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Assessing House Prices in Canada:
Borrowing Capacity and Investment Approach

by Michal Andrle and Miroslav Plašil

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ASSESSING HOUSE PRICES IN CANADA: BORROWING CAPACITY AND INVESTMENT APPROACH[1]

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Abstract

This paper assesses house prices in 11 Canadian Census Metropolitan Areas (CMA) using the borrowing-capacity and the net-present-value approaches. The results indicate that by the end of 2018, house prices in most metropolitan areas are aligned with macroeconomic fundamentals. However, in Hamilton, Toronto, and Vancouver house prices have increased beyond the values implied by the fundamentals.

CONTENTS   **PAGE**

FIGURES

I. INTRODUCTION

Canadians love real estate. Or so it seems from observing the increasing real-estate prices, price-to-income ratios, and the amount of attention devoted to real estate in every-day news. This paper provides an analysis of house prices in 11 census metropolitan areas (CMAs) in Canada, focusing on key macro-economic fundamentals – current and expected household income and mortgage interest rates.

Following Andrle and Plašil (2019), two approaches are used to assess house prices. The first is the borrowing-capacity approach, a hypothesis that house prices essentially reflect households' capacity to borrow and pay for the purchase of a house. These estimates are labeled "attainable house prices". The second approach is an investment approach, equating the house value with the net present value of its net rental income. While distinct, the two complementary approaches should provide a medium- to long-run anchor to house price development and can serve as a benchmark to judge under- and over-valuation of house prices.

The analysis suggests that in most areas considered, house prices can be explained by household income and mortgage rate dynamics. In most CMAs, the evolution of house prices can be well explained by knowing the dynamics of household median income, mortgage rates, and the area-specific share of income typically allocated to servicing mortgages. In Hamilton, Toronto, and Vancouver (HTV) the analysis suggest that house prices rose beyond the values supported by economic fundamentals.

The increasing price-to-income, price-to-rent, and loan-to-income ratios in Canada are predictably driven by the decline in mortgage rates and households' willingness to keep their debt-service-to-income (DSTI) stable. With lower interest rates and an unchanged mortgage-payment-to-income share, households can borrow more for their house purchase. The analysis suggests that the decline of mortgage rates has significantly contributed to the increase in house prices, as households' increased borrowing capacity gets promptly priced in by the market.

Unless the decline in nominal interest rates observed over last couple of decades reverts, the price-to-income and price-to-rent ratios are unlikely to ever return to their historical values. An important consequence of the increasing price-to-income ratio is that it takes longer to save the required down payment, with down payments becoming a larger share of household income. This lowers housing affordability in Canada and may nudge households towards higher loan-to-value mortgages.

Although house prices in most metropolitan areas are well-aligned with the fundamentals, risks have built up in the housing market. House prices in HTV seem significantly over-valued and there is limited scope for further declines in mortgage rates, which would increase the fundamental values. In addition, because of lower rates and stable DSTI, Canadian

households are much more leveraged than in the past. This increases their exposure to shocks to income, unemployment, interest rates, or house prices correction, see Debelle (2004).

Policymakers are acutely aware of the housing market challenges and lower housing affordability in Canada. As in other countries, such as the United Kingdom or the United States for example, there are efforts to implement policies to increase housing affordability. These policies address the supply-side constraints but also aim to ease housing financing.

The present analysis suggests that if house prices quickly reflect households' ability to borrow, policy measures aimed at boosting households' access to credit are likely to just increase house prices. In a tight housing market, increasing household borrowing capacity or ability to pay through direct subsidies, increasing or implementing interest expense tax deductibility, extending mortgage amortization period, or otherwise relaxing macro-prudential DSTI or LTI limits, will most likely only result in further price increases.

The structure of the paper is as follows. First, the static borrowing-capacity approach and investment approach to house prices assessment are described, however consult Andrle and Plašil (2019) for greater detail. Second, the results from applying the methods to eleven census metropolitan areas (CMAs) are discussed, together with the key assumptions behind the analysis. Policy implications and conclusions follow.

II. Theory

A. Borrowing Capacity Approach

The static borrowing-capacity (SBC) approach determines how much housing a household can afford given its income, the prevailing mortgage rate, and leverage requirements.[2] While such an approach may not be optimal from an economic-theory viewpoint, a recent survey by Canada Mortgage and Housing Corporation (CMHC) showed that 85 percent of first-time buyers spent the most they could afford (CMHC, 2018).

A household, or a family, can allocate a portion α of their income Y_t (at loan origination) to service its mortgage payment, A_t:

$$A_t = \alpha Y_t. \tag{1}$$

Given the monthly mortgage payment, A_t, the mortgage interest rate, i_t^m (per month), and the maturity of the mortgage loan in months, N_t^m, the bank determines the mortgage loan amount attainable, L_t, using standard mortgage-contract calculations:

$$L_t = \left[\frac{(1 + i_t^m)^{\wedge N_t^m} - 1}{i_t^m (1 + i_t^m)^{\wedge N_t^m}} \right] \times \alpha Y_t \equiv f(i_t^m, N_t^m) \times \alpha Y_t. \tag{2}$$

The mortgage loan available for the household, L_t, and its savings for the down payment, D_t, add up to the "housing", PH_t, it can afford:

$$PH_t \equiv P_t^h H_t = L_t + D_t, \tag{3}$$

where the value of the house is a combination of price per quantity of housing, P_t^h, and the quantity of housing, H_t.

Assumptions about the household's down payment are crucial for estimates of "attainable" house prices. One possible assumption is to consider the down payment as a constant share of income. Another option is to let the households choose their down payment as implied by a constant loan-to-value (LTV) ratio (for example, a down payment of 20 percent of the property price). Given that the LTV is observed for the marginal buyer, it is used in the baseline model, resulting in a closed-form solution for the housing purchase:

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[2] Andrle and Plašil (2019) also develop the concept of "dynamic borrowing capacity", where the future path of income and interest rates are reflected in household capacity to borrow, with emphasis on the financial stability and loan repayment when economic conditions deteriorate.

$$PH_t = \frac{1}{LTV} f(i_t^m, N_t^m) \times \alpha Y_t.$$

(4)

The house pricing formula (4) is the key relationship used to assess house prices.[3] It estimates expected house prices, conditioned on the static borrowing-capacity hypothesis. The pricing formula has several important implications, discussed below.

- *Under the SBC hypothesis, house prices will grow in line with household nominal income in the long run.* With constant loan-to-value ratios, debt-service-to-income ratios, and mortgage interest rates, house prices will grow with households' nominal disposable income.

- *A permanent decline in mortgage rates will lead to a permanent increase in the debt-to-income ratio.* If a household keeps its debt-service-to-income (DSTI) ratio constant (at origination), a permanent decline in nominal interest rates will lead to a permanently higher loan-to-income (LTI) ratio. Lower interest rates quickly increase the LTI of new home-owners first and then gradually increase the overall household sector's debt-to-income ratio. Figure 4 demonstrates the non-linear relationship between the LTI and interest rates for different maturities. Households allocating some 30 percent of their income to service their mortgage (at origination) could have borrowed around 3 times their income in 2000. By 2016, households could have borrowed nearly 5 times their income, due to a reduction in mortgage rates (from 8 percent to less than 4 percent). The observed increase in the total household sector's debt-to-income ratio will be gradual and depend on the structure of the old mortgage pool and the credit exposure across generations.

- *Permanent declines in mortgage rates will permanently increase price-to-income ratios.* Often, the price-to-income ratio is used to assess whether house prices are overvalued, under an implicit or explicit assumption that the ratio is mean-reverting. Under the SBC hypothesis, it is the DSTI that is stable, or mean-reverting, and permanently lower interest rates permanently increase the price-to-income ratios. This limits the usefulness of the price-to-income ratio for house price assessments, as it ignores the impact of interest rates.

- *With a stable loan-to-value (LTV) ratio, a decline in mortgage rates increases the down payment as a share of income.* This implies that the number of years and months to save for the down payment increases together with house prices, after a decline in interest

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[3] The formula is labeled as "pricing", rather than "valuation" due to the difference between the static borrowing-capacity approach and the investment approach, see Andrle and Plašil (2019) for details.

rates. This may worsen housing affordability for many households.[4] Sometimes, a variant of the SBC model is used, where—instead of the attainable price—the DSTI (α) required to purchase a house is backed out using the formula (4) for a given observed house price. The parameter α is then interpreted as "housing affordability" (see, for example, Bank of Canada, 2019). One limitation of this approach is that affordability can worsen even when the "housing affordability" indicator remains constant. More specifically, the indicator masks the fact that the required down payment (as a share of income) can be significantly higher if mortgage rates decline.

- *It is the flow of credit, the new loans, that are relevant for the assessment of house prices and banks' credit stance.* The static borrowing-capacity model makes it clear why focusing on the newly-issued credit for the marginal buyers is relevant for house prices rather than the stock of credit. The stock of mortgage credit is a combination of new and historical vintages of credit, complicating the view on credit stance for house prices.[5] The SBC approach, however, is applicable even in the markets where the detailed data on new mortgage origination are not available, as the model effectively estimates the value of the median mortgage.

The house prices implied by the SBC formula (4) are labelled as "attainable" – a level that households can attain with a considerable effort. That is because the down payment is assumed to adjust and increase in response to a decline in mortgage rates. At this price, housing is attainable but not necessarily "affordable".

Both the borrowing-capacity approach and the investment approach clearly indicate that declining interest rates are not necessarily beneficial for prospective home buyers. As mortgage rates decline, house prices are bid up due to expanded borrowing capacity of households and by investors demand for real estate. The prospective buyers do not benefit from lower interest rates, if these are quickly reflected in higher prices. On the other hand, for existing home owners, the decline in mortgage rates both increases the value of their assets and offers an opportunity to re-finance their mortgages at lower cost.

Households who are buying real estate at historically low mortgage rates, on the other hand, can expect only moderate increase in their home value in the medium term as increasing mortgage rates will offset the effect of increasing incomes. Also, there will probably be no

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[4] The analysis assumes that LTI limits are not binding. Should one assume that the down payment is, for simplicity, a constant fraction of income $D_t = \kappa Y_t$, the resulting estimate of the price of housing would be $PH_t = [f(i_t^m) \times \alpha + \kappa]Y_t$. Under this assumption, the estimated house price would be less elastic with respect to the mortgage rate and the estimated α would differ. Also, assuming each household saves a portion of its current income for R years results in a similar expression. Binding loan-to-income (LTI) limits would have similar effects. Once LTI limits are binding, the decline in interest rate will spill-over into decline DSTI.

[5] Adalid and Falagiarda (2018) illustrate in detail the delayed effects of new loan origination and loan repayment on the stock of credit.

opportunity to re-finance at lower interest rates for some time, motivating household to stay "locked" in the current mortgage and property.

The interest rate effects will change, once the loan-to-income limits are binding. In most countries there are explicit loan-to-income (LTI) macro-prudential limits, either for the individual loan or at the overall debt-to-income level for households. With a binding LTI limit, further declines in nominal interest rates will mostly get translated to lower debt service, as the borrowing capacity of households can no longer be increased. Loan-to-income limits are thus a very powerful tool to regulate household indebtedness.

B. Investment Approach

The value of a property can also be appraised by the net present value (NPV) of its expected net income stream. This is often more relevant for investors than for most owner-occupier households. The "investment" (or arbitrage) approach explicitly acknowledges the expected path of cash flow and it is firmly grounded in economics and finance theory.[6] This paper follows Andrle and Plašil (2019), who operationalize the concept for practical analysis of house prices, reflecting some specifics of owner-occupier households and smaller buy-to-let investors. For instance, it is assumed that that households will fully repay their mortgage, unlike corporate real-estate investors who may keep their leverage stable over time.

The valuation approach puts the expectations about the rents, household income, and interest rates at the center of the analysis. It assumes that the buyer values the expected income from the market rent, $Rent_t$, after adjusting for mortgage payments, A_t, and taxes, τ. The mortgage interest rate is implicit in the mortgage payment annuity. The time-varying interest rate expense, U_t, lowers the cost of finance. As it is not tax deductible in Canada, it is set to zero in the present valuation. Since the net rental income in the numerator of equation (5) is already a flow to the owners, it is converted to the present value using their cost of equity, or their opportunity cost, i_t^e:

$$V_{t|t} = \sum_{i=0}^{\infty} \frac{(1-\tau)Rent_{t+i|t} - A_{t+i|t} + \tau U_{t+i|t}}{\prod_{j=0}^{i}(1 + i_{t+j|t}^e)}. \tag{5}$$

The practical application of the valuation formula (5) explicitly acknowledges the mortgage amortization period, the 5-year intervals for which interest rates are fixed, zero tax deductibility of interest expenses, and the retail investor's desire to fully repay the mortgage in full, see Andrle and Plašil (2019) for the details.

When using the investment approach, it is very important to understand how the long-term interest rate deviate from the expected long-term growth of rents (income): "i – g". That is

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[6] See Damodaran (2011), for instance, for application of present-value computations to valuation.

mainly because, under some simplifying assumptions, the steady-state version of the valuation formula (5) can be restated as:

$$V_{ss} = \frac{Rent_{ss}}{[LTV(1-\tau)i_{ss}^m + (1-LTV)i_{ss}^e - g]},$$

(6)

where LTV denotes the loan-to-value ratio, weighting the effects of the mortgage rate and the cost of equity, τ is the marginal income tax rate (relevant when interest expense is tax deductible), and g is the long-run growth of nominal income.[7]

Effectively, a large part of the housing valuation in (5), depends on the capitalization factor, "i-g", as is clear from (6). If both interest rates and nominal growth decline, the capitalization rate stays unchanged. Hence, lower interest rates on their own do not necessarily rationalize higher valuation, as is often thought.

If the long-run nominal interest rate (and cost of equity, if the risk premium is kept constant) declines more than the nominal growth rate, the capitalization rate increases and, correspondingly, the asset values increase. The formula (6) also suggest that investors who can deduct their interest expense from their income taxes will tend to appraise the expected cash flow with a higher value.

The steady-state formulations of the NPV approach in (6) and the static borrowing-capacity approach in (4) react differently not only to income expectations but also to interest rates. Under the investment approach, the differential between the required yield and nominal income growth is not affected by the steady-state rate of inflation. However, under the borrowing-capacity approach it is the nominal, not real, interest rate that is relevant for the size of the available loan. With real mortgage rates unchanged, lower long-run inflation also lowers the nominal rates, making larger loans available, while the new, lower inflation rate devalues the nominal debt at a much smaller pace.

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[7] It would be, however, a capital mistake to use the formula (6) for the actual valuation, see Andrle (2019).

III. APPLICATION

A. Data and Assumptions

One important assumption is that house prices are in expressed in Canadian dollars, not as an index number. While saying that house prices are analyzed in money terms seems obvious, most of the existing house-prices literature relies on house price index numbers. House price indexes are useful to study house price growth, acceleration, or normalized price-to-income ratios, but are useless for valuation. House prices assessment really needs to deal with prices. Only then can market prices be compared with the estimates of value in a meaningful way over time and across cities or countries.

The data for house prices were sourced from the RPS Real Property Solutions, LLC and Tera Net. The RPS data for 2005:Q1—2019:Q1 were spliced back to 2000:Q1 using the Tera Net data. See RPS (2017) and Tera Net (2019) for the methodology of constructing the data. The present analysis uses multiple data sources, full details are provided in the Appendix.

Median-income households are assumed to take on mortgage loans for 25 years with interest rates fixed for 5-years intervals. Correspondingly, the "conventional mortgage lending rate" for the five-year term from Canada Mortgage and Housing Corporation (CMHC) is used in all calculations. Unless noted otherwise, the baseline loan-to-value (LTV) ratio is 80 percent. Median-income households are assumed to be the prospective buyers of median-priced housing.

The share of income dedicated to mortgage servicing at origination α is the crucial assumption. An obvious option is to set α to an identical value across all CMAs, say 30 percent of after-tax median household income. This choice, however, ignores the fact that there may be good reasons for α to vary across regions. Even under an assumption of perfect regional mobility and households equalizing utility across regions, outlays on housing as a share of income can differ, as indicated by the literature on spatial equilibrium (see Roback, 1982, for example). Regions differ in their amenities, productivity, local taxes, price of services, etc. But even with the same amenities, the share of income allocated for housing expenses can vary with income. For instance, earning C$100,000 a year and paying 50 percent of your income on housing may still be preferable to earning C$70,000 and allocating "only" 30 percent of your income to housing but having lower "ex-housing residual income".[8]

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[8] This would be a natural result with non-homothetic preferences. For instance, with Stone-Geary utility over housing, H, and other goods, C, a minimum necessary consumption of other goods, C_min, the share of housing services in total income will increase with income, Ph*H = alpha * (Y – Pc*C_min). It will be a constant share of "after-necessities residual income", (Y – Pc*Qc).

For transparency, both the region-specific housing share of income, α, and the common share are estimated. To estimate the region-specific $\alpha_{i,t}$, SBC formula (4) is used with available income, mortgage rate, and observed regional house prices. An average for 2004—2006 is then used for the whole sample of 2000Q1—2018Q4. The normalization aims to avoid the sample around the dot-com and financial crisis episodes. The profiles of $\alpha_{i,t}$ are provided in Figure 2.

On top of assumptions about the share of income allocated for mortgage payments, or for rent, the investment approach requires the path of expectations for rents, mortgage rates, and cost of equity. The application of the net-present-value approach uses data from the Long-Range Consensus Forecast to impute households' expectations. Since 1989, the Consensus Forecast for Canada publishes bi-annually (and later quarterly) paths of expected GDP growth, CPI inflation, and 10-year bond yields for ten years ahead and these are used as inputs for the valuation.

The expected growth of rents is approximated by the growth of "nominal output" (real output and inflation) from the Long-Range Consensus, assuming that rents are a stable fraction of income. The path of the 5-year horizon mortgage rate is approximated by the path of the 10-year bond yields, after accounting for the average premium between the ten-year bond yields and the mortgage rate. While this is only an approximation, it is believed to provide a reliable one, namely at the end of the 10-year horizon. The cost of (housing) equity is assumed to evolve as a 10-year bond yield plus a constant risk premium, discussed below. While median household incomes differ across CMAs, the expected growth of income is assumed to be the same across the CMAs due to the lack of granular expectations data.

B. Results

Borrowing Capacity Approach

Using the borrowing-capacity model, house prices in most CMAs can be explained by fundamentals, except for Hamilton, Toronto, and Vancouver. Under the assumptions detailed above, house prices in most metropolitan areas were growing due to an increase in median nominal income and significant declines of mortgage interest rates. Figure 1 depicts the observed house prices alongside the estimate of "attainable" house prices using the static borrowing-capacity approach. This baseline computation uses region-specific DSTI ratios.

The estimates of average region-specific DSTI ratios point towards sizeable differences among the CMAs, see Figure 2. The implied DSTI, $\alpha_{i,t}$, describes what portion of their median income household must allocate to buy a median property. In Hamilton, for instance, households needed DSTI around 30 percent until 2016Q1, when house prices started sharply increasing, pushing the required DSTI for median household towards 45 percent. Further, Figure 8 in the Appendix presents the estimated "attainable" house prices from the SBC

model under the common assumption of 30 Percent of after-tax median household income going to mortgage payments (at origination).

House prices in Hamilton, Toronto, and Vancouver decoupled from fundamentals at the beginning 2016. The pricing gap in 2018 is around 50 percent for Toronto and Vancouver, and almost 60 percent for Hamilton.[9] House prices would have to drop by roughly 30 percent to align with the current fundamentals in these markets.

Such large estimates of pricing gap are not without precedent in Canada, with developments in Calgary and Edmonton over 2006 to 2012 being examples of an overvaluation cycle. The experience of Calgary and Edmonton metropolitan areas are examples of a "soft landing". In Edmonton, housing is estimated to have been overvalued by 60 percent at its peak in 2007Q3. By 2012Q1, Edmonton house prices were better aligned with fundamentals due to a moderate decline in house prices, income growth, and sizeable declines in mortgage interest rates. However, looking ahead, housing markets are highly unlikely to benefit from similar large declines in mortgage rates that would increase fundamental prices. The experience in Alberta suggests that over-valuations do not last forever.

The past developments in Calgary and Edmonton with a strong overvaluation and subsequent alignment with the fundamentals offer support for the SBC model and its current assessment for Hamilton, Toronto, and Vancouver. While a 30 percent drop in house prices is rather unlikely, the larger the estimated price discrepancy, the larger the probability of price correction. Further, reduced-form econometric models may underestimate the probability of price correction, unless the limited scope for mortgage rate declines is accounted for.

Declining mortgage rates contributed sizably to house prices increase in the past. Given the SBC formula (4), it is easy to decompose the contribution of both income and interest rates to attainable house prices, assuming the mortgage duration and DSTI are kept constant. Figure 3 illustrates a decomposition for Edmonton. The contribution of interest rates is due to the difference between the prevailing market interest rate and the mortgage rate in 2001Q1. Under the assumptions of the SBC model, the decline in mortgage rates from their levels in 2001 have added up 100 out of 400-thousand-dollar house in 2017, see Figure 3. This also explains the increase of the price-to-income ratio in Edmonton.

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[9] Hamilton house prices seemed aligned with borrowing capacity of households until very recently. The recent misalignment might reflect the commuting distance to Toronto's tight housing market.

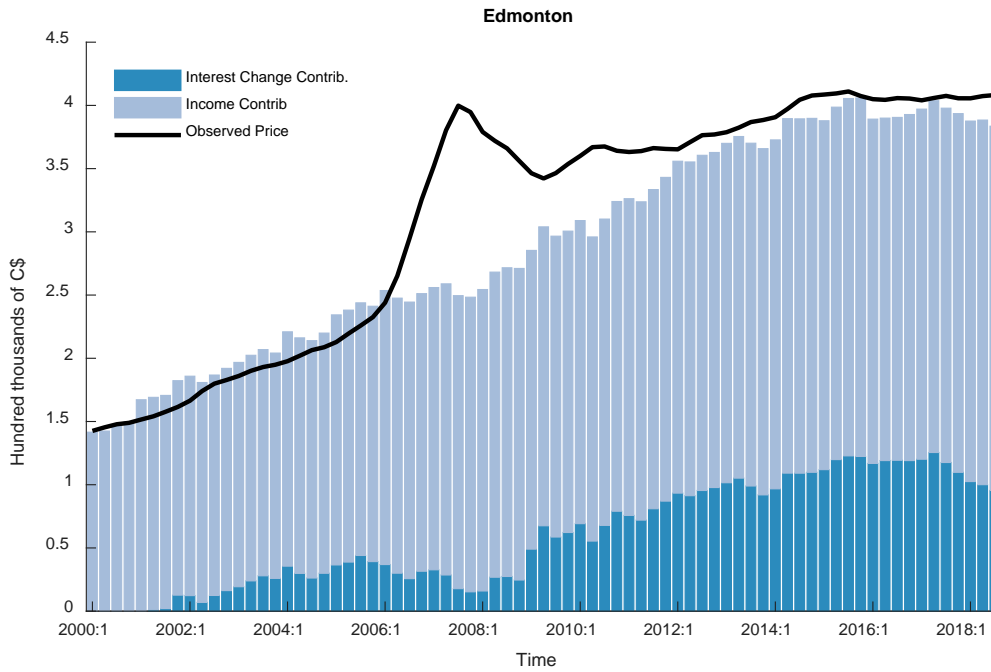**Figure 1: Observed Aggregate House Prices in Canada vs. "Attainable" Prices**
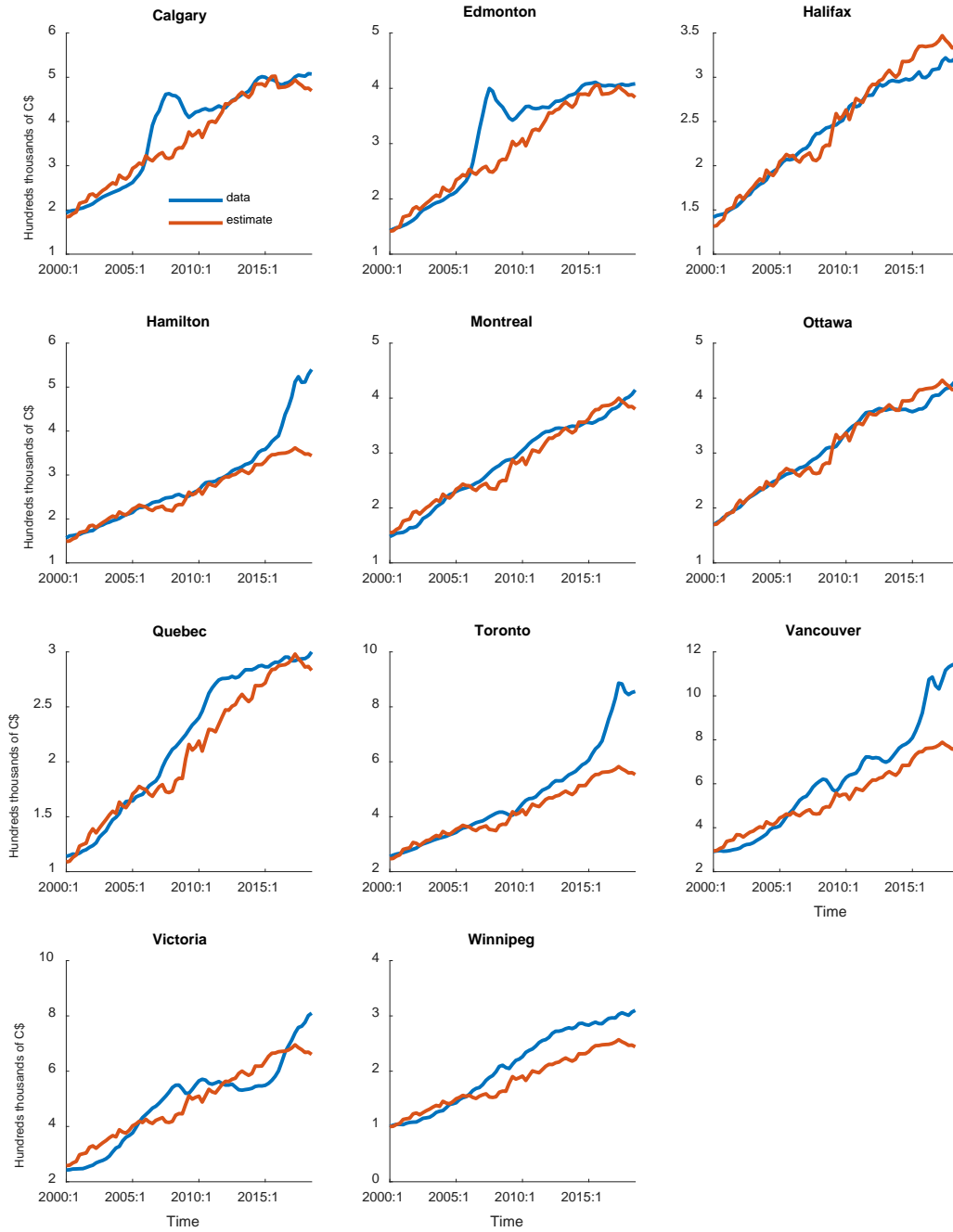
Source: Statistics Canada, CMHC, Haver Analytics, Real Property Solutions, LLC., Teranet, own calculations

Figure 2: Implied share of debt-service to after-tax median household income
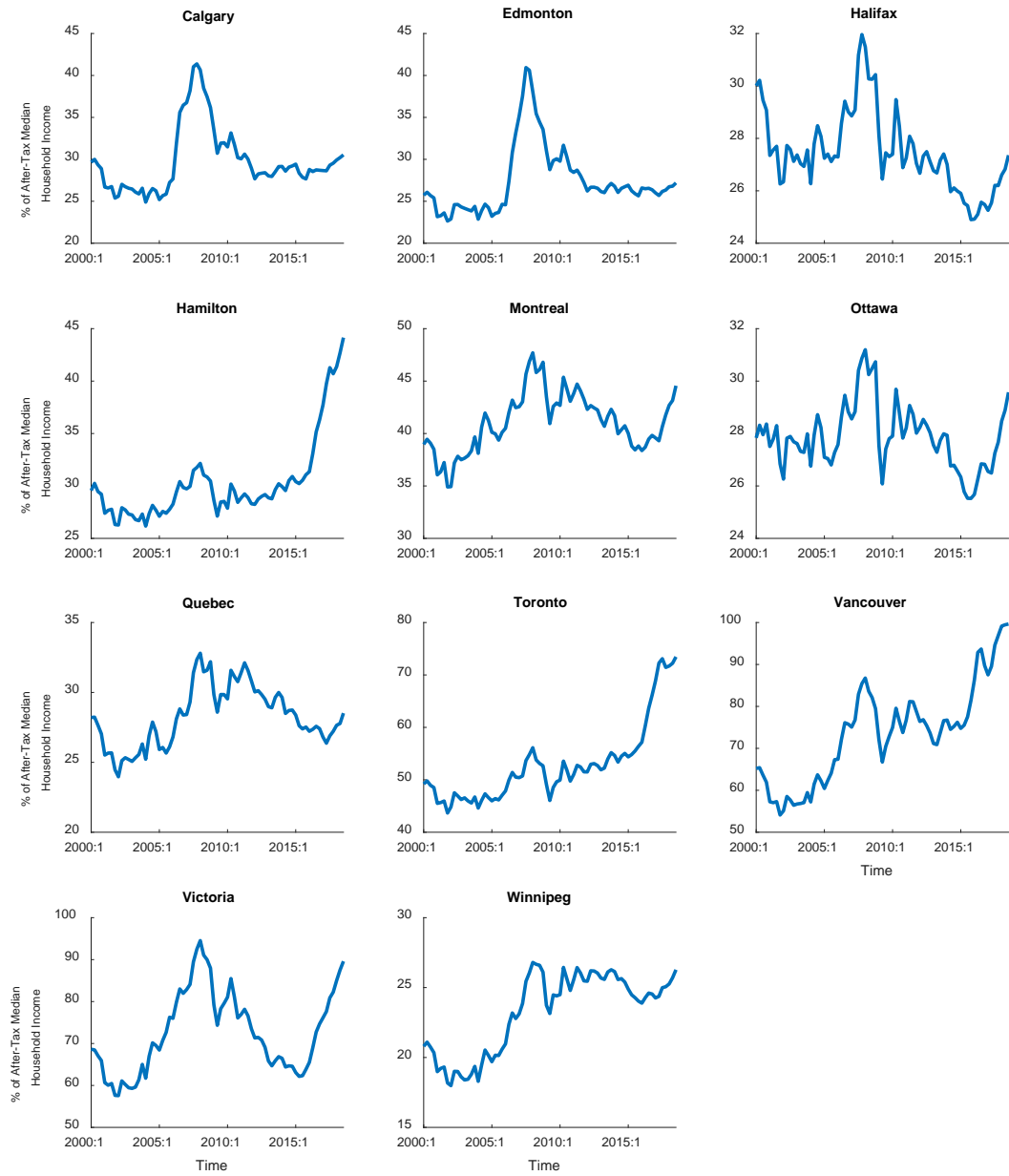
Source: Statistics Canada, CMHC, Haver Analytics, Real Property Solutions, LLC., Teranet, own calculations

Figure 3: Attainable House Prices – Income vs. Interest Rate Contribution

Source: Statistics Canada, CMHC, Haver Analytics, Real Property Solutions, LLC., Teranet, own calculations

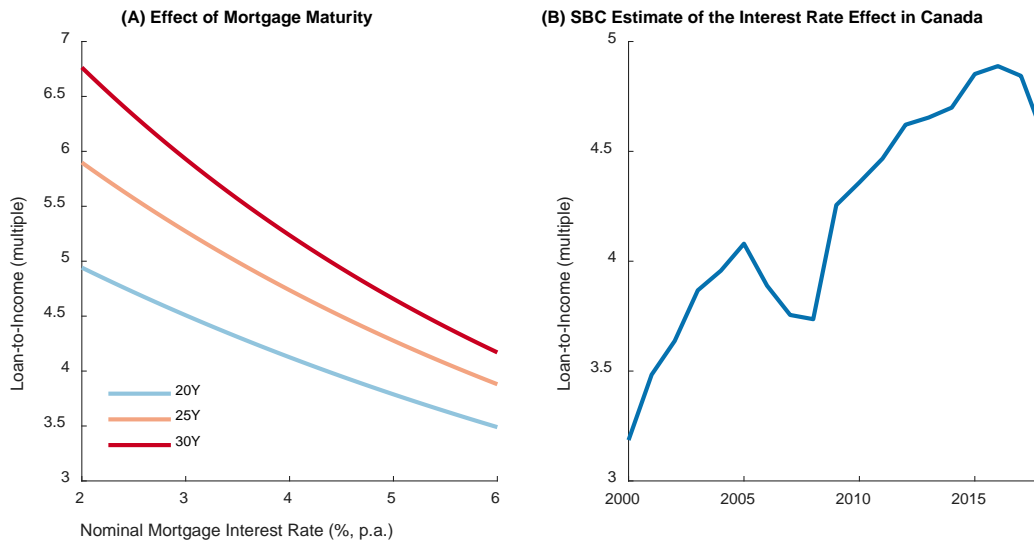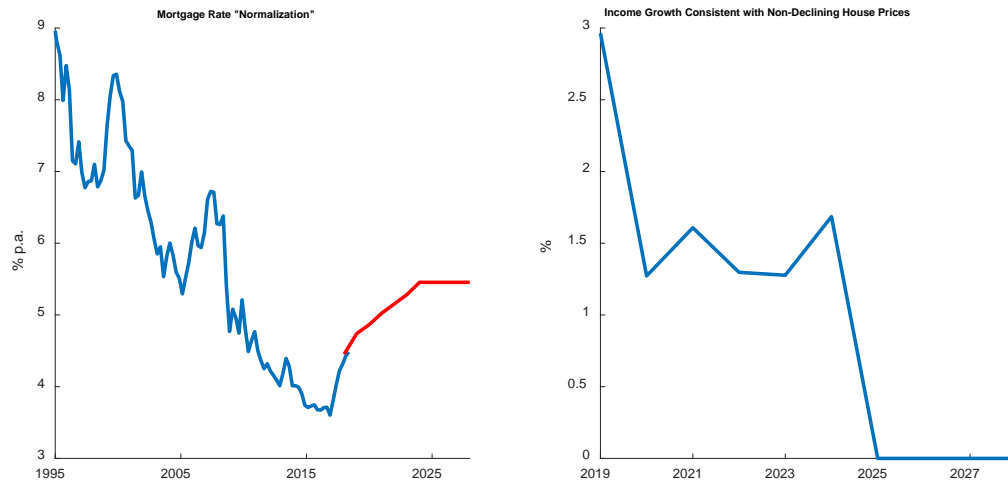**Figure 4: Interest Rate Effect on LTI**

Figure 5: Nominal Income Growth Consistent with Non-Declining House Prices

(Conditioned on Interest Rate Forecast)

Source: Statistics Canada, CMHC, Long Range Consensus Forecast, own calculations

The analysis also helps explain the increase in households' debt-to-income ratio in Canada. Consistent with the SBC model prediction, the loan-to-income of new mortgage borrowers is (or has been) increasing. Figure 4 illustrates the theoretical relationship between the interest rate and the loan-to-income (LTI) ratio for a household that allocates 30 percent of their income to mortgage payment, at origination. The left-hand panel points out the importance of the mortgage-loan maturity for the relationship between LTI and interest rates. The longer the horizon, the greater the sensitivity to interest rates. Under the prediction of the SBC model, increasing the mortgage-loan maturity would most likely lead to increased house prices and more indebted households, until the LTI limits become binding. The right-hand panel of Figure 4 illustrates the estimated effect of the actual path of Canadian mortgage rates on the loan-to-income ratio.

Using the borrowing-capacity approach and forecasts of mortgage rates, what income growth would keep the attainable house prices from declining? As of early 2019 and forecasting the mortgage rate using the Consensus Forecast 10Y bond yield, adjusted for the 180 bps premium, the median income growth required for house prices to not decline (i.e. zero growth in house pries) is at least 3 percent in 2019 and around 1.5 percent until 2025 – see the right-hand panel in Figure 5 (when interest rates stop increasing, zero house prices growth is consistent with no growth of income). If income growth is lower that this it will not be sufficient to offset the effects of increasing interest rates. The required growth rate, however, is quite sensitive to the changes in the mortgage rates, as implied by the non-linear formula (4).

The borrowing-capacity computations use "median" household income, which has some limitations. While median income of households is a robust measure of location, it does not reveal much about the income inequality of a given area. By definition, at least 50 percent of households enjoy a higher-than-median income. In Toronto, for example, data for 2016 Census suggest that more than 12 percent of households take in at least double the median income.[10] On the other hand, income of roughly 34 percent of households is only half the median income. Further, the composition of the unit of demand matters. Households and families, as defined by Census, differ. For instance, overall family income is higher, with incomes of "couple family with children" being usually the highest. Thus, even when households with median income may not be able to afford the median house, there are many households who can. Nevertheless, the assumptions about the sources of demand, and their income, affects mainly the level of attainable house prices but not their dynamics.

Investment Approach

The results from applying the investment approach shed some light on the price increases in 2005 and 2016 for Hamilton, Toronto, and Vancouver, but fall short of explaining them. The results of the investment approach are illustrated in Figure 6. The valuation approach suggests that in 2015 and 2016 some investors might have perceived the increasing house prices as warranted by their appraised value. The key to this valuation is the narrowing difference between the expected long-run interest rates and expected long-run growth, "i-g", see Figure 7.

However, even using the investment approach, aggregate house prices in Hamilton, Toronto, and Vancouver remain overvalued. It should be noted, however, that the net-present-value approach significantly overvalues the markets in most CMAs in 2016Q4 and thus it cannot be used as a reliable explanation of the price increases.

The sharp decline of the "i-g" differential between the interest rates and income growth has contributed to the spike in valuation in 2016. It might have contributed to increase in prices, particularly in markets with tight supply and a larger portion of buy-to-let investors.

The valuations are pseudo real-time, using the Consensus forecast to project the growth of household income and the path of interest rates. After accounting for the average premium of 180 bps between the 10-year bond yields and the mortgage rate, the expected path is reflected under the assumption of fixed-5-year-mortgage-rate periods in a 25-year mortgage. The 10-year bond yield is also used to compute the opportunity cost by adding a constant premium for the whole sample period. As indicated, rents are assumed to growth on par with

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[10] Given the reported income ranges in 2016 Census, 7 percent of Toronto households reported income between 125—149 thousands of dollars and 12 percent of households reported income higher than 150 thousand, for a median income of $68,632.
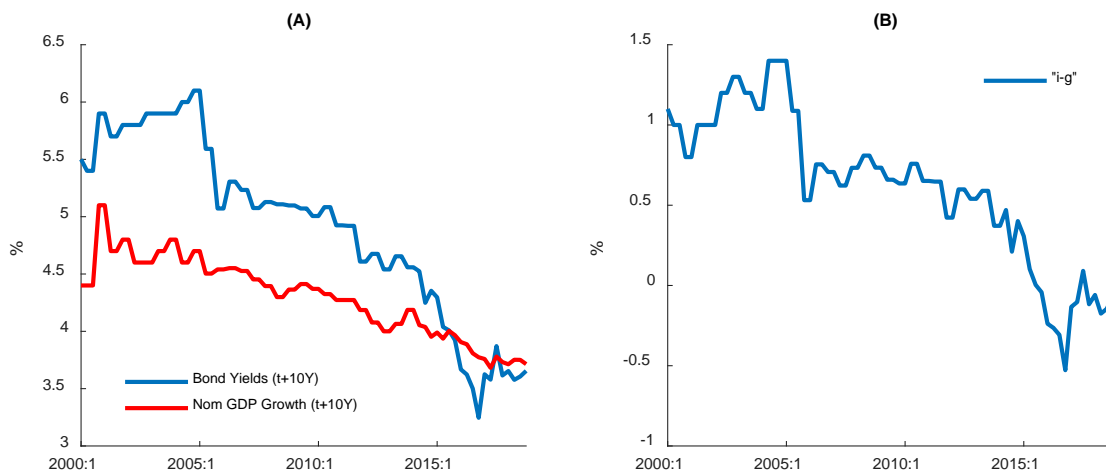
household income, extrapolated using Consensus Forecasts' expectations of nominal GDP growth.

Figure 6: Investment Approach Results
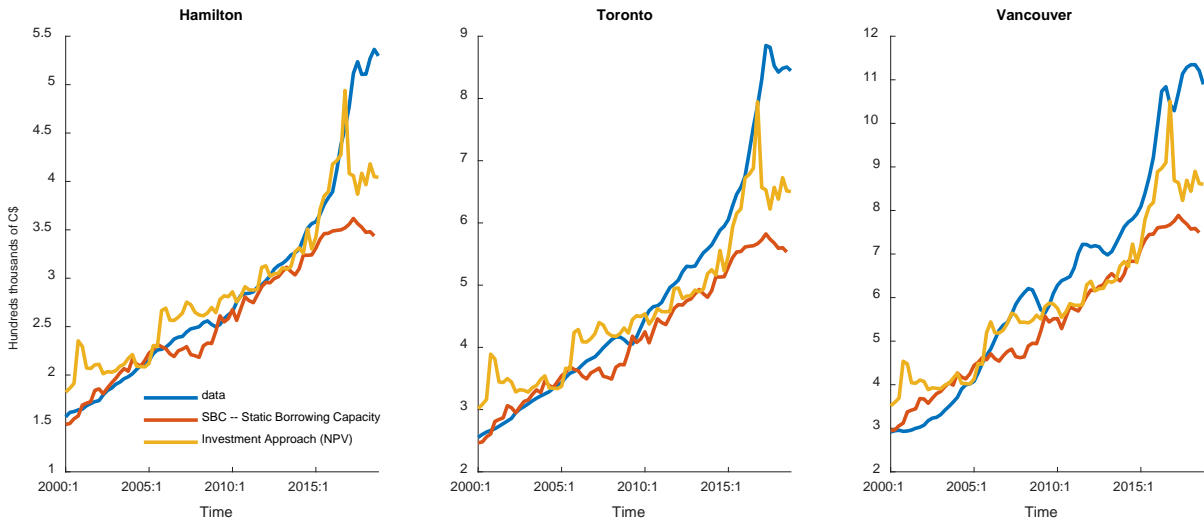
Source: Statistics Canada, CMHC, Haver Analytics, Real Property Solutions, LLC., Teranet, own calculations, Consensus Forecast

Figure 7: Long-Run Expectations of Interest Rates and Growth (Percent)

Source: Consensus Forecast

The steepest housing value changes in 2005Q4 and 2016Q4 are implied by the "i-g" differential narrowing. It is the narrowing of the difference between the expected long-run

interest rates and the expected long-run growth rate in those periods that, ceteris paribus, increases the net present value of the expected income flow. The dynamics of the "i-g" in 2016 is very dramatic, as is its impact on the valuations, under the assumption of the constant "risk premium", see Figure 6.

Given the infinite horizon of the valuation, long after the mortgage is re-paid, the assumption about the continuation value often drives a sizeable portion of the valuation. Continuation value is usually the term reflecting the NPV of the periods where the cost of equity, mortgage rates, and income growth are considered constant. As a sum of an infinite geometric series, the present value is finite only as long the series converges. All that is needed is the cost of capital to exceed income growth in the very long run.

As mortgage rates get lower and first mortgage contracts with negative mortgage rates started to be offered by some banks, see Bloomberg (2019). Intuitively, the borrowing-capacity and investment approach suggest that house prices should grow further in response. However, if there exist prudential regulation with loan-to-value (LTV) and loan-to-income limits (LTI), there is a clear upper bound on what housing, in relation to their income, households can afford to buy and what down payment they can save up for. The limits can be less binding for large-scale real-estate investors and private-equity managers. If their alternative assets' risk-adjusted yields are very low or negative as well, price-to-income ratios may continue to grow, with prospective home-buyers turning into renters as housing stops being affordable.

IV. CONCLUSION

While house prices in most Canadian regions can be well explained by economic fundamentals, prices in Hamilton, Toronto, and Vancouver rose above estimated "attainable" levels. House price developments from 2000 to 2018 can be explained by robust income growth and a significant decline in mortgage interest rates over the period. House prices have been rising together with increasing households' borrowing capacity. However, in 2015, house prices in Hamilton, Toronto, and Vancouver started to dramatically deviate from values supported by underlying economic fundamentals. While the most dramatic price increases apply to single detached family houses, condominium prices have increased as well.

Overvaluations observed in Hamilton, Toronto, and Vancouver are not unprecedented. In 2006, house prices in Calgary and Edmonton increased sharply above the estimates of attainable house prices. The valuations normalized by 2012 due to a moderate decline in house prices, strong household income growth, and a decline in interest rates. Going forward, however, the housing markets in Hamilton, Toronto, and Vancouver are not likely to benefit from such significant declines in interest rates. This could increase risks associated with rapid price corrections.

Declines in mortgage rates have been quickly priced in by housing markets, increasing price-to-income and loan-to-income ratios. A household's capacity to borrow increases when interest rates decline and its debt-service ratio is stable. Over the sample examined here, estimated attainable house prices closely track observed house prices in most metropolitan areas. With interest rate declines quickly reflected in house prices, the price-to-income, loan-to-income, or price-to-rent ratios increase. Higher loan-to-income ratios for new home buyers increase the economy's sensitivity to shocks to interest rates, income, and employment.

The nation-wide increase in price-to-income ratios significantly lowers housing affordability. While rent-to-income ratios in most metropolitan areas have been broadly stable or have declined, price-to-income ratios have predictably increased along with declining mortgage interest rates. With rising price-to-income ratios and stable loan-to-value ratios, required down payments are becoming larger, increasing the time it takes to save for down payments, and adversely impacting housing affordability.

If house prices rapidly reflect households' ability to borrow, even well-intentioned policies that improve access to credit are likely to increase house prices and adversely impact affordability. Policy measures that increase households' capacity to borrow—such as increasing mortgage loan amortization period, making mortgage interest expenses tax deductible, or subsidizing loans—will likely put additional upward pressure on prices. Indeed, for such measures to work, the supply of housing would need to be exceptionally (and unrealistically) elastic even in the short run. As such, policy measures focused on increasing housing supply and/or reducing tax benefits associated with mortgage debt are the most likely to durably improve housing affordability in Canada in the future.

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VI.   APPENDIX -- DATA SOURCES AND TRANSFORMATIONS

House Prices Data

Multiple data sources are used to analyze house prices in selected Census Metropolitan Areas (CMAs) in Canada, but the main resource is the RPS Real Property Solutions, LLC, (RPS) database[11] with house prices in Canadian dollars. This database is at monthly frequency, available back to 2005M1, see RPS (2017) for details of the methodology of estimating the median house prices. The RPS dataset is extend as far back as 2000M1 using the dynamics of house price indices from the Teranet database. The RPS and Teranet database dynamics in the overlapping sample are similar, however, with the dollar values of the Teranet indices not available.

Income, Population, and Other Data

Income data for the assessment of house prices should match well the information about the dwelling concerned (aggregate, house, condo), its size, and the likely demographic demanding the dwelling. The analysis uses the pre-tax median income of a family for which annual estimates are available. To work with household median income, the levels of the family income are scaled to household income levels from the 2016 Consensus for each CMA. The annual numbers are interpolated to quarterly frequency in 2000–2016 and extrapolated to the end of 2018 using the disposable income dynamics for the province as an auxiliary series. The results are rather robust to the use of alternative measures of household income.

The choice of the demand unit is mainly relevant to the level of income, less so for its dynamics. The median family income is higher than the median household income in Canada. The composition matters – in 2016 the median pre-tax income of a "couple family with or without children" was $89,610. This is 58 percent higher than the "all family units" income and higher than "lone-parent" families. The dynamics of median family income are converted to median "household" income using the income levels from 2016 Census. Population data are sourced from Statistics Canada via Haver Analytics database. For 2018, the annual series were extended by the monthly three-month averages of population estimates from Labor Force Survey, via Haver Analytics. The average size of the household is based on 2016 Census (Statistics Canada, Census Profile).

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[11] RPS Real Property Solutions provided the database free of charge for this analysis. **Terms of Use and Disclaimer:** All rights reserved. Any reproduction or distribution with respect to the content of the RPS House Price Index is prohibited. The information provided herein is for informational purposes on matters of general interest, and is not intended to provide the basis for investment, financial, real estate, tax or other professional advice or services. The information is derived from sources believed reliable; however, no warranties or representations are being made with respect to the information, and RPS Real Property Solutions, along with its parent companies, subsidiaries and affiliates, disclaims all liability with respect to the accuracy of the information. The information is not a substitute for the advice of a qualified professional.
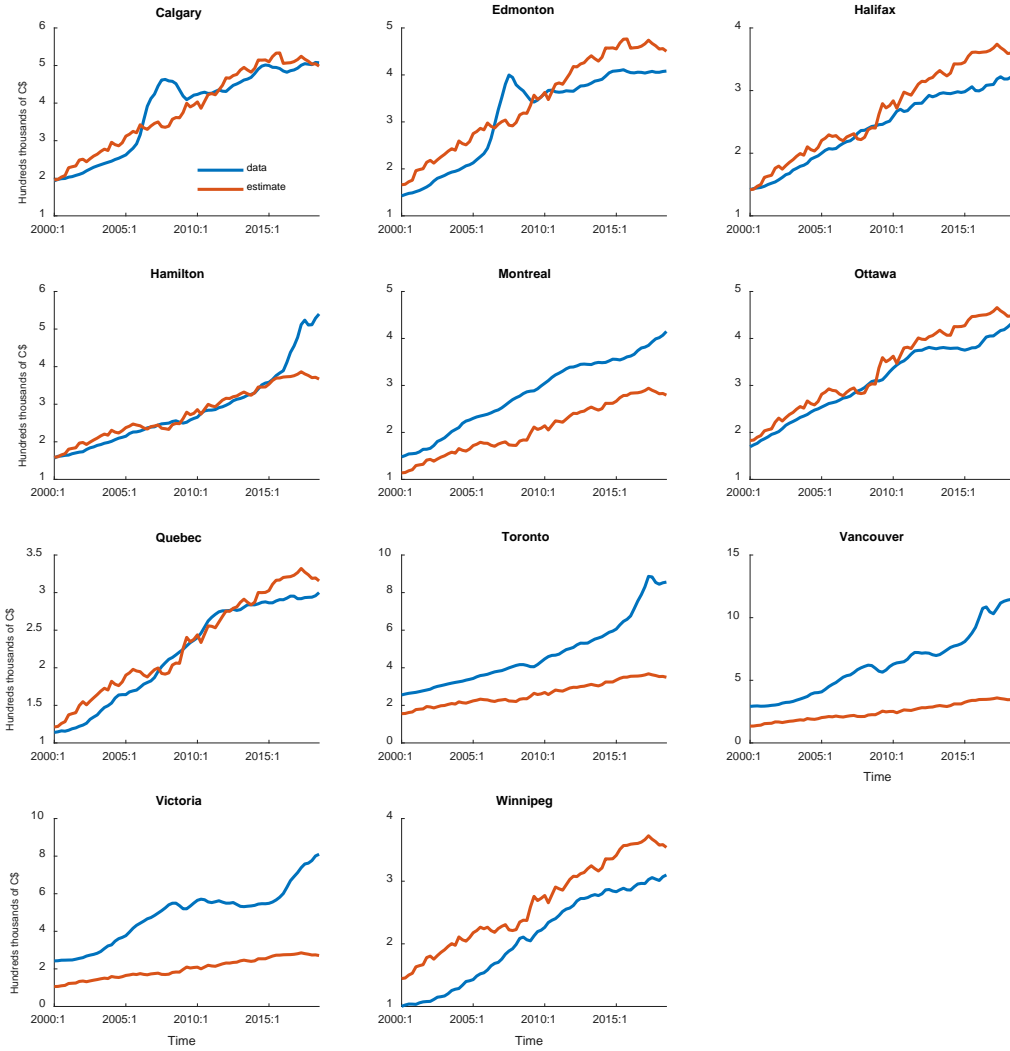
Appendix – Additional Results

Figure 4: House Prices: Aggregate, Condos, and Single-Detached Family House
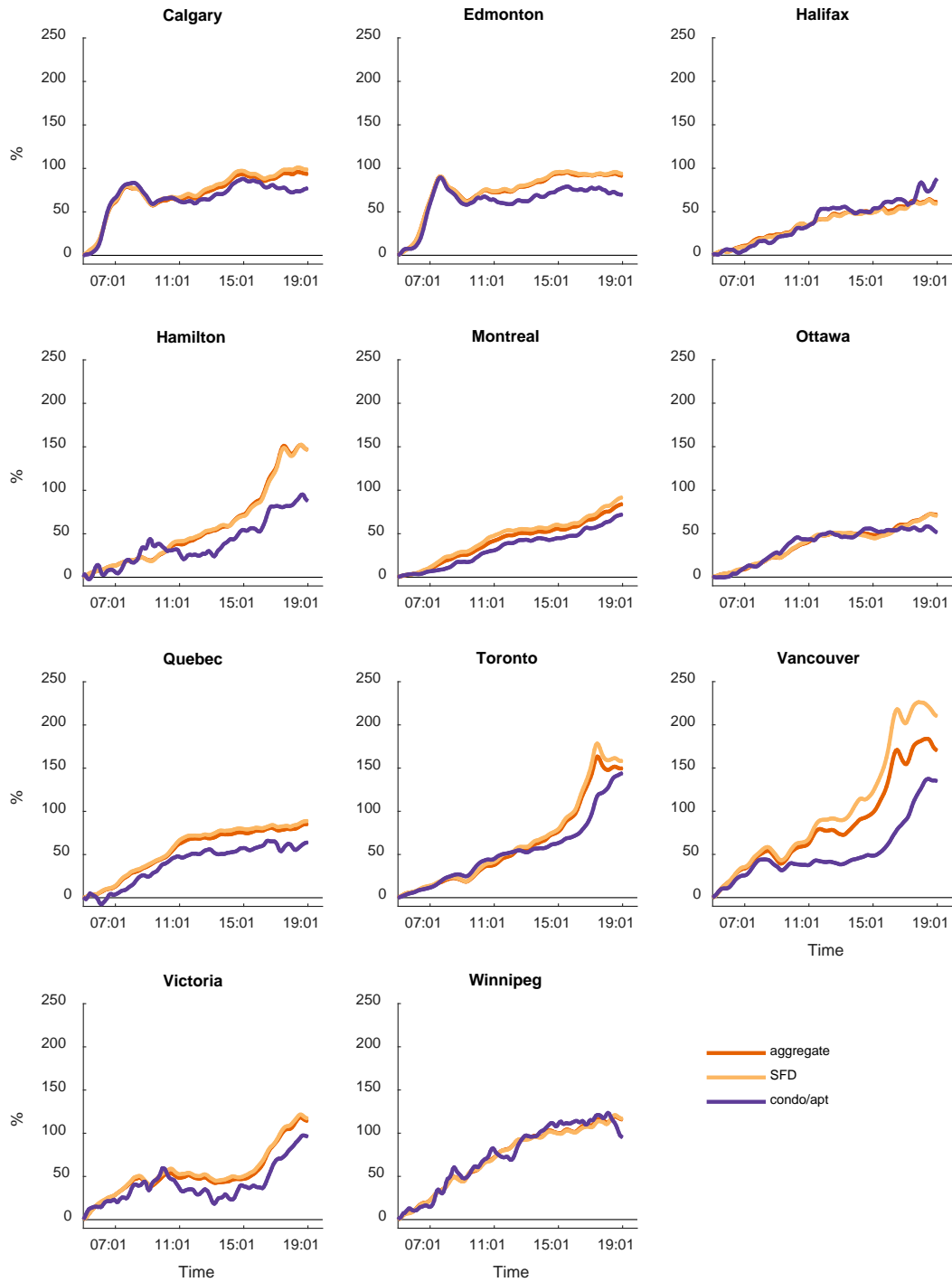
Note: Percent increase since May 2005. SFD = Single Family Detached house
Source: RPS-Real Property Solutions, LLC.

Figure 5: Uniform LSTI, α = 30 Percent of after-tax household income

Source: RPS-Real Property Solutions, LLC., Tera Net, Statistics Canada