINGS BEFORE WWII	—	-.003 (1.6)	—
NET MIGRATION	—	.001 (4.0)	—
BARRIERS TO EXPANSION	—	—	.179 (1.2)
REGION	—	—	-4.30 (4.9)
$\overline{R}^2$	.89	.82	.77
F	41.8	19.6	11.9

* Figures in parentheses are t-statistics.

Nested Model Testing Results

The above discussion indicates that, at least for shelter expenditure components HSEPAY and RENT, both the land rent and agglomeration/congestion theories can be shown to apply. The estimated coefficients for both theories "work", given the hypothesized sign on the city size variable for each hypothesis. It was decided to test the models further. Nested testing was undertaken for all model results reported (see, for example, [8]).

The nested model experiments were carried out in the following way. First, a general unrestricted model for each of the three consumer spending components was estimated by regressing each inter-city index on all the pooled exogenous variables from the models. Now consider each of the models discussed—Haworth and Rasmussen; Cebula; Langston, Rasmussen and Simmons; and the "best" equation reported by the authors—as imposing restrictions on certain coefficients of this general model, for each inter-city price component. The idea is to test whether the restrictions imposed by each of the models are valid, given that each model must exclude some of the variables of the general model. To do this, likelihood-ratio tests were constructed from the unrestricted models and the restricted models for each endogenous variable. The results are shown in Table 5. As can be seen, the restrictions for all three models from the literature reviewed in the second section should be rejected. Also, the restrictions for the "best" model for RENT should be rejected. But our "best" model specifications for the other two inter-city price variables were supported by the data. The validity of the restrictions for HSEPAY is marginally acceptable, and the validity of the FOODPRIC is acceptable.

Table 5

NESTED MODEL TEST RESULTS

Variable	L/R Statistic	Critical Chi-square Stat.		Restrictions of Model
HSEPAY				
H/R	34.4	9.2	(.10)	reject
Cebula	30.8	9.2	(.10)	reject
L/R/S	35.8	9.2	(.10)	reject
Authors	10.8	11.1	(.05)	accept
RENT				
H/R	48.5	13.4		reject
Cebula	56.1	14.7		reject
L/R/S	59.3	14.7		reject
Authors	45.6	13.4		reject
FOODPRIC				
H/R	16.7	7.8		reject
Cebula	28.9	9.2		reject
L/R/S	23.7	9.2		reject
Authors	.6	6.3		accept

Conclusion

The nested model tests give us a way of choosing results of models that give "acceptable" results with regard to t-statistics, goodness-of-fit, and hypothesized signs of the coefficients. For the house payments inter-city price index, since we accept the linear restrictions for the reformulated model, we can say that the price effects from agglomeration/congestion theory dominate. For the household rent price index, none of the restrictions implied by the models were consistent with the data, but the (negative) sign of the total population variable in the general unrestricted model indicates that the agglomeration hypothesis is dominant also. Finally, our specified model for inter-city food prices suggests that the effects predicted by land rent theory are predominant.

These nested-model results, for the most part, are not very intuitively appealing. For house payments, one would think that rent theory would dominate, since land prices make up a significant part of total housing costs. For rent payments, an argument could be made that agglomeration economies could exist in larger centres (bigger apartment units, larger and more efficient construction firms). For food prices, one would expect the agglomeration theory to hold, although our nested model results show that the land rent model prevails. But the ordinary-least-squares results do show that the price formation effects from both theories may be at work. The results indicate that the expected signs on the city size variable may show that both theories may be part of a more full-fledged model of city price formation.

Our model testing is limited to one-equation modelling. An argument could be made to endogenize urban densities. In this paper, the inclusion or the exclusion of the density tended to "switch" the reported sign of the total population variable. In open-city land-price models, density is endogenous [9]. A two-equation model could be constructed, with density and housing prices endogenous, and formal non-nested model testing could then be undertaken.

Our research has also been restricted due to limitations of the data. Modelling of only three price variables was undertaken. An attempt could be made to collect inter-city price data for all major consumption groups, and for more urban areas. In this way a more complete comparison could be undertaken between the Canadian and American results.

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Appendix

MNEMONICS AND SOURCES OF DATA

CLIMATE — This variable measures the overall effect of climate for each city. It is a composite variable of the number of hot days, cold days below freezing, rainfall, and windchill. The data were taken from D. W. Phillips and R. B. Crowe, *Climate Severity Index*.

DENSITY — Population density: number of persons per square kilometre, Statistics Canada, *Census Metropolitan Areas with Components, Population, Occupied Private Households and Census and Economic Families in Private Households*, Ottawa, catalogue 95-943, "Table 1: Selected Population, Dwelling, Household, and Family Distribution, showing Selected Social and Economic Characteristics, for CMA's with Components, 1981", 1984.

FOODPRIC — This variable was estimated by applying Canadian quantity weights to each city used in the analysis (as discussed in the text). The weights were then multiplied by the prices of the respective goods in each city. Since the weights were weekly quantities, the resulting expenditures were scaled up to give a monthly spending figure for each item. The results were then summed for each city across food commodities. The quantity weights were obtained from Statistics Canada, *Family Food Expenditures in Canada*, Ottawa, catalogue 62-544, 1982. The prices come from Statistics Canada, *Consumer Price and Price Indexes*, Ottawa, catalogue 62-010, "Table 10: City Average Retail Prices, Third Week of April/October 1981".

HSEPAY — The average monthly payments made by owners of dwellings. This includes utilities, mortgage, and taxes. Statistics Canada, catalogue 95-943, *op. cit.*

INCOME	Average income received by occupants of rented accommodation. Statistics Canada, catalogue 95-943, *op. cit.* Average income accruing to the city's employed population both in owner occupied and rented accommodation. Statistics Canada, *Occupied Private Dwellings, Private Households, Census Families in Private Households*, Ottawa, catalogues 93-937 to 93-946, "Table 3, Private Households by Selected Dwellings and Household Characteristics, showing Household Income, for Census Metropolitan Areas, 1981", 1984.
MAPDUMMY	These data were estimated by using large scale maps in the same manner as Haworth and Rasmussen by assigning a dummy variable the value of one for each estimated thirty degrees of geographical barriers that would prove difficult to overcome if the city was to expand. The major barriers were large bodies of water, both lakes and rivers, mountains or marshes.
NETMIG	Net migration over the past five years. Statistics Canada, catalogue 95-943, *op. cit.*
NO. OF OCCUPIED DWELLINGS	The number of owner-occupied dwellings in each city. Statistics Canada, catalogues 93-937 to 93-946, *op. cit.*
PROPTAXS	Average property taxes paid per residential family in each city. These data were kindly provided by Mr. Elmer A. Cronk, Director of Assessment, Department of Municipal Affairs for the province of New Brunswick, who requested and received these data from his counterparts in the other cities of this study.
PRWARENT	The number of rented dwellings built prior to World War II. Statistics Canada, catalogues 93-937 to 93-946, *op. cit.*
REGION	Cities located in Manitoba, Ontario, and Quebec were given a dummy value of one.
RENT	Gross rent monthly. Statistics Canada, catalogue 95-943, *op. cit.*

RENTEDHS	The number of dwellings rented. Statistics Canada, catalogues 93-937 to 93-946, *op. cit.*
RENTREPA	The number of rented dwellings needing serious repairs. Statistics Canada, catalogues 93-937 to 93-946, *op. cit.*
TOTPOP	Total population for each city, 1981. Statistics Canada, catalogue 95-943, *op. cit.*