The Impact of Urban Growth on Affordable Housing:

An Economic Analysis

Chris Bruce, Ph.D. and Marni Plunkett

October 2000

Project funding provided by:

ALBERTA REAL ESTATE FOUNDATION

Canada West FOUNDATION

P.O. Box 6572, Station D • Calgary, Alberta, CANADA • T2P 2E4

Ph: 403-264-9535 • Fax: 403-269-4776 • www.cwf.ca

ISBN # 1-895992-77-X. This report was authored by Chris Bruce, Ph.D., Professor of Economics at the University of Calgary, and Marni Plunket, economist. Research funding was provided by the Alberta Real Estate Foundation. The opinions expressed in this document are those of the authors only, and not necessarily those of the Canada West Foundation's donors, funders, subscribers, or Council.

Introduction

As Canada grows increasingly urbanized, municipal governments are under pressure to deal with the costs associated with urban growth, such as increased demands upon municipal infrastructure. Many cities attempt to deal with urban growth costs by requiring developers to pay development cost charges. However, critics argue that this can have a negative impact upon citizens, as developers must then pass these costs along to consumers in the form of increased housing costs. The end result of such a “solution” is a reduction in the availability of affordable housing.

The Impact of Urban Growth on Affordable Housing: An Economic Analysis examines two central research questions: (1) What is the relationship between urban growth and affordable housing?, and (2) In light of the need for affordable housing, how are development costs best allocated? The first section of this report, “Urban Growth and Affordability,” is an empirical study of the relationship between growth and affordability, based on census data for approximately 300 cities. The second section of this report, “Paying for Urban Growth,” presents a theoretical model to assess the relationship between the allocation of growth costs and affordable housing. Three alternative methods of paying for municipal government expenditures on infrastructure are investigated: development cost charges (pass all such expenditures on to real estate developers), equal tax loading (use municipal taxes to spread infrastructure expenditures across all residents of the urban area), and differential tax loading (use municipal taxes to spread these expenditures across residents of the new suburbs).

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Urban Growth and Affordability

It is commonly argued that increases in the urban population growth rate are associated with increases in average house prices. According to this argument, therefore, high rates of growth will decrease the affordability of housing. A counter-argument, however, is that high rates of population growth are also associated with relatively high incomes. Thus, although house prices are expected to be relatively high in quickly growing cities, incomes may be commensurately high. It is possible, therefore, that housing affordability might not be affected by urban growth. The purpose of this section is to subject these hypotheses to empirical analysis. In particular, we provide statistical evidence concerning the effect of urban population growth on house prices, income, and a measure of housing affordability. A more detailed presentation of the statistical analysis is presented in Appendix A.

Data

To assess the relationship between urban growth and affordable housing, statistical analysis was conducted on Census Canada data (1986, 1991 and 1996) for 317 census subdivisions in Canada with populations greater than 10,000.[1] Data analyzed include aggregate data concerning population, average house prices, owned dwellings, rented dwellings, household income, households with payments on shelter greater than 30% of household income, and households with rent greater than 30% of household income. The Royal LePage House Price Survey average house prices data were used to verify the results from the census data.

[1] Census subdivision is a general term applied to municipalities or their equivalent.

House Prices

The first issue is to determine the impact that urban growth has on average house prices. To that end, we estimate an equation of the form:

$$\text{House prices} = \beta_0 \text{ Population} + \beta_1 \text{ Income} + \beta_2 \text{ Year2} + \beta_3 \text{ Year3} + \beta_i \text{ City}_i \qquad (1)$$ [2]

A 10% increase in population is associated with a 1.7% increase in average house prices.

The estimated coefficients (the β values) provide information about the effect that a percent change in any of the variables on the right-hand side of the equation will have on house prices.[3] Simply, equation (1) attempts to answer the question, what happens to house prices when there is a change in population or median income?

The results of the statistical estimation of equation (1) were:

$$\text{House prices} = 1.164 + 0.1684 \text{ Population} + 1.016 \text{ Income} + 0.1439 \text{ Year2} + 0.2127 \text{ Year3} + \beta_i \text{ City}_i \qquad (2)$$

House prices were, on average across Canada, 15.5% higher in 1991 than in 1986 and 23.7% higher in 1996 than in 1986.[1] In 1996, house prices were found to be 7.1% higher than in 1991.

Our model suggests that, all else being equal, a 10% increase in population is associated with a 1.7% increase in average house prices. This implies that for a city such as Calgary, where the population has been projected to grow by 22% (from 768,000 to 938,000) between 1996 and 2004, house prices on average are predicted to rise by 3.7% - from an average of \$162,000 in 1996 to \$168,000 in 2004 (holding all other factors, such as inflation and family income, constant). Furthermore, our results suggest that a 1% increase in median income is associated with a 1% increase in house prices.

The variables for 1991 (year2) and 1996 (year3) were included to account for any impact on house prices directly attributable to the year. The year2 and year3 dummy variables show that house prices were, on average across Canada, 15.5% higher in 1991 than in 1986 and 23.7% higher in 1996 than in 1986.[4] In 1996, house prices were found to be

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[2] House prices, population, and (median household) income were all measured in logarithmic form. “Year 2” refers to 1991, “Year 3” to 1996, and “City” to the individual cities in the sample.
[3] The terms value of dwelling, average house price, and house price will be used interchangeably.
[4] These results are found by subtracting 1 from the antilog of the estimated coefficient in each case.

7.1% higher than in 1991. These increases are based on average prices converted to 2000 constant dollars. Thus, inflation has been accounted for.

We also estimated equation (1) using the Royal LePage data set for average house prices. Using these data reduced the number of cities for which information was available to 62 and the number of years to two (1986 and 1996). These changes may explain the small differences in the estimated coefficients between the two data sets.

$$\text{House prices} = 2.6019 + 0.2751\ \text{Population} + 0.5807\ \text{Income} + 0.118\ \text{Year3} + \beta_i\ \text{City}_i \quad (3)$$

A 1% increase in population is associated with a 0.275% increase in average house prices according to the Royal LePage data. The corresponding figure using census data was 0.168%. Similarly, the Royal LePage data find that a 1% increase in household income is associated with a 0.581% increase in house prices while the census data found house prices increased by 1% when household income increased by 1%. Interestingly, though, changing data sets did not cause unexplainable changes in the results.

A 10% increase in population is associated with a 1.9% increase in household median income.

Income

We establish the relationship between population and income by estimating the following equation:

$$\text{Median Income} = \beta_0\ \text{Population} + \beta_1\ \text{Year2} + \beta_2\ \text{Year3} + \beta_i\ \text{City}_i \quad (4)$$

A positive relationship is established between population growth and real household median income. The results are shown in equation (5).

$$\text{Median Income} = 9.186 + 0.1854\ \text{Population} + 0.0295\ \text{Year2} - 0.0516\ \text{Year3} + \beta_i\ \text{City}_I \quad (5)$$

The model finds that a 10% increase in population is associated with a 1.9% increase in household median income. For example, as the population of Calgary is expected to rise by 22% between 1996 and 2004, this equation predicts that household median income will increase by 4.2%, from $49,439 in 1996 to $51,505 in 2004 (holding all other factors constant).

Housing Affordability

Finally, we wished to conduct a direct test of the impact of population growth on housing affordability. We employed the common assumption that a family that spent more than 30% of its income on shelter was experiencing difficulty “affording” housing. Thus, our measure of lack of affordability was the percentage of families in the city that spent more than 30% of their income on shelter. We estimated two equations, one for homeowners and one for renters. In both equations, the left hand (dependent) variable was percentage of families spending more than 30% of family income on shelter (either ownership or rental). The primary right hand (explanatory) variables were population and median income.

First, we found that an increase in population of 10,000 was associated with a 0.285% increase in the proportion of homeowners with payments on shelter greater than 30% of household income. For example, in Calgary, our equation predicts that this proportion will increase from 16.7% in 1996 to 21.6% by 2004, (due to a projected 22% increase in population). We also found that a $1,000 increase in household median income was associated with a 0.0966% decrease in the proportion of homeowners with payments greater than 30% of household income. In other words, if household median income increased by $10,000, the proportion of households with payments greater than 30% of household income would be expected to fall by approximately 1% (i.e., 0.966%).

As the rate of growth of population increases, the percentage of homeowners who spend more than 30% of their income on shelter increases. In short, affordability decreases.

Note that these results imply that population growth affects affordability in two ways. First, there is the *direct* (negative) effect of growth on affordability that occurs because housing prices rise. Second, because population growth is associated with increased incomes, and because increased incomes are associated with increased affordability, population growth also has an *indirect* (positive) effect on affordability. Our results suggest, however, that the indirect effect is very weak relative to the direct effect. Thus, we find that, as the rate of growth of population increases, the percentage of homeowners who spend more than 30% of their income on shelter increases. In short, affordability decreases.

Next, we measured the impact of growth and median income on the affordability of *rental* housing. We found, that when population increases by 10,000, the proportion of households with rent greater than 30% of household income *decreases* by 0.03414% (i.e., three one-hundredths of a percent). This effect was compounded slightly when the indirect effect of population growth on income was taken into account.

Summary

The statistical analysis found evidence for a positive relationship between population growth and house prices; a positive relationship between population growth and income; a positive relationship between population growth and the proportion of homeowners with payments on shelter greater than 30% of household income; and a negative relationship between urban growth and the proportion of households with rent greater than 30% of household income. Our results suggest, therefore that, on average, homeowners are made worse off and renters are made better off when a city experiences population growth.

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Paying for Urban Growth

Most urban population growth is accommodated through expansion of peripheral suburbs. This expansion requires government investment in urban infrastructure - roads, schools, water lines, sewers, etc. In this section, we investigate three alternative methods for paying for this investment, comparing the effects that these methods have on the average cost of housing. The three methods are:

Developer fees: Require that the companies that develop the new suburbs pay for the additional municipal infrastructure.[5]

Equal tax loading: Use municipal taxes to spread the expenditures on infrastructure across all residents of the municipality.

Differential tax loading: Use differential municipal taxes to "load" the expenditures for new infrastructure onto the residents of the new suburbs.

Most urban population growth is accommodated through expansion of peripheral suburbs. This expansion requires government investment in urban infrastructure - roads, schools, water lines, sewers, etc.

Theoretical Assumptions[6]

In each case, we make the following simplifying assumptions:[7]

- The population of the city in question is, initially, 1,000,000.
- The population of this city will grow by two per cent per year over the foreseeable future. (Hence, in the first year, it will grow by 20,000.) This rate is unaffected by changes in house prices or municipal tax policies.*
- There are four individuals living in each housing unit. Hence, the initial housing stock is 250,000 units and 5,000 new units must be built in the first year.

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[5] Developer fees are also referred to as development cost charges and development charges.
[6] All of these assumptions are made for ease of exposition only. None of our results hinge on them.
[7] The effects of altering the assumptions marked with an asterisk (*) are investigated in a later section.

- Infrastructure in new suburbs costs the government $25,000 per lot. That is, in the first year the government must spend $125,000,000 (= 5,000 x $25,000) on new infrastructure.

- Except with respect to location, all houses are identical.*

- Buyers are willing to pay higher prices for houses the closer they are to the city center. For additional simplicity, we assume that all existing (i.e. "old") houses are the same distance from the city center.

- All new houses are built at the city's periphery and all are an equal distance from the city center (a distance that exceeds that of old houses). We later allow for "in-fill" housing.*

- The premium that buyers are willing to pay in order to live "close" to the city center (i.e. in existing houses) rather than at the periphery (i.e. in new houses) is a fixed dollar amount, $10,000. For example, if the price of new houses rises from $100,000 to $150,000, the amount that buyers will be willing to pay for existing houses will rise from $110,000 to $160,000.*

- The market for new housing is competitive. This implies that all new houses will sell for the same price; and that that price will equal the cost of construction (including the cost of land).*[8]

- There are no economies or diseconomies of scale in new house construction. That is, all houses cost the same to build. That cost is assumed to be $100,000 (excluding the cost to the government of providing additional infrastructure).

- Initially, the supply of houses equals the demand. Hence, when the population increases by 2%, the number of houses must also increase by 2%. That increase consists entirely of new houses (built at the city periphery).

- Finally, assume, initially, that the province had been paying for the costs of infrastructure in new housing developments. Hence, the price of new housing has equaled its private cost, \$100,000, and the price of existing housing has equaled the new house price plus \$10,000, that is, \$110,000. Now, the province decides to require that the costs of infrastructure be borne by the city. The city must find a method of paying for these costs. We consider three such methods in the following sections.

Developer Fees

One method the city could use to recover infrastructure costs would be to pass them along to new home builders (developers). As infrastructure is assumed to cost \$25,000 per house, this adds \$25,000 to the private cost of building each house. Because the new housing market is assumed to be competitive, this will necessarily increase the retail price of a new house by \$25,000, from \$100,000 to \$125,000.

As each new family enters the city, it must choose between a new home and an existing home. Initially, new homes cost \$125,000 and existing homes cost \$110,000. Families will attempt to buy existing homes. But, as the supply of existing homes initially equaled the demand, and as the supply of existing homes is fixed, the only effect that increased demand for those homes can have is to increase their price. The price of existing homes will rise until it equals \$135,000, at which point, buyers will be indifferent between existing homes and new homes.[9] At that point, families will buy new homes.

Furthermore, as the \$25,000 development fee will be applied to all new homes, and as new homes are built every year (because population is assumed to increase by 2% per year), the cost of new homes must remain at \$125,000. Accordingly, the price of existing homes will remain at \$135,000.

To summarize, because the cost of building new homes determines the price of existing homes, if the city shifts the costs of suburban infrastructure onto new home developers, the prices of *all* houses in the city will increase by the cost, per lot, of that infrastructure.

Because the cost of building new homes determines the price of existing homes, if the city shifts the costs of suburban infrastructure onto new home developers, the prices of* all *houses in the city will increase by the cost, per lot, of that infrastructure. All houses will increase in price and, therefore, decrease in "affordability."

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[8] For mathematical simplicity, we assume that there is no profit margin.

[9] By our assumptions, new homes and existing homes are identical except for location. As buyers are willing to spend \$10,000 more to live near the city center than at the city periphery, the price differential between new houses and existing houses must always remain \$10,000. Note that this result does not require that new and existing homes be identical, except for location. It requires only that "locational preference," here \$10,000, be invariant to the price of new houses.

All houses will increase in price and, therefore, decrease in “affordability”, by $25,000 per house.

Equal Tax Loading

The government could pay for the cost of infrastructure by spreading that cost equally across all houses, new *and* existing. At the end of the first year, for example, there will be 250,000 existing housing units plus 5,000 new ones. Therefore, taxes will have to increase by $490.20 per unit (= ($25,000 x 5,000)/255,000).

Indeed, it can be shown that, as long as population grows at 2% per year and infrastructure costs $25,000 per lot, the taxes required to pay for infrastructure will be $490.20 per year in *every* future year. Calling the number of housing units h, the tax necessary to spread infrastructure costs equally across all units, t, can be found using the formula:

$$t = \frac{0.2 \times h \times \$25{,}000}{h \times (1 + .02)}$$

$$= \frac{0.2 \times \$25{,}000}{(1 + .02)}$$

$$= \$490.20$$

Because we have assumed that the number of individuals entering the city is invariant to the cost of housing (including the cost of taxes), the addition of $490.20 to taxes will have no effect on the demand for housing and, therefore, no effect on house prices. That is, new house prices will remain at $100,000 and existing house prices at $110,000.

The new tax will, however, raise the effective "cost" of each house in the city by an amount equal to the present discounted value of the future stream of increased taxes. Because of discounting, this increase in cost is considerably less than $25,000. At a discount rate of 3%, for example, an infinite stream of payments of $490.20 per year is valued at $16,340.00.[10] And because most homeowners can be assumed to ignore future

[10] 0.03 x $16,340 = $490.20.

tax obligations beyond 25 years (or even beyond 10 or 15 years), the *perceived* present discounted value of the annual tax increase will be considerably less than $16,340.[11]

To summarize, if the city spreads the costs of new infrastructure equally across all housing units, the effective increase in house prices will be substantially less than would have resulted had the city required that all infrastructure costs be borne by builders of new homes. The effect of this policy, therefore, is to increase the "affordability" of housing.[12]

If the city spreads the costs of new infrastructure equally across all housing units, the effective increase in house prices will be substantially less than would have resulted had the city required that all infrastructure costs be borne by builders of new homes. The effect of this policy, therefore, is to increase the "affordability" of housing.

Differential Tax Loading

Finally, the city could pay for the new infrastructure by increasing taxes on new homes alone. For example, if the city was to borrow the $25,000 needed to service each new lot, its annual "mortgage" payments would be approximately $1,393.88 per lot per year, (at a real rate of interest of 3%).

In effect, this would raise the cost of each new house by the present discounted value of that annual tax. But if homeowners discounted the $1,393.88 tax at 3%, the present discounted value would be $25,000. That is, whether the city imposed the cost of the infrastructure as a lump sum or as a tax equal in value to the repayments of a loan, the increase in the cost of new housing would be $25,000. Accordingly, the price of "old" housing would also rise by $25,000.

However, if homeowners implicitly discount future tax payments at a higher rate than the city, (that is, at a rate higher than 3% per annum), the present discounted value of the tax stream would be less than $25,000 and the prices of existing homes would rise by that lesser amount. Thus, if the city is constrained in its ability to spread the costs of new infrastructure across all homeowners, a second best policy might be to increase the taxes of only the new homeowners.

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[11] $490.20 per year discounted at 3% for 25 years is $8,792; and discounted at 3% for 15 years is $6,028.

[12] It does so by reducing the wealth of existing homeowners. When all of the infrastructure costs are imposed on real estate developers, the price of *existing* houses increases by $25,000 with no increase in costs. When the infrastructure costs are spread across all taxpayers, the price of existing homes does not change, yet the present discounted value of property taxes increases by as much as $16,340.

Variation of Assumptions

In this section, we investigate the impact of varying five of the assumptions that were introduced earlier. First, we assumed that the growth of population was unaffected by changes in the rate of growth of housing prices. If this assumption is incorrect, we would expect that the use of "developer fees" would lead to slower growth than would "differential tax loading" and that the latter would lead to slower growth than would "equal tax loading." But this result would have no effect on our conclusion concerning the relative affordability of housing under the three schemes. In our model, city-wide house prices are determined primarily by the cost of providing the infrastructure for one new house. Unless this cost was affected significantly by small changes in the rate of growth of population, house prices would not be affected significantly in any of the three methods of paying for infrastructure.

If the city is constrained in its ability to spread the costs of new infrastructure across all homeowners, a second best policy might be to increase the taxes of only the new homeowners.

Second, we assumed that new and existing homes differed only with respect to location, not with respect to quality. This assumption has no effect on our qualitative conclusions. The only effect of quality differentials would be to increase or decrease the premium that buyers would be willing to pay for existing homes.

Third, the effect of allowing for "in-fill" housing is to reduce the number of new homes that will be built in new districts and to increase the amount of crowding in existing districts. House prices will not change, however, as those prices are determined by the cost of building homes in new districts, by (fixed) quality and locational preferences, and by the property tax regime.

Fourth, we assumed that the locational premium would remain fixed at $10,000. In fact, we would expect that, as additional housing was constructed at the city's perimeter, the locational preference for houses near the city center would increase relative to that for houses near the periphery. The premium would rise over time, as would average house prices. However, as we discussed in the first point above, this can be expected to have the same effect on affordability under each of the three systems of taxation.

Finally, we assumed that the construction industry is competitive. We stand by this assumption. However, we also implicitly assumed that the market for land was imperfectly competitive. This assumption is important because it leads to the prediction that landowners will be able to maintain the price of land when additional costs are imposed on construction companies and homebuyers. If the market for land could be characterised as being competitive, part of any increase in the costs of house construction would be “passed back” to landowners in the form of lower land prices. In turn, this would imply that if the city was to force construction companies to pay for infrastructure costs, house prices would rise by much less than those costs. If, for example, $15,000 of the $25,000 infrastructure costs could be passed back to landowners, house prices would rise by only $10,000. In that case, forcing construction companies to pay for the costs of infrastructure might lead to more affordable housing than would either of the other methods of paying for infrastructure. The evidence suggests, however, that land markets are not competitive; therefore, increased costs are passed on to homebuyers.

Summary

Theory suggests that if the city’s primary goal is to maintain the affordability of housing the costs of growth should be spread across all homeowners. They should not be borne strictly by new residents or by construction companies. If infrastructure costs are imposed on new residents, all house prices will increase by the “per unit” cost of infrastructure, (in our example, by $25,000). If the city uses equal tax loading, however, the increase in the costs of housing will be diluted, through the expedient of spreading those increases across all residents.

Conclusion

In this report, we have analysed the impact of population growth on the affordability of housing. We began with a statistical investigation of the effect that growth has on housing prices and on median incomes. Our hypothesis was that population growth would lead to increases in both of these variables. Thus, if incomes grew at least as rapidly as prices, population growth might leave the “affordability” of housing unaffected. We found that our first hypothesis was confirmed – the rates of growth of both housing prices and median incomes were positively correlated with growth of population. However, because house prices increased more rapidly than incomes, home ownership became less affordable. This finding was further confirmed by the statistical result that the number of homeowners who spent more than 30% of their incomes on shelter increased as the rate of growth of population increased. On the other hand, population growth did not appear to have a significant effect on the numbers of *renters* who could afford shelter.

We also investigated the theoretical impact that various methods of paying for infrastructure would have on the affordability of housing. We concluded that the method that would reduce affordability by the lowest percentage was one in which the costs of infrastructure were spread equally across all residents. Of course, this method has the undesirable effect that it increases the costs of housing to existing residents by more than it increases those residents’ incomes. This effect is partially compensated for, however, by the fact that because this method offers the least incentive for developers to build in-fill housing, it creates the least amount of crowding in inner city neighbourhoods.

Appendix A: Statistical Report

The purpose of the empirical analysis is to establish the effect of population growth on house prices, income and a measure of housing affordability. Essentially, the purpose is to provide a concrete basis for beginning to think about the benefits and costs of urban growth. Many of the results confirm a priori expectations, but at least one result is surprising. Population and house prices are positively related; population and income are positively related, but the effect of population growth on the housing affordability measure is unexpected. Population growth is found to reduce the affordability of owned homes, but increase the affordability of rental units. In thinking about who benefits and who loses as a result of urban growth, we did not expect that renters would fall into the better off category.

Data

As noted in the main report, two sources of data are used in this study: aggregate Canadian census data (1986, 1991 and 1996) and the Royal LePage House Price Survey. All the variables used in the analysis are listed in table 1 along with their definitions. All prices and incomes have been converted to year 2000 constant dollars using the Consumer Price Index published by Statistics Canada. Dummy variables for each of the 317 cities were included in each regression to account for city-specific effects. For example, housing prices are in part explained by land values and changes in supply relative to demand. If supply keeps pace with demand, prices will remain relatively stable, assuming all other variables are held constant. However, if supply falls below demand, there will be pressure for prices to rise. The effect of supply as well as land value on average house prices is likely to differ in Calgary, for example, from other Canadian cities. Therefore, the variation in Calgary's house prices attributable to such factors as supply and land value is captured by the city dummy variable for Calgary.

Table 1: Definition of Variables

Variable	*Definition*
lnvofd	Log average value of dwelling.
lnpop	Log population.
lnrehny	Log real household median income.
prhwp	Proportion of households with payments for shelter greater than 30 percent of household income. Equal to the number of households with payments for shelter greater than 30 percent of household income divided by the number of owned dwellings.
newprhwp	Logit transformation of the proportion of households with payments for shelter greater than 30 percent of household income.
thpop	Population in 10000's.
threhny	Real household median income in thousands of dollars.
prhwr	Proportion of households with rent greater than 30 percent of household income. Equal to the number of households with rent greater than 30 percent of household income divided by the number of rented dwellings.
newprhwr	Logit transformation of the proportion of households with rent greater than 30 percent of household income.
year2	Dummy variable for 1991.
year3	Dummy variable for 1996.
city dummies	Dummy variables for each of the 317 census subdivisions.

House Prices

The first issue at hand is to determine the impact urban growth has on average house prices. To that end, we follow the methodology of Bourassa and Hendershott (1995) in estimating an equation of the form shown by equation (1).

$$\text{lnvofd} = \beta_0 \text{ lnpop} + \beta_1 \text{ lnrehny} + \beta_2 \text{ year2} + \beta_3 \text{ year3} + \beta_i \text{ city dummies} + u_i \qquad (1)$$

The estimated coefficients provide information on the effect of a percent change in an independent variable (i.e., any variable on the right-hand side of the equation) on the dependent variable, in this case, value of dwelling.[13] Simply, equation (1) attempts to answer the question, what happens to house prices when there is a change in population or median income?

[13] The terms value of dwelling, average house price and house price will be used interchangeably.

Both linear and log-linear models were estimated, but the log-linear specifications provided statistically significant results where the others did not. Models were run with and without weights; however, weighting did not change the estimated coefficients appreciably, but did reduce the standard errors. Therefore, we opted for the log-linear, weighted specifications.

Following equation (1), we consider how well changes in house prices are explained by changes in population and real household median income. Table 2 provides a summary of the empirical results including the estimated coefficients, their t-statistics and the R square of the model. The results of the OLS regression are as follows:

$$\begin{aligned} \text{lnvofd} = -1.164 + 0.1684\ \text{lnpop} + 1.016\ \text{lnrehny} + 0.1439\ \text{year2} \\ + 0.2127\ \text{year3} + \text{city dummies} \qquad \text{(A)} \end{aligned}$$

These results appear in table 2 as Model A.

Table 2: Summary of Model A and B Results

Dependent Variable:	log value of dwelling census data	log value of dwelling Royal LePage data
Explanatory Variables	A	B
lnpop (log population)	0.1684	0.2751
	(-3.092)	(-1.215)
lnrehny (log household median income)	1.016	0.5807
	(-12.71)	(-1.928)
year2 (1991)	0.1439	n/a*
	(12.62)	
year3 (1996)	0.2127	0.118
	(15.69)	(2.531)
city dummies	y**	y**
constant	-1.164	2.6019
	(-1.297)	(0.741)
R squared	0.9351	0.8834

* not applicable with this data set.
** included in the regression, but not reported.

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Our model suggests that, all else equal, a 10% increase in population is associated with a 1.7% increase in average house prices. This implies that for a city such as Calgary, where the population has been projected to grow by 22% from 768,000 to 938,000 between 1996 and 2004, house prices on average will rise by 3.7% from an average of $162,000 in 1996 to $168,000 in 2004 (City of Calgary, 1999).

Furthermore, our results suggest a unitary elastic, positive, relationship between household median income and house prices. That is, a 1% increase in median income is associated with a 1% increase in house prices. Median income data was used rather than average income because it is not influenced by outliers to the extent that average income is and provides a better measure of income distribution.

The dummy variables for 1991 (year2) and 1996 (year3) are included to account for any impact on house prices directly attributable to the year. The year2 and year3 dummy variables show that house prices were, on average, across Canada, 15.5% higher in 1991 than in 1986 and 23.7% higher in 1996 than in 1986.[14] In 1996, house prices were found to be 7.1% higher than in 1991. These increases are based on average prices converted to 2000 constant dollars, thus, inflation has been accounted for.

We estimate the same regression the Royal Lepage data set for average house prices. In table 2 the results of this regression are shown as Model B. Using this survey reduced the number of cities for which data was available to 62 and the number of years to two (1986 and 1996) rather than three. These changes may explain the small difference in the estimated coefficients between the two data sets and the significant increase in the standard errors of the estimates.

$$\text{lnvofd} = 2.6019 + 0.2751 \text{ lnpop} + 0.5807 \text{ lnrehny} + 0.118 \text{ year3} + \text{city dummies} \qquad \text{(B)}$$

A 1% increase in population is associated with a 0.275% increase in average house prices according to the Royal LePage data. The corresponding figure using census data was 0.168%. Similarly, the Royal LePage data find that a 1% increase in household income is associated with a 0.581% increase in house prices while the census data found house prices increased by 1% when household income increased by 1%. Interestingly, though,

[14] These results are found by subtracting 1 from the antilog of the estimated coefficient in each case.

changing data sets has not caused unexplainable changes in the results. Thus, we conclude that Model A is robust.

Income

We establish the relationship between population and income by estimating the following equation, which takes a slightly different form from that of equation (1). In quantifying the effect of population growth on real household median income, Model C is estimated according to equation (2).

$$\text{lnrehny} = \beta_0 \text{ lnpop} + \beta_1 \text{ year2} + \beta_2 \text{ year3} + \beta_i \text{ city dummies} + u_i \qquad (2)$$

A positive relationship is established between population growth and real household median income. The results are shown in equation (C) and summarized in table 3.

$$\text{lnrehny} = 9.186 + 0.1854 \text{ lnpop} + 0.0295 \text{ year2} - 0.0516 \text{ year3} + \text{city dummies} \qquad (C)$$

The model finds that a 10% increase in population is associated with a 1.9% increase in household median income. As the population of Calgary is expected to rise by 22% between 1996 and 2004, Model C predicts that household median income will increase by 4.2%, from $49439 in 1996 to $51505 in 2004.

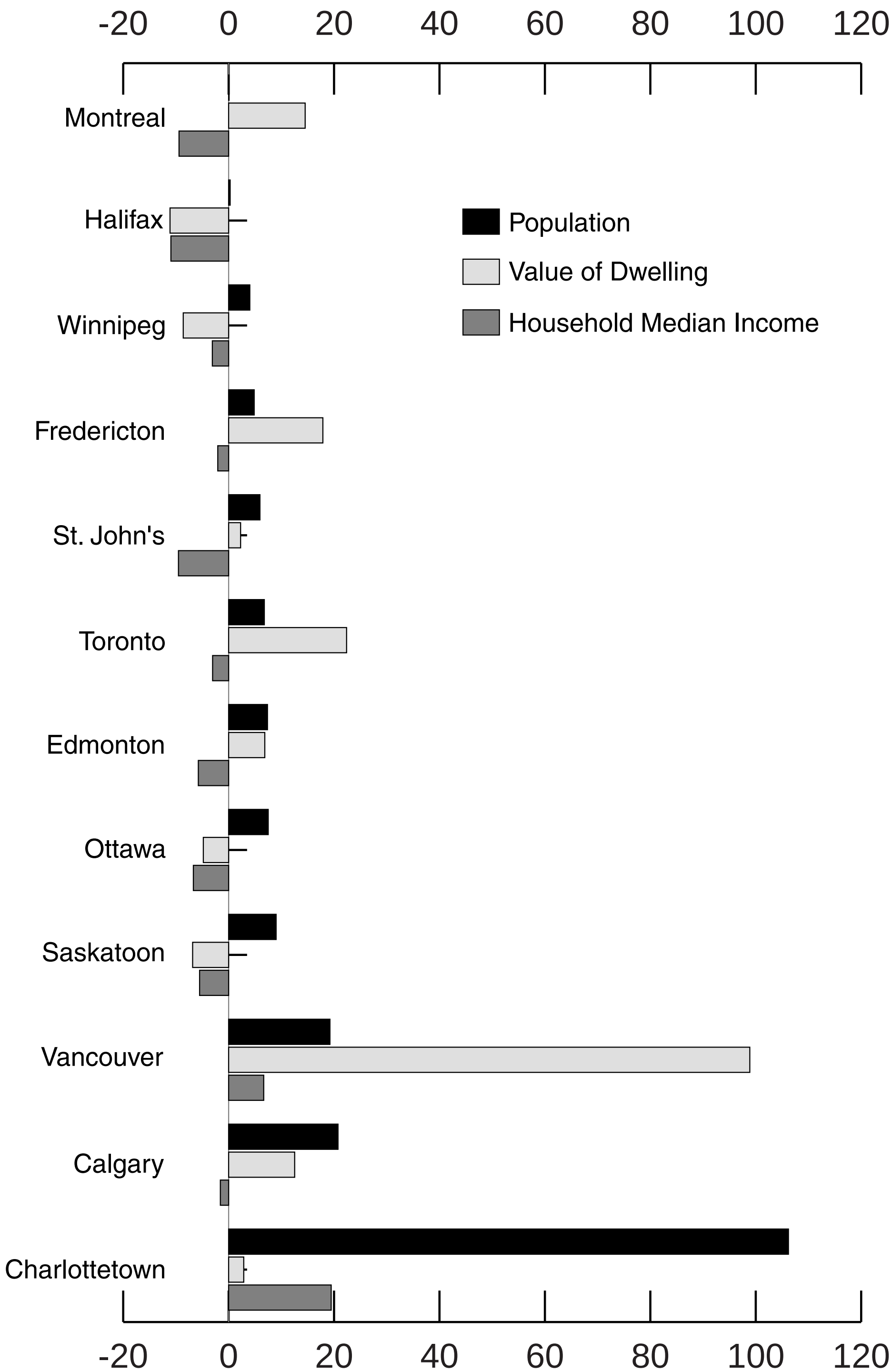
Table 3: Summary of Model C Results

Dependent Variable:	log household median income
Explanatory Variables	C
lnpop (log population)	0.1854
	(7.099)
year2 (1991)	0.0295
	(5.309)
year3 (1996)	-0.0516
	(-8.022)
city dummies	y*
constant	9.186
	(35.67)
R squared	0.9512

* included in the regression, but not reported.

Figure 1 provides a graphical representation of population, house price and median income growth rates for 12 Canadian cities over the period 1986–1996. The 12 cities are graphed from left to right according to increasing population growth rates. Montreal had the lowest growth rate of the 12 cities and Charlottetown had the highest. Even though most cities saw an increase in average house prices only two cities, Vancouver and Charlottetown, saw an increase in median income over the same period. For many cities across Canada, the growth rate of income did not keep pace with the growth rate of house prices between 1986 and 1996. Calgary, with the second highest population growth rate, also shows an increase in average house prices over the period. However, both of these increases (in population and house prices) occurred as median household income fell.

Figure 1: Population, Value of Dwelling and Household Median Income Growth Rates in 12 Canadian Cities Over the Period 1986-1996 (%)



CanadaWest

Housing Affordability

The remaining models require a logit transformation in order to apply an empirical analysis. Model D relates population, household median income and the year and city dummy variables to the proportion of households with *payments* for shelter greater than 30% of household income. Model D takes the form of equation (3).

$$\ln (prhwp/(1-prhwp)) = \alpha_0 + \alpha_1 \text{ thpop} + \alpha_2 \text{ threhny} + \alpha_3 \text{ year2} + \alpha_4 \text{ year3} + \alpha_i \text{ city dummies} + u_i \qquad (3)$$

Equation (3) was estimated with the following results, which appear in table 4.

$$\ln (prhwp/(1-prhwp)) = -1.0737 + 0.018083 \text{ thpop} - 0.001317 \text{ threhny} - 0.27092 \text{ year2} + 0.24743 \text{ year3} + \text{city dummies} \qquad (D)$$

Table 4: Summary of Model D, E, F and G Results

Dependent Variable:	log odds of households with payments >30% of household income	log odds of households with payments >30% of household income	log odds of households with rent >30% of household income	log odds of households with rent >30% of household income
Explanatory Variables	D	E	F	G
thpop (population in 10000's)	0.018083	0.018273	-0.00141	-0.00296
	(5.055)	(5.09)	(-0.4)	(-0.8277)
threhny (household median income in 1000's)	-0.006132	n*	-0.01342	n*
	(-2.419)		(-5.276)	
year2 (1991)	-0.27092	-0.28559	-1.2353	-1.2588
	(-14.38)	(-15.95)	(-70.55)	(-72.82)
year3 (1996)	0.24743	0.25088	0.3201	0.34592
	(13.11)	(13.28)	(19.12)	(21.16)
city dummies	y**	y**	y**	y**
constant	-1.0737	-1.4143	0.35997	-0.39126
	(-4.558)	(-7.46)	(0.9748)	(-1.125)
R squared	0.8396	0.8382	0.9484	0.9462

n* not included in the regression.
y** included in the regression, but not reported.

Interpretation of these results requires some mathematical manipulation. As an example, we substitute values for the population and median income of Calgary in 1996 into equation (D). Rearranging we find

$$\text{prhwp} = 0.1958.$$

This result is used to determine the effect of a change in population or median income on the proportion of households with payments on shelter greater than 30% of household income using the following formulas:

$$\frac{f\text{prhwp}}{f\text{thpop}} = \alpha_1 * \text{prhwp} * (1 - \text{prhwp}) = 0.002847$$

$$\frac{f\text{prhwp}}{f\text{threhny}} = \alpha_2 * \text{prhwp} * (1 - \text{prhwp}) = -0.0009655$$

The first result describes the effect of a one unit (i.e., 10000) increase in Calgary's population on the proportion of households with payments on shelter greater than 30% of household income, holding median household income constant. An increase in population of 10000 is associated with a 0.285% increase in the proportion of households with payments on shelter greater than 30% of household income. In Calgary, where the proportion of households with payments greater than 30% of household income was 0.167 (i.e., 16.7% of owned dwellings) in 1996, this proportion is expected to increase to 0.216[15] (i.e., 21.6% of owned dwellings) in 2004 by which time the population is projected to increase by 170000, to 938000. That is, a 22% increase in population is expected to increase the proportion of households with payments greater than 30% of household income by 4.9 percentage points.

The second result implies that a one unit (i.e., $1000) increase in household median income is associated with a 0.0966% decrease in the proportion of households with

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[15] This number is calculated as follows:

$$\text{number of units population increases by} * \frac{f\text{prhwp}}{f\text{thpop}} + \text{prhwp in 1996}$$

$$17 * 0.002847 + 0.1672 = 0.2156$$

payments greater than 30% of household income. In other words, if household median income increased by \$10000 the proportion of households with payments greater than 30% of household income is expected to fall by just less than 1% (i.e., 0.966%).

Model D allows changes in population to affect the proportion of households with payments greater than 30% of household income directly as well as indirectly through household median income. A variation on Model D, Model E, is run to separate the direct and the indirect effects of population growth on the proportion of households with payments greater than 30% of household income. Model E is similar to Model D with the difference between them being that E is estimated excluding the household median income variable. The results of running Model E are:

$$\text{newprhwp} = -1.4143 + 0.01827\ \text{thpop} - 0.2856\ \text{year2} + 0.2509\ \text{year3} + \text{city dummies} \quad \text{(E)}$$

After some mathematical manipulation, Model E determines that when the population of Calgary increases by 10000 the proportion of households with payments greater than 30% of household income increases by 0.288%. This result is nearly identical to that of Model D where the corresponding result was 0.285%.

As discussed above, Model C found weak evidence that increases in population are associated with increases in household median income. We say the evidence is weak because the effect of population growth on income depends on the specification of the model. In Model D, removing income from the equation has minimal impact on the remaining variables, therefore, there is little evidence to suggest that the weak relationship between population growth and household income is driving the result that increases in population are linked with increases in the proportion of households who have payments greater than 30% of household income. That is, while we have reason and some evidence to believe that changes in population lead to changes in income, we do not find that that indirect mechanism is significant relative to the direct effect of population on the proportion of households with payments greater than 30% of household income.

The next set of models introduces a new dependent variable, proportion of households with *rent* greater than 30% of household income. Models F and G correspond to Models D and E, respectively. Models F and G were estimated with the following results, which are also reported in table 4.

$$\text{newprhwr} = 0.35997 - 0.00141 \text{ thpop} - 0.01342 \text{ threhny} - 1.2353 \text{ year2} + 0.3201 \text{ year3} + \text{city dummies} \qquad \text{(F)}$$

$$\text{newprhwr} = -0.39126 - 0.002963 \text{ thpop} - 1.2588 \text{ year2} + 0.34592 \text{ year3} + \text{city dummies} \qquad \text{(G)}$$

Following the same steps to transform the coefficients as in Model D, Model F provides two results:

$$\frac{\partial \text{prhwr}}{\partial \text{thpop}} = -0.0003414$$

$$\frac{\partial \text{prhwr}}{\partial \text{threhny}} = 0.00325$$

The first result says that when the population of Calgary increases by 10000, the proportion of households with rent greater than 30% of household income *decreases* by 0.03414% (i.e., three one-hundredths of a percent). A very small, yet unexpected, result. Intuition suggests a positive relationship between population growth and households with rent greater than 30% of household income. However, there may be more than one explanation for this result. Assuming that most of the population growth is attributable to in-migration rather than births, it may be that newcomers buy homes, and therefore do not put pressure on the relatively fixed supply of rental units or their price.

Model G is run to separate the direct and indirect effects of population growth on the proportion of households with rent greater than 30% of household income. The indirect effect is through household median income. The estimated coefficient on the population variable in Models E and G measures all the effects of population growth not accounted for in the year or city dummy variables, not just those attributable to population growth alone. These coefficients also include the effects attributable to changes in other variables, such as income, that are correlated with population growth. Models D and F isolate the effects of population growth and income by including both variables separately. Model G finds:

$$\frac{d\text{prhwr}}{d\text{thpop}} = -0.0003287 \cdot$$

When the population of Calgary increases by 10000, allowing only for the direct effect of population growth on the prhwr variable, the proportion of households with rent greater than 30% of household income falls by 0.03287%. Excluding household median income from the equation does not change the result significantly. As determined in Model C, we do find some evidence that changes in population affect median income, but we do not find that that mechanism is significant relative to the direct effect of population growth on the proportion of households with rent greater than 30% of household income.

An interesting trend was discovered in the proportion of households with rent greater than 30% of household income variable. The average proportion across Canada was 34.9% in 1986, fell to 15.1% in 1991 and rose to 41.6% in 1996. The proportion of households with rent greater than 30% of household income in 1991 was so much lower than in 1986 and 1996 that it warranted further investigation. Verifying the definition of the variable across years, as well as the data, confirmed that the drop in 1991 was not simply a flaw in the data, but rather an actual occurrence. The trend may be a result of a combination of factors. In 1991 there may have been relatively more Canadians in subsidized housing when compared to 1986 and 1996. Moreover, median and average incomes were found to be higher in 1991 than in 1986 and 1996 which would also account for some of the variation in the proportion of households with rent greater than 30% of household income between 1986 and 1996. To observe the effect the trend had on the results of Models F and G we ran these regressions excluding 1991 data and found little difference from the original specification.

Conclusion

The statistical analysis provides empirical evidence for a positive relationship between urban growth and house prices; a positive relationship between urban growth and income; a positive relationship between urban growth and the proportion of households with payments on shelter greater than 30% of household income; and, a negative relationship between urban growth and the proportion of households with rent greater than 30% of household income. According to our analysis, on average, homeowners are made worse off and renters are made better off when a city experiences population growth.

Sources

Bourassa, S. and P.H. Hendershott (1995) “Australian Capital City House Prices.” *Australian Economic Review.* 3rd quarter. pp.16-26.

City of Calgary (1999) “Population Size, Calgary, Alberta.” Social Research Unit. www.gov.calgary.ab.ca/81/research/dpsize.htm

PCensus. “PCensus-Canada, desktop demographic software.” Version 5.1. Tetrad Computer Applications. Vancouver.

Royal LePage (2000) “House Price Survey.” www.royallepage.com

Statistics Canada (2000) “Consumer Price Index.” Cansim label p200000.