The Integrated Housing Model (IHM):

Technical documentation

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Introduction

Background

Canada Mortgage and Housing Corporation's (CMHC) report on Canada's housing supply shortages released in 2022 has taken initial steps to estimate how much additional supply would be required to restore affordability by 2030. This report demonstrated the feasibility of using econometric modeling to estimate how much housing is required at the provincial level to address housing affordability.

However, further modelling developments were needed to quantify supply gaps at the metropolitan regions level (i.e., Census Metropolitan Areas, CMA) and accounting for the impact of an increase in housing supply on population mobility, household formation, the rental sector and ownership rates.

A more comprehensive housing framework has recently been developed: the **Integrated Housing Model (IHM).** This framework is inspired by the approach outlined in Meen et al. (2005), Meen et al. (2008) and Meen (2011).[1]

Purpose and scope

This document introduces the IHM. This new model is a forecasting framework that has originally been developed to assess the level of supply required to restore affordability in the 6 largest CMAs (Toronto, Montréal, Vancouver, Calgary, Ottawa-Gatineau, Edmonton) and 10 provinces. It considers the key interactions between house prices, housing supply, inter-regional migration, household formation and economic factors.

In addition to greater geographical detail (16 regions), the complexity of the IHM is significantly greater than the prior analytical framework. For instance, the model captures that improvements in affordability in a given region can influence positively:

- individuals to form households
- households to move from renting to homeownership and
- population inflows into that region to benefit from reduced prices and increased housing availability

This increased demand, in turn, puts upward pressures on house prices and mitigates the improvement in affordability. Consequently, larger increases in housing supply are necessary to achieve predefined affordability price targets. Ignoring these key interactions likely leads to overstate the impact on affordability of an increase in supply. Household formation, ownership rates and population mobility are therefore determined within the IHM and respond to changes in housing and economic factors.

[1]The Meen's modeling framework was originally developed in 2005. The model was subsequently extended, and the 2008 and 2011 papers cover these additions.

The IHM also allows:

- to consider the implications of increasing supply on the rental sector by projecting rents and rental market affordability
- to assess how supply improves affordability for households with different income levels, both in the owner-occupied and rented sectors and
- to breakdown by tenure (own vs. rent) the projected additional number of units required to reach predefined affordability price targets

The IHM is more than a supply gap model

The IHM is a hybrid model: it combines macro reduced-form models (in the form of an error correction representation) with probit models relying on microdata. This allows to project both the short-term dynamic and longer-run paths of key housing and demographic variables for 6 CMAs and 10 provinces. Such variables include house prices, rents, migration flows, population, household formation, ownership rates, tenure choices, housing starts, housing stock, etc.

The IHM is an integrated framework designed for forecasting and shock scenario analysis. In addition to "supply gap" estimations, the IHM can be used to perform a broad range of different economic, demographic and policy shock scenarios to support other functions at CMHC. Its hybrid design allows for a reliable and consistent modeling of the housing system.

Moreover, the micro features of the IHM allow to project households and their distribution across tenures (own vs. rent) at a very detailed level. This can be used to assess the effects of different economic, demographic and policy shock scenarios on the future demand for housing for many different individual and household types.

Interactions are central to the IHM

The interactions between housing, economic and demographic variables in the IHM create a system similar to an equilibrium model.

Accounting for key interconnections between variables have important benefits. When implementing a change on any variable in the model, feedback effects ensure all the endogenous variables will adjust to create a new equilibrium. This is of utmost importance when performing projections and shock scenarios. This structure allows to understand key interactions between variables and regions and the transmission channels of the shock through the model. It allows to investigate in a consistent way the impacts of various movements or shocks in the system.

Structure of this document

The first chapter (Chapter 1) provides a model overview, beginning with the theoretical motivation and then focusing in more detail on central features of the econometric model structure that are responsible for the main model's simulation properties.

Chapter 2 clarifies important features of the IHM when it comes to estimate the required level of supply to achieve predefined affordability price targets. In particular, it provides a short technical rationale to identify key differences between the IHM and the demographic approaches that are often adopted to estimate supply gaps.

The central properties of the IHM are explored through two projection scenarios in Chapter 3, beginning with the base projection scenario (what we call the business-as-usual) and then describing in detail the effect on key variables if increasing housing supply (beyond business-as-usual) to achieve over the next decade affordability levels last observed in 2019.

Sensitivity scenarios are performed in Chapter 4 to examine how sensitive the results presented in Chapter 3 are. To illustrate how the IHM can be used in the future to conduct a broader range of economic and demographic scenarios, the impact of improving productivity in the construction industry on affordability is also described in this fourth chapter.

The appendices describe the sub-models underlying the IHM: house prices (Appendix 1), housing starts (Appendix 2), inter-regional migration (Appendix 3), population (Appendix 4), household formation (Appendix 5), tenure choice (Appendix 6) and rent (Appendix 7) models.

It also discusses in more detail the exogenous economic variables (Appendix 8) and affordability targets developed in the owner-occupied and rental sectors, the attainable targets by income percentile and the distribution of prices, rents and income that allows to assess how additional supply impacts affordability across the income distribution (Appendix 9).

Chapter 1: Model Overview

1.1 Further modelling developments were needed

In the prior analytical framework used to support the initial report released in 2022, econometric long-run price equations for each province were estimated. Using these econometric equations, the demand for housing in 2030 was projected based on predefined affordability price targets, projected income, household numbers, and interest rates. The gap between this level of demand for housing units and the supply projected under the business-as-usual scenario generated the announced 3.5-million-unit supply gap.

However, further modelling developments were needed in order to quantify supply gaps at the CMA level, while also accounting for key interactions such as population mobility between regions. There were also other areas of the analytical approach that required enhancements.

For instance, the impact of an improvement in affordability on household formation. Lack of housing affordability has likely suppressed household formation in several regions. Quantifying the level of supply required to restore affordability means considering the relationship between household formation and improvements in affordability.

The increase of housing supply also has implications on the rental sector and ownership rates. This requires the development of explicit rent and tenure choice models that allow to project rents and ownership/renting rates.

As described later in Chapter 3, projected ownership/renting rates can be used, under simplifying assumptions, to break down by tenure (own vs. rent) the additional number of units required to achieve predefined affordability price targets.

1.2 Theoretical motivation and model selection

The first objective when developing the IHM was to estimate the level of housing supply required to meet predefined regional affordability price targets, considering the interactions between house prices, supply, inter-regional migration, household formation and the economic environment. However, it also had to provide a consistent structure for forecasting and shock scenario analysis to support other functions at CMHC.

As a result, it was also necessary to build a reliable housing model:

- to project both the short-term dynamic and longer-run paths of key housing and demographic variables and
- to assess the effects of different economic, demographic and policy shock scenarios on these variables

A more complex and comprehensive housing model was therefore needed. After considering different options, we based our approach for the IHM on the model outlined in Meen et al. (2005), Meen et al. (2008) and Meen (2011). This model was used in England to quantify at a regional level the housing supply required to reach predefined affordability price targets and accounts for the interactions between affordability, population mobility and household formation.

The comprehensive econometric framework developed by Meen is considered a hybrid model as it combines macro time-series and micro-based models. It allows to project the short-term dynamic and longer-run paths of key housing and demographic variables.

This fine-grained modeling can be used to assess the effects of various economic, demographic and policy shock scenarios on future housing demand for different individual and household types. These key features made the Meen model a valuable reference for the IHM.

Other types of models were considered, such as dynamic-stochastic general equilibrium (DSGE) models. DSGE models rely on solid theoretical foundations, and their coefficients are usually calibrated. These models are particularly well-suited for scenario and policy analysis as the transmission channels of a given shock through the model are highly tractable.

However, DSGE models are much less useful for forecasting. This important weakness made these types of models unattractive given our needs and objectives.

Building an integrated econometric model like the one developed by Meen can be seen as a good “jack-of-all-trades model”, as it provides:

- a consistent econometric framework to produce reliable projections over the short- to long-term horizons (consistent with economic, housing and demographic fundamentals based on theory) and
- a comprehensive housing model to perform a broad range of different economic, demographic and policy shock scenarios

Such an integrated framework helps to think in a more consistent way when performing forecasts and shock scenarios. It allows to understand key interactions between variables and regions and the transmission channels of the shock through the model. Finally, model’s parameters are primarily estimated using appropriate econometric methods, which is a desirable feature in our context.

1.3 A macro structure that combines hybrid approaches

The IHM is a hybrid model combining macro time-series and micro-based models. Given its macro structure, the determinants that are formally modeled within the IHM are aggregated outcomes. Thus, some of the most important econometric equations of the IHM, like house prices, housing starts, rents and inter-regional migration rely on macro time-series data.

However, the estimation of other sub-models, like household formation and tenure choice models, requires the use of micro panel data. Inspired by the comprehensive econometric framework developed by Meen, these two sub-models in the IHM allow to estimate the probabilities of forming a household and the probabilities of being an owner or a renter at a very detailed level for a broad range of groups of individuals and households.

Since these probabilities depend on key demographic and socio-economic characteristics such as marital status, age, gender, presence of children, previous headship status, and income, their estimations rely on probit model and micro panel data. The household formation and tenure choice sub-models are the most detailed sub-models in the IHM as the estimations supporting these two models are conducted at the individual (micro) level.

Moreover, the microstructure underlying the household formation and tenure choice models, where different individual and household types respond differently to changes in housing and economic factors, allows to generate disaggregated household projections and their distribution across tenures (own vs. rent) at a very detailed level.

This important element of granularity built into the IHM can be used to assess the effects of different economic, demographic and policy shock scenarios on the future demand for housing for many different individual and household types. For instance, the IHM properly captures the fact that younger age groups and people living in unaffordable regions have overall lower probabilities to form households, but benefit the most from improvements in affordability.

1.4 Short-term vs long-run dynamics

Housing markets take several periods to clear due to some rigidities (see Di Pasquale and Wheaton, 1994 and Riddel, 2004).[2] Given they are important in determining the historical behaviour of house prices and housing starts, it is essential to use an error correction framework that accounts for these rigidities.

This is particularly important for forecasting and shock scenario analysis. As a result, the house price and housing starts models embedded within the IHM take the form of an error correction representation. The use of an error correction framework provides:

- a robust and consistent long-run relationship that delivers reliable house prices and housing starts projections reflecting their economic and demographic fundamentals (derived from economic theory) and
- a short-run dynamic that allows these two key housing variables to react to short-term shocks and deviations from their fundamental levels

Incorporating a proper error correction framework to project both the short-term dynamics and long-run movements of house prices and housing starts is a central feature of the IHM and its simulation properties.

It is important to highlight that, unlike the model developed by Meen, where housing supply is always treated as an exogenous policy variable, the IHM includes an explicit housing starts error correction model, which is fully integrated into the rest of the model[3]. This key sub-model of the IHM allows us to perform a much broader range of demographic, economic and policy scenarios that will be developed over time to consider alternative outcomes for the housing system. To illustrate potential uses, the impact of improving productivity in the construction industry is explored in Chapter 4, Section 4.2.

[2] There is a consensus in the literature that housing markets adjust slowly to changes in market conditions due to heterogeneity and search and transaction costs among other factors.

[3] Refer to Appendix 2 for a complete description of the housing starts model in the IHM.

1.5 Parameter estimations and calibrations

The IHM is mainly based on econometric estimations of the historical behaviour of key economic, housing and demographic variables, and the interactions between them. This provides a solid statistical foundation for the model by ensuring it properly captures these long-run relationships.

However, due to the imperfect nature of data and many interacting components in the model, some coefficients are calibrated to ensure consistency and stable properties when performing simulations.

This combination of econometric estimations and prudent calibrations allows to optimize the IHM model performance and usefulness.

1.6 Coverage: why breaking down Canada this way?

The IHM is currently designed to generate results for the 6 largest CMAs (Toronto, Montreal, Vancouver, Ottawa-Gatineau, Calgary, Edmonton) and 10 provinces.

Following Meen et al. (2005), each region in the IHM is linked to other regions through inter-regional migration patterns. Incorporating population mobility as an endogenous variable in the model is highly important when estimating supply gaps at the CMA level. Inter-regional migration patterns between regions (both long and short distance moves) are determined within the IHM using relative housing and economic conditions. The main factors are[4]:

- relative house price movements
- distance
- relative housing availability
- relative income and unemployment rate
- terms of trade

Explicitly modeling population mobility in the IHM directly influences the way Canada is broken down in the model. Housing market conditions are likely more important than economic conditions in determining short distance moves (Cameron & Muellbauer, 1998).

Therefore, migration flows induced by relative price movements are expected to be more important between contiguous regions. However, most CMAs are not contiguous to other CMAs.

Therefore, the IHM also needs to consider inter-regional migration flows between the 6 CMAs and the rest of their province. This imposes to model the rest of each province as well, i.e., the rest of the territory not covered by the 6 CMAs explicitly modeled in the IHM. As a result, all Canada's provinces are covered in the IHM.

Since the 6 largest CMAs are explicitly modeled in the IHM, all other CMAs are merged with non-CMA areas to form regions named 'rest of province'.

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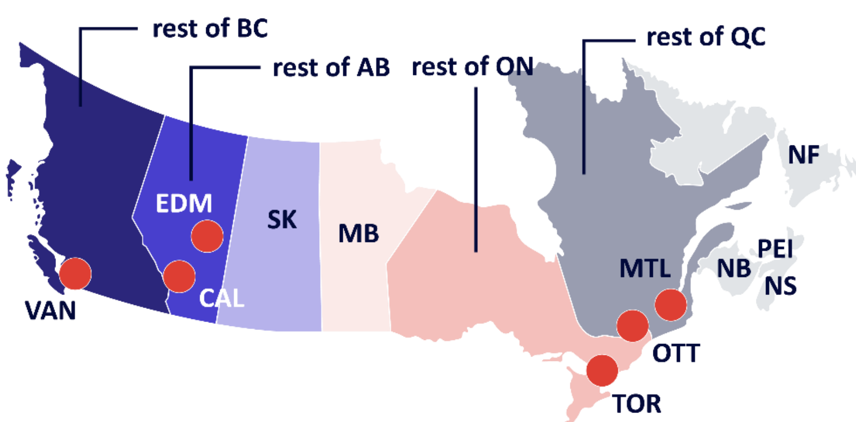
[4] Refer to Appendix 3 for a complete description of the inter-regional migration model.

As a result, Canada is broken down into 16 regions (Figure 1.1):

- Newfoundland and Labrador (NF)
- Prince Edward Island (PEI)
- Nova Scotia (NS)
- New Brunswick (NB)
- Montréal (MTL)
- Rest of Quebec (Rest of QC)
- Ottawa-Gatineau (OTT)
- Toronto (TOR)
- Rest of Ontario (Rest of ON)
- Manitoba (MB)
- Saskatchewan (SK)
- Calgary (CAL)
- Edmonton (EDM)
- Rest of Alberta (Rest of AB)
- Vancouver (VAN)
- Rest of British Columbia (Rest of BC)

Figure 1.1: 16 regions in the IHM



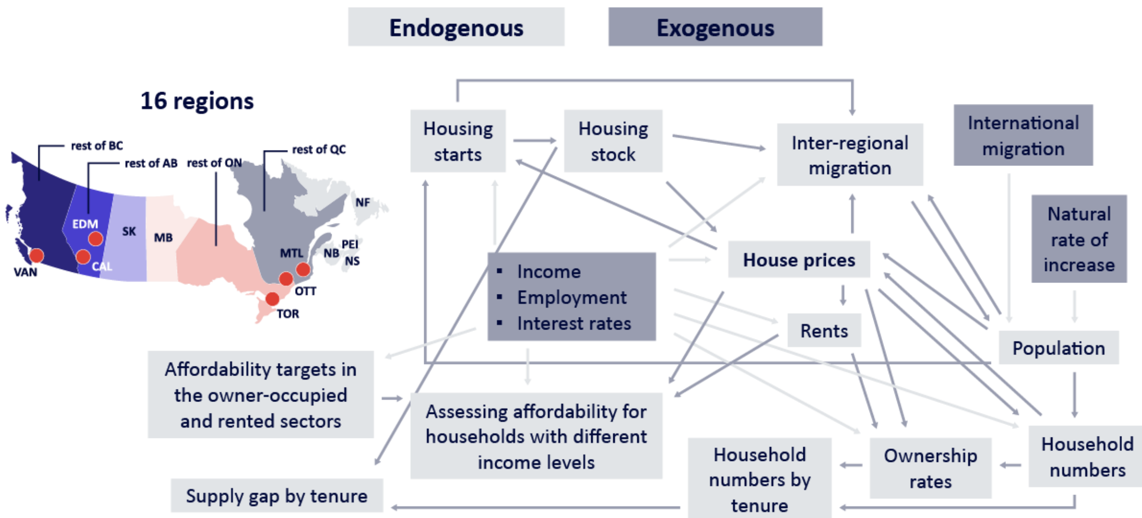
The inter-regional migration sub-model is fully integrated with the rest of the IHM. All 16 regions modeled in the inter-regional migration sub-model are also modeled in all other sub-models of the IHM. As a result, the way Canada is broken down is the same across all sub-models. This ensures consistent inter-regional migration flows and feedback effects between regions when running simulations in the IHM.

1.7 Overview of the model structure

1.7.1 Exogenous variables, micro and macro based sub-models

The main variables (inputs and outputs) of the model are illustrated in the flow chart below (Figure 1.2). This is illustrative only and does not show the whole complexity/richness of the IHM and all the technicalities/features that have been considered to develop this framework.

Figure 1.2: Flow chart of the IHM: relations between endogenous and exogenous variables



The IHM consists of a range of endogenous (light gray boxes) and exogenous (dark gray boxes) variables. As with any other model, the IHM is an oversimplification of reality. While many key elements of reality can be directly determined within the model as endogenous variables, others have to be treated as independent of the rest of the model (i.e., not determined within the structure of the model) or simply ignored.

The first main exogenous elements are economic variables. This is mainly because modeling income, interest rates and employment as endogenous variables within the IHM has not yet been possible given the timeframe for this project. Instead, these variables are projected using the Oxford Economics Global Economic Model and Canada Provincial Territorial Model. They reflect CMHC's most recent demographic and economic assumptions.

While treating these variables as exogenous is not ideal, it is likely not having a large impact on the model results. For instance, Meen (2011) explicitly models the labour market, but clearly states that feedback effects from housing to the labour market are relatively weak.

The assumption that feedback effects from housing to economic factors are small and their influence on simulation results are negligeable is realistic for most of the economic, demographic and policy shock scenarios performed in the IHM.

However, the assumption that economic factors are unresponsive to changes in housing variables becomes more difficult to justify under scenarios that imply a sharp decline in house prices triggered by a major adverse event.

For example, a global economic downturn leading to widespread unemployment and mortgage defaults, where the ability of households to continue to service their debt is dramatically affected. The assumption that economic factors are unresponsive to housing becomes a clear limitation of the IHM if performing such shock scenarios.

The other main exogenous elements in the IHM are part of the demographic framework. As in the Meen's model, projections of birth, death and international migration rates are taken from official sources, i.e., they are not determined within the model.

More specifically, a custom version of Statistics Canada Centre for Demography's population projections specially requested for CMAs and non-CMA areas. This is an assumption that can be made as the responsiveness of these variables to housing variables are likely small and so is the impact on the overall results[5].

Most (but not all) of the endogenous variables (light gray boxes) are the result of an econometric exercise and are formally modeled. Some of them, like house prices, housing starts, rents, and inter-regional migration models rely on macro time-series data. However, the estimation of the household formation and tenure choice models rely on probit model and micro panel data to estimate household formation and the probabilities of being an owner or a renter at a very detailed level for a broad range of groups of individuals and households.

1.7.2 Key interconnections between variables/regions in IHM

All the arrows illustrated in the flow chart above (Figure 1.2) illustrate the key interactions between all endogenous and exogenous variables in the IHM. They show the important inter-linkages between key determinants (housing, economic and demographic variables) and between regions (through inter-regional migration patterns) which bring them together as an integrated whole. These interconnections are central to the IHM.

Given all interactions and feedback effects between variables and regions, the IHM is an equilibrium environment. The model is built such that every endogenous variable is directly and/or indirectly influenced by all the other components of the model. When implementing a shock on a variable, there are feedback effects between explicitly modeled variables and regions in the model.

These key interactions can be grouped into 2 main categories examined in the following sections:

- the demographic block, and
- the housing block.

[5] The data in the Oxford framework is adjusted to reflect the latest CMHC demographic projections.

1.7.2.1 *Demographic block: inter-regional migration, population and household formation*

Regional population projections are determined by the natural population increase, as well as the inter-regional and international migration.[6] Birth, death and international migration rates are exogenous, but not population mobility between regions which depends on relative housing and labour market conditions. As a result, any shock in the model impacting inter-regional migration flows generates population projections differing from the counterfactual scenario.[7,8]

Population estimates, housing costs and other economic factors such as income and the unemployment rate affect household formation projections via the impact on headship rates. The household formation model within the IHM determines household formation probabilities at a very detailed level for a broad range of groups of individuals (400 groups in total for each region). These different groups of individuals respond differently to changes in housing and economic factors. This is possible given the nonlinearity of the probit regression function.

Household formation probabilities depend on demographic factors, e.g., age, gender, marital status, the presence of children, as well as housing and economic variables like housing costs, income and unemployment rate.

These probabilities are then multiplied by the projected number of individuals in each group in order to estimate the total number of households in each group for each region[9]. Household projections for all groups are then aggregated to form the total number of households (a key determinant of housing demand) to feed into the house price model.

Like the model developed by Meen et al. (2005), household formation probabilities (headship rates) vary over the projected period with changes in housing and economic variables, such as housing costs (function of house prices and mortgage rates), income and unemployment rate. As a result, any shock in the model that affects household formation probabilities generates different household projections relative to the counterfactual scenario. More precisely, household formation is endogenous via two key channels in the IHM:

- the direct effect on headship rates captured by the household formation model and
- the indirect effect on population mobility captured by the inter-regional migration model, which feeds into the population framework and then into the household formation model.

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[6] There is an important element of heterogeneity in the population model built into the IHM, which is the differential exposure to international migration. For instance, when performing shocks on national immigration rates, the population changes more in centers that are more exposed to immigration, like Toronto, Vancouver, and Montréal and in younger age groups as immigrants are typically in the first-time homebuyer's bracket. Refer to Appendix 4 for a complete description of the population framework.

[7] Although birth and death rates are exogenous in the IHM, endogenous population mobility can affect the natural increase for a given region. For example, when a region with high house prices and low natural increase, such as Toronto, experiences a surge in house price growth, the net outflow to a region with low house prices and high natural increase, such as Edmonton, rises. As a result, the total natural increase will be higher than in the counterfactual scenario in which the house prices grew more moderately in the high house price region.

[8] It is important to mention that endogenous migration flows projected by the inter-regional migration model are aggregated values (for all ages), so they need to be distributed by age before feeding into the population framework. The complete approach to break down inter-regional migration flows by age is detailed in Appendix 3.

[9] Refer to Appendix 5 for a complete description of the household formation model.

1.7.2.2 Housing block: house prices, housing starts, rents and ownership rates

The number of households, the stock of housing, the housing user cost of capital, the household income and the share of population aged 25-34 (a key demographic group supporting new housing demand) affect house prices,[10] which in turn impact housing starts. Because higher house prices provide an incentive to build new houses and/or maintain the existing stock of housing, they have a positive influence on new residential investment.[11]

Housing starts also depend on other factors such as the output gap,[12] the cost of labour and the short-term interest rate. This latter is used as a broad measure of short-term financing costs faced by housing developers. The cost of labour and the short-term interest rate have a negative effect on residential investment since they reduce profits of housing developers for a given level of house prices.[13]

In turn, housing starts also affect house prices via the effect on the housing stock. They also affect inter-regional migration flows both by reducing relative housing costs and by increasing housing availability, which in turn affect population and household formation projections.

The rental sector is also modeled in the IHM. The future path of average rents is projected separately from house prices.[14] Both respond to changes in supply and demand and to each other. But their paths can diverge because they react differently to changes in other variables such as the mortgage rate.[15]

Changes in ownership costs (function of house prices and mortgage rates) relative to rents affect in turn ownership and renting rates, which also depend on other economic factors. The tenure choice model within the IHM determines the probabilities of being an owner or a renter at a very detailed level for a broad range of different household groups (200 groups in total for each region). Different household types respond differently to changes in housing and economic factors as a result of the nonlinearity of the probit regression function.

These tenure choice probabilities depend on demographic factors such as gender of the household head, age of the head, presence of children and marital status as well as housing and economic variables such as relative costs by tenure, income, unemployment rate and credit restrictions. These probabilities are then

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[10] Refer to Appendix 1 for a complete description of the house price model.

[11] The price elasticity of new housing supply, which represents the responsiveness of housing starts to price changes, is key to the IHM's properties. This elasticity is close to reported estimates in the literature as outlined in the Appendix 2 that describes the housing starts model.

[12] The output gap is defined as the difference between the actual GDP and potential GDP.

[13] As mentioned earlier in Section 1.4, unlike the model developed by Meen (2011) where housing supply is always treated as an exogenous policy variable, the IHM includes an explicit housing starts error correction model, which is fully integrated into the rest of the model. This key sub-model of the IHM allows us to perform a much broader range of demographic, economic and policy scenarios that will be developed over time to consider alternative outcomes for the housing system. To illustrate potential uses, the impact of improving productivity in the construction industry is explored in Chapter 4, Section 4.2.

[14] The data on rents and house prices are different concepts in the IHM. Unlike average house prices which instantly reflect the transactional value of properties that were sold, the average rents variable in the IHM capture the cost of all units, i.e., the contractual rent of currently occupied units, and the listed rent of vacant units. As only a fraction of rental units turns over to new tenants each year, changes in listed rents have a limited impact on overall rent measures in the short-term.

[15] Refer to Appendix 7 for a complete description of the rent model.

multiplied by the number of households in each group (obtained from the household formation model) to get the distribution of households across tenures.[16]

Like household formation probabilities (headship rates), the probabilities of being an owner or a renter vary over the projected period with changes in housing and economic variables, such as tenure relative costs, income, unemployment rate and credit restrictions.

As a result, any shock in the model that affects the probabilities of being an owner or a renter generates different ownership and renting rates and a different distribution of households across tenures relative to the counterfactual scenario.

[16] Refer to Appendix 6 for a complete description of the tenure choice model.

Chapter 2: Key implications and model properties when estimating supply gaps with the IHM

This chapter presents important features of the IHM when using the model to estimate the level of supply required to achieve predefined affordability price targets. In particular, it details the implications for different model components of increasing housing supply, and it explains how the IHM differs from the demographic approaches commonly used to estimate supply gaps.

2.1 Key implications of increasing housing supply in the IHM

This section explores the implications on household formation, population mobility, second homes and vacancies when housing supply is exogenously increased in the IHM. By design, this scenario assumes that the government has the capacity to significantly increase housing supply like a policy instrument to meet predefined affordability price targets.

This means that housing supply is exogenously increased in all 16 regions according to their respective predefined affordability price targets. That is, the housing starts model is muted and not part of the long-run adjustment process in the IHM housing system. In other words, following the shock on housing supply, feedback effects from the overall model on housing starts, like changes in house prices, are shut off.

In reality, housing supply responds to changes in house prices. Lower house prices provide a disincentive to build new homes and have a negative influence on new residential investment, which lowers housing starts. These interactions are properly captured by the IHM when performing "real life" economic, demographic and policy shock scenarios such as productivity improvements explored in Chapter 4, Section 4.2.

But in the case of supply gap estimations, the objective is to isolate the impacts of additional supply on house prices. Turning off the housing starts model is what allows to measure the theoretical number of units that, if they existed, would have created a world where house prices meet predefined affordability price targets.

Depending on the selected targets, this number of additional units isn't necessarily going to be realistic or even desirable from the perspective of building capacities, allocation of economic resources, public finances, etc. This exercise is meant to illustrate the magnitude of affordability challenges.

Except for the feedback effects on housing starts which are muted, all other components of the IHM are active when using the model to estimate a supply gap. In particular, there are key implications of additional housing supply for household formation, population mobility and second homes and vacancies.

2.1.1 Increasing housing supply in the IHM: implications on household formation

In response to an increase in housing supply, the decrease in house prices influences positively new household formation as it affects the decisions of individuals to form households through the positive effect on headship rates.

Since the number of households is a key determinant of housing demand and house prices (via the price equation in the IHM), this increased demand puts upward pressures on house prices and mitigates the improvement in affordability. Consequently, larger increases in housing supply are necessary to achieve predefined affordability price targets.

Without considering this key mechanism, the effect of an increase in housing supply on affordability is overestimated. For that reason, household formation is determined within the IHM with endogenous reactions to housing costs and other key economic factors.

2.1.2 Increasing housing supply in the IHM: implications of an unbalanced scenario on population mobility

Increases in housing supply targeted exclusively at one region generate relative price changes and migration inflows into that region from people taking advantage of reduced prices and increased housing availability. This increased housing demand, in turn, puts upward pressures on house prices and partly offsets the improvement in affordability (Meen et al., 2005).

As a result, a larger increase in housing supply is necessary to meet the affordability price target in this region. This illustrates why incorporating the effect of population mobility is so important when estimating a supply gap at a more regional scale.

Therefore, if a policy objective is to achieve affordability in a given region by targeting housing supply in only one region, the required level of units in this region to restore affordability is higher than the required level under a scenario where supply is increased in a more balanced way across all regions. A more balanced scenario limits the effect on relative prices and reduces the impacts on migration flows between regions (Meen et al., 2005).

At the same time, this also implies that the number of units required to restore affordability for a given region under a balanced scenario is conditional to the fact that supply is expanded in all regions according to their respective predefined affordability price targets.

This has important policy implications: it highlights the need for coordination between regions to address affordability challenges in Canada. If all regions work together, especially the contiguous ones, the number of units required to achieve affordability will be lower in each region.

2.1.3 Increasing housing supply in the IHM: implications for second homes and level of vacancies

A significant increase in housing supply to meet predefined affordability price targets impacts household formation via the direct effect on headship rates. More individuals take the decision to form a household when the level of affordability increases.

However, even with this induced increase in household numbers as housing costs decrease in response to increased supply (what we can call the supressed household formation), the growth in housing units must be superior to the expected growth in the number of households to improve affordability.[17]

By design, the IHM accounts for the increased demand from existing households in addition to suppressed household formation when estimating the impacts of additional supply on prices (see next Section 2.2).

As a result, when aiming to restore affordability in the IHM by reaching predefined affordability price targets, the net additions to the stock are superior to the expected growth of household numbers.

Consequently, under a well-functioning housing system that improves affordability, the new equilibrium level of vacancies is expected to be higher than in the past when there were housing supply shortages (Meen et al., 2005).

Note that second homes, vacancies, conversions and demolitions must also respond to resulting changes in prices and housing availability. For that reason, in the Meen model, these variables are endogenous and part of the long-run adjustment process in the housing system. This ensures that the identity below, which links expected increases in household numbers to net additions to housing stock, holds in the context of affordability targets (Meen et al., 2008).

ΔNumber of households = New house construction - ΔSecond homes – ΔVacancies + Conversions – Demolitions

However, these variables are not explicitly modeled in the current version of the IHM. This work is still underway, and the plan is to integrate this into the model at a future stage. Consequently, the current version of the IHM implicitly assumes that the level of vacancies and second homes increases with the level of affordability, without explicitly quantifying them.

2.2 Supply gap estimations: differences between the IHM and demographic approaches

Demographic approaches, given their simplicity, are commonly used to estimate supply gaps. In general, these approaches are primarily interested in a single straightforward question: "how many households would have formed if attainable housing options had existed". For example, if headship rates were the same as those observed in more affordable regions, or during a period where house prices were more affordable.

[17] Even when the affordability target is reached, only matching housing supply to the number of households does not ensure stabilisation of affordability in the IHM as discussed later in Section 2.3.2.

While convenient, these approaches fail to consider two fundamental components modeled in the IHM: housing affordability and changes in housing demand. This section identifies key differences between the IHM and demographic approaches, and their implications on supply gap estimations.

2.2.1 Demographic approaches understate supply gap estimates

Demographic approaches imply that if all suppressed households get a roof over their heads, then the need for housing is addressed and there is no more unmet demand in the market. “Housing need” in the context of demographic approaches solely focus on the 1:1 adequation between the number of potential households and the number of dwellings. However, housing need is not the same as housing demand.

Housing demand is the total amount of housing economic agents wish to consume both in terms of quantity and quality, which fluctuates based on economic conditions. Housing demand can be (and is) greater than the number of potential households. What matters in order to meet specific predefined affordability price targets is housing demand (Meen et al., 2005).

By targeting housing need, demographic approaches consider exclusively potential demand from “suppressed households” and ignore changes in housing consumption from existing households. These approaches estimate household gaps, not supply gaps. As a result, demographic approaches yield the following equality:

Required additional supply to meet housing need = Suppressed households

Demographic approaches also fail to specify housing affordability targets: by targeting housing need rather than a predefined affordability price targets, demographic approaches assume that the increase in housing supply required to match the estimated number of suppressed households is sufficient to lower prices and allow all suppressed households to form.

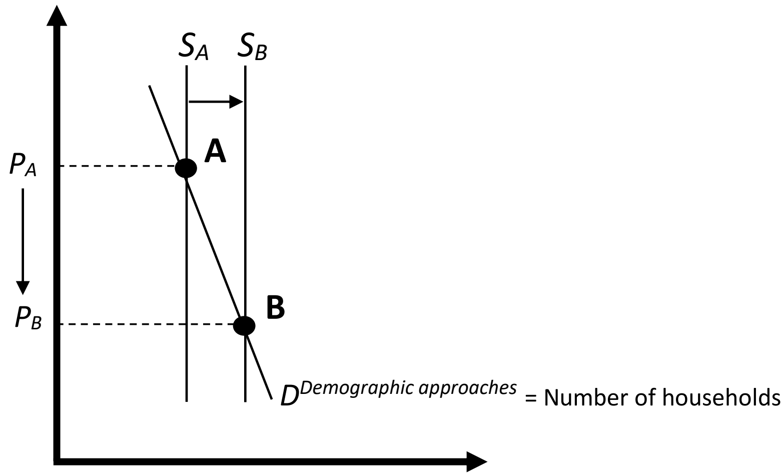
In other words, demographic approaches assume that any additional increase in housing supply has to be matched by the exact same increase in the number of households to restore equilibrium.

In contrast, the IHM is an economic model which makes use of explicit affordability targets, and models key interactions between house prices, construction, migration patterns, household formation, labour market, etc. By design, the IHM implicitly accounts for the increased demand from existing households in addition to suppressed household formation when estimating the impacts of additional supply on prices.

As a result, when aiming to restore affordability in the IHM by reaching specific predefined affordability price targets, the net additions to the stock must be superior to the expected growth of household numbers.

Central to the demographic approaches is the assumption that the demand curve is inelastic ($D^{Demographic\ Approaches}$ in Figure 2.1) as they consider exclusively potential demand from “suppressed households” and ignore changes in housing consumption. This has important implications (see Section 2.3.1.4). If any additional increase in housing supply (S_A to S_B in Figure 2.1) had to be matched by an increase in the number of households to produce an equilibrium, then any modest additional increases in housing supply would generate a large decrease in house prices (Meen, 2005), which does not align with reality.

Figure 2.1: Additional supply dynamics - Demographic approaches



But the world described above ignores the effect of house price changes on the housing demand from households already formed, which must also be considered (Meen et al., 2005). Failing to account for this implies higher prices and worsening affordability. That is, the modest additional increase in housing supply which is required, according to demographic approaches, to match the estimated number of suppressed households is in fact not enough to restore affordability and allow all suppressed households to form.

As noted by Meen et al. (2005), increasing demand from existing households is not just a question of buying second homes. With lower prices, existing households can trade their current dwelling for another one of better quality (e.g. a bigger house and/or a better neighbourhood) and can consume more housing services. This means that the demand for housing services can increase even when there is no net change in terms of the number of housing units demanded (Meen et al., 2005).

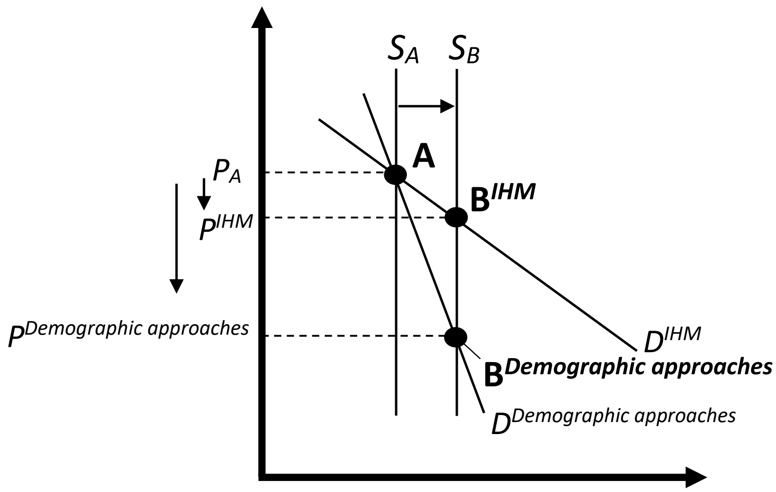
Changing demand from existing households also includes changes in tenure. With lower house prices, it is likely that more young households would become owners rather than renters. This group is, in fact, important for helping the filtering process at the bottom end of the market (Meen et al., 2005).

All these factors that affect the demand for housing services are of crucial importance when estimating the impacts of additional supply on prices and must be taken into account. With lower prices, the demand for housing services from existing households also rises and total demand increases even if there is no increase in the number of households. This increased demand for housing by existing households induced by lower prices is not captured by demographic approaches. Consequently, they understate supply gap estimates.

In the IHM, by accounting for the increased demand from both existing households and new households being formed (i.e., supressed households) when estimating the impact of additional supply on house prices, a more elastic demand curve is assumed (D^{IHM}) relative to demographic approaches ($D^{Demographic\ approaches}$ in Figure 2.2).

As a direct result, for a same additional increase in housing supply (from S_A to S_B in Figure 2.2), the IHM implies a smaller drop in house prices relative to demographic approaches ($P^{IHM} > P^{Demographic\ approaches}$). Therefore, the net addition to the housing stock needs to be larger in the IHM to improve affordability.

Figure 2.2: Additional supply dynamics between IHM and demographic approaches



2.2.2 Demographic approaches likely understate household gap estimates (suppressed households) over a projected period

A supply gap can be measured as of today or assessed from the perspective of a future point in time. It is useful to look at supply shortages over a longer-term horizon, as by the time additional supply is delivered to the market, the demographic and economic environment will have changed, and housing demand will not be the same.

By targeting current housing need based on historical data rather than specific affordability targets based on projections of the future, demographic approaches implicitly ignore the fact that as income rises over time, existing households demand a higher quantity of housing services through more demand for higher-quality homes than they currently hold. This implies higher house prices and worsening affordability over the projected period (see Section 2.3.2).

Demographic approaches often rely on historical data, such as headship rates measured in the Census, to project the future number of households. But in a region where affordability is projected to worsen, future headship rates are likely going to be lower than they were in the past. There will be more suppressed households than suggested by projections of historical headship rates. As a result, relying on historical data understates projected household gaps (suppressed households) in the region.

2.3 Key elasticities when estimating supply gaps

Among all parameters of the IHM, 2 key elasticities have a crucial impact on supply gap estimations:

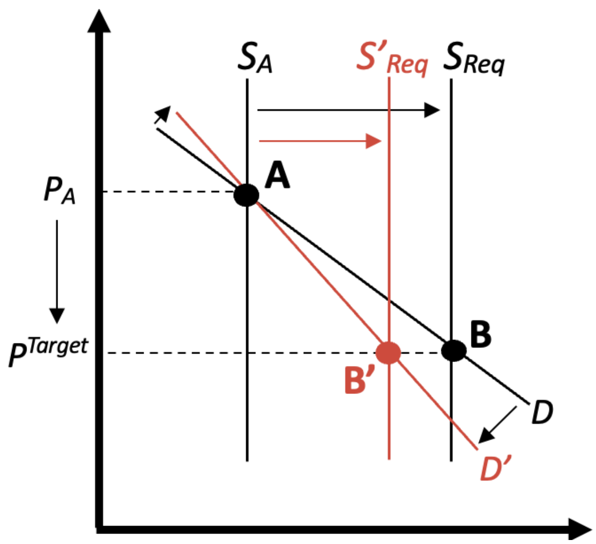
- the price elasticity of housing demand; and
- the income elasticity of housing demand

The price elasticity represents the elasticity of the demand curve. It captures the changes in housing demand from existing households and new household formation induced by variations in house prices.

This price elasticity has a major impact on supply gap estimations. For instance, a lower price elasticity of demand in the IHM would make the demand curve less elastic (red demand curve *D′* on Figure 2.3). That is, as supply increases from the supply curve S_A to the red supply curve S'_{Req} (Figure 2.3), the increased demand from existing households and new households being formed given lower house prices would be reduced.

For that reason, it would require fewer additional housing units (difference between **B′** and **B** on Figure 2.3) to reach the predefined affordability price target P^{Target}.

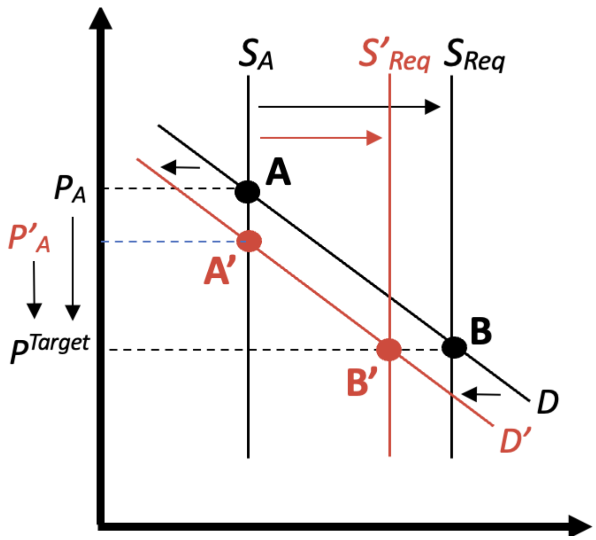
Figure 2.3: Implication of reducing the price elasticity of demand in the IHM



As for the income elasticity of housing demand, it captures the changes in housing demand from households following variations in income. This elasticity also has important implications on supply gap estimations. For instance, a lower income elasticity of demand would imply a lower increase of housing demand from households as their income rises. This means a movement of the demand curve to the left from *D* to *D′* (Figure 2.4).

This lower demand for housing would reduce the projected prices, from P_A to P'_A. The new equilibrium would go from **A** to **A′**. Reducing the income elasticity of demand would reduce the number of additional units required to reach the predefined affordability price target P^{Target} in the future (difference between **B′** and **B** on Figure 2.4) as housing supply would only increase from S_A to S'_{Req}.

Figure 2.4: Implication of reducing the income elasticity of demand in the IHM



Section 2.3.1 further details the price elasticity of demand and its two components: the price elasticity of demand from existing households, and the price elasticity of household formation. It also presents their implications for house prices and for the proportion of additional housing units taken up by new households being formed when supply is increased in the IHM.

Section 2.3.2 focuses on the income elasticity of housing demand and its implication on affordability if supply was only matched to the number of households (the need) over time.

2.3.1 Price elasticity of housing demand in the IHM and its implications for supply gap estimates

The price elasticity of housing demand is decomposed into two price elasticities in the IHM:

- the price elasticity of housing demand from existing households
- the price elasticity of household formation

Section 2.3.1.1 and Section 2.3.1.2 below describe these two price elasticities. Section 2.3.1.3 presents how they combine into the total price elasticity of demand. Section 2.3.1.4 illustrates the importance of using the total price elasticity of demand in the IHM. Section 2.3.1.5 discusses the low proportion of additional housing supply taken up by new households in the IHM.

2.3.1.1 Price elasticity of housing demand from existing households

The IHM models an aggregated economic demand (*D*) which is function of its traditional determinants: real income (*Y*), real house prices (*P*), the number of households (*HH*) and other relevant determinants of housing demand, so we have:

$$D = f(Y, P, HH, \text{other determinants}) \quad (1)$$

To simplify the discussion and to make things more concrete, let us first assume that the relationship between fundamental determinants of housing demand in equation (1) is a specification that is additive in logarithms, so that we can express the aggregated long-run housing demand as:

$$d = \alpha_0 + \alpha_1 y - \alpha_2 p + \alpha_3 hh + \text{other determinants} \qquad (2)$$

with lower case letters denoting variables in log-form and α_i representing coefficients associated with demand fundamental determinants. The price elasticity of housing demand is denoted by the coefficient $-\alpha_2$. This elasticity corresponds to the change in the demand for housing services from existing households following variations in house prices.

For instance, lower house prices as a result of additional supply can lead existing households to demand a higher quantity of housing services than they currently hold. This might imply buying a second home, upgrading to a larger house, moving to a better neighborhood or transitioning from renting to owning. This price elasticity of housing demand is estimated to be about –0.4 in the IHM, which is in line with Meen et al. (2005).

2.3.1.2 Price elasticity of household formation

The number of households is endogenous in the IHM. It responds to changes in house prices (*P*) and other economic factors such as income (*Y*). The estimation of the household formation equation relies on a probit model and micro panel data that allows to estimate household formation probabilities (headship rates) for 400 groups of individuals in each region.[18] To facilitate the discussion and to clarify further, let us assume a log-log relationship between fundamental determinants of household formation, so that we can express the household formation model this way:

$$hh = \theta_0 + \theta_1 y - \theta_2 p + \text{other determinants} \qquad (3)$$

with lower case letters denoting variables in log-form and θ_i representing coefficients associated with fundamental determinants of household numbers. The price elasticity of household formation is indicated by $-\theta_2$.[19] For instance, lower house prices in response to additional supply can influence positively the decisions of individuals to form households in the IHM.

This elasticity is estimated to be about –0.1 in the IHM, varying from –0.05 to –0.13 in more expensive regions like Vancouver (Figure 2.5). Essentially, a price elasticity of –0.1 means that a 10% decrease in house prices in a given region increases its number of households by 1% relative to the counterfactual scenario (ceteris paribus). These results are consistent with Meen et al. (2005).

The larger price elasticity of household formation in unaffordable regions like Vancouver and Toronto stems from the nonlinearity of the probit regression function in the household formation model. Because of this

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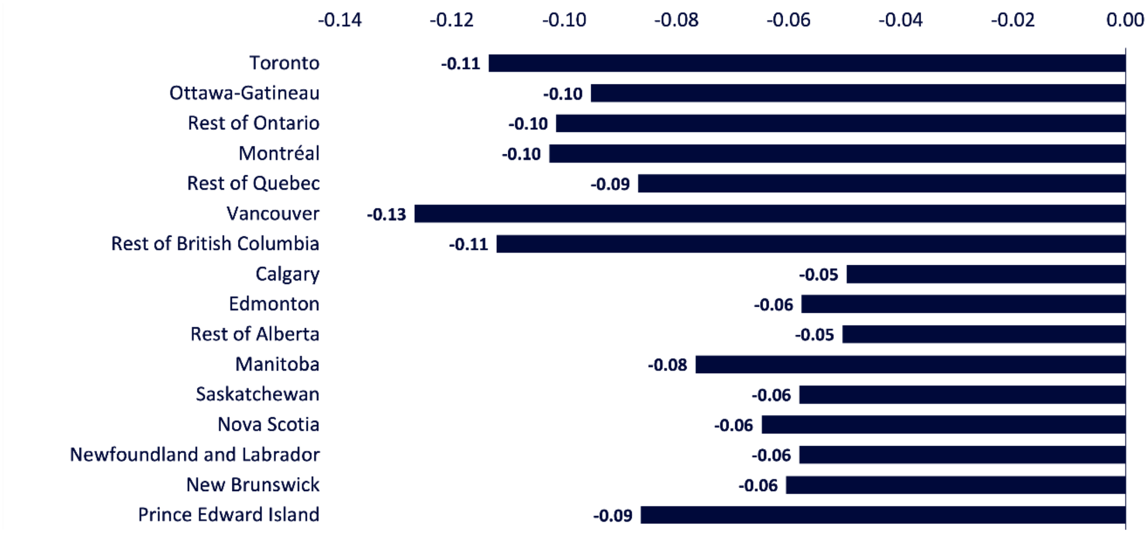
[18] Household formation probabilities (headship rates) depend on demographic factors, e.g., age, gender, marital status, the presence of children, as well as economic variables like housing costs, income and the unemployment rate. For a complete description of the household formation model, see Appendix 5.

[19] It should be mentioned that our estimate of the price elasticity of household formation for a given region cannot be read directly from probit estimations. We had to perform a specific shock on house prices in the IHM to isolate this elasticity for each region, obtained by aggregating over 400 individual types. Moreover, to isolate the price elasticity of household formation for each region, we had to mute some key channels in the IHM.

key nonlinearity feature, the IHM properly captures the fact that people have overall lower probabilities to form households in more expensive regions, but benefit the most from improvements in affordability.

Figure 2.5: 16 regions, price elasticity of household formation in the IHM



Source: CMHC calculations

2.3.1.3 Total price elasticity of demand and its implications for prices as supply is increased

In the IHM, decreases in house prices in response to additional supply depend on the two key elasticities discussed in the 2 previous sections, abstracting away population mobility: [20]

- the price elasticity of housing demand from existing households $-\alpha_2$ and
- the price elasticity of new household formation $-\theta_2$

An alternative way to illustrate this point is substituting equation (3) into equation (2) and assuming that the demand for housing rises proportionately to the number of households (α_3 = 1), so that the demand for housing equals:

$$d = (\alpha_0 + \theta_0) + (\alpha_1 + \theta_1)y - (\alpha_2 + \theta_2)p + \text{ other determinants} \quad (4)$$

As we can see, the total price elasticity of demand (the elasticity of the demand curve, Figure 2.6) in the IHM represents the sum of the two key price elasticities of demand outlined above, when abstracting away inter-regional migration flows.

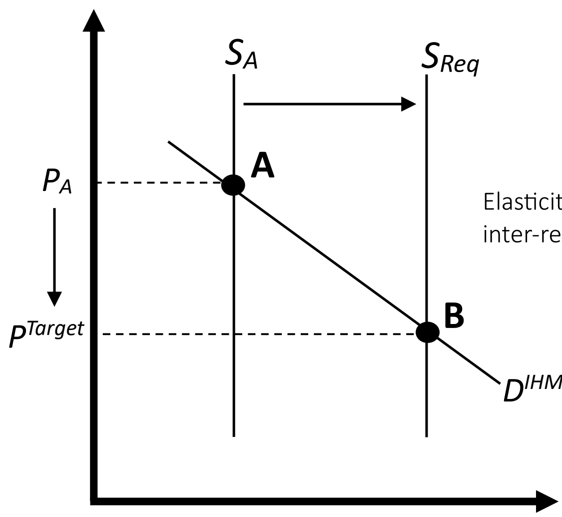
[20] For instance, a balanced scenario, where supply is increased in all regions according to their predefined affordability price targets, limits the effect on relative prices and minimizes the impacts on migration flows between regions. In such a case, the elasticity of gross inter-regional migration flows with respect to relative regional house prices can be ignored in the IHM.

As a result, when supply is increased (from S_A to S_{Req} on Figure 2.6) to reach a predefined affordability price target in the IHM (P^{Target} on Figure 2.6), the rise in housing demand induced by lower house prices captures the:

- increased demand for housing by existing households (indicated by $-\alpha_2$) and
- increased demand for housing by new households being formed (indicated by $-\theta_2$)

This is why the IHM implies that in order to improve affordability, the net additions to the stock must be superior to the expected growth of household numbers.

Figure 2.6: Supply[21] and demand dynamic implied by the IHM



Elasticity of the demand curve in the IHM, abstracting from inter-regional migration flows $= -(\alpha_2 + \theta_2)$

Combining the price elasticity of housing demand from existing households (estimated to be about –0.4) with the price elasticity of new households being formed (estimated to be about –0.1) gives a total price elasticity of housing demand of about –0.5, abstracting away the population mobility. This price elasticity of demand implies that a 5% increase in housing supply generates a decrease of 10% in house prices to restore equilibrium between supply and demand in the IHM, as described below.

The price elasticity of demand is:

$$\frac{\Delta D/D}{\Delta P/P} = -(\alpha_2 + \theta_2) = -(0.4 + 0.1) = -0.5$$

[21] The housing supply curve is perfectly inelastic in these figures because when supply gaps are estimated, housing supply is exogenously increased, i.e., the housing starts model in the IHM is muted. However, when conducting other economic, demographic and policy shock scenarios in the IHM, the supply curve is not perfectly inelastic. That is, the explicit housing starts model is part of the equilibrium framework and the long-run adjustment process of the housing system in the IHM, so that housing starts react to changes in house prices and other key economic factors. The scenario presented in Chapter 4, Section 4.2 which explores the impact of improving productivity in the construction industry, can be seen as a "real-life" scenario in the sense that the increase in productivity that leads to lower prices has a dampening effect on the incentive to build more housing.

To restore equilibrium, we have: $\Delta D/D$ = $\Delta S/S$. Therefore, the decrease in house prices to restore equilibrium in the IHM is:

$$\frac{\Delta S/S}{-0.5} = \frac{\Delta P}{P} = \frac{5\%}{-0.5} = -10\%$$

2.3.1.4 Importance of using the total price elasticity of demand in the IHM

As discussed previously, demographic approaches consider exclusively potential demand from "suppressed households" and ignore changes in housing consumption from existing households. That is, in these approaches, the decrease in house prices in response to additional supply depends exclusively on the price elasticity of household formation.

If the price elasticity of household formation in the IHM of about –0.1 (which accords with Meen and most of the literature) was the only elasticity considered, then any modest increase in housing supply would generate a large decrease in house prices (Meen et al., 2005), which does not align with reality.

For instance, if housing supply was increased by 5%, given the price elasticity of –0.1, the decline in house prices to restore equilibrium would need to be 50%, as described below.

The price elasticity of demand (household formation) is:

$$\frac{\Delta D/D}{\Delta P/P} = -\theta_2 = -0.1$$

To restore equilibrium, we have: $\Delta D/D$ = $\Delta S/S$. Therefore, the decrease in house prices to restore equilibrium in the IHM would be:

$$\frac{\Delta S/S}{-0.1} = \frac{\Delta P}{P} = \frac{5\%}{-0.1} = -50\%$$

2.3.1.5 Only a small proportion of additional housing units is taken up by new households being formed in the IHM

The price elasticities of housing demand in the IHM imply that only a small proportion of the increased supply of housing goes to new households. In the example presented in the previous Section 2.3.1.3, of the 5% increase in housing stock, only one percentage point will be occupied by new households. That is, abstracting away population mobility, only 20% of additional homes go to new households (more or less depending on the regions).

The remaining 80% are taken up by existing households who are improving the quality of their housing with lower prices. As raised by Meen et al. (2005), this partly occurs because the number of existing households trading in the market is always much greater than the number of new households being formed.

These results are obviously controversial if a policy aims to provide homes to new households. However, if the aim is to improve affordability, existing households attempting to become owners for the first time or those attempting to get a home that better fits their needs are amongst the main beneficiaries (Meen et al., 2005).

2.3.2 Income elasticity of housing demand: only matching housing supply to the number of households (the need) does not ensure stabilization of affordability in the IHM

The other key elasticity with regards to supply gap estimations is the income elasticity of housing demand.

From equation (2) in previous Section 2.3.1.1, market equilibrium (i.e. housing stock *S* equals housing demand *D*) implies the following empirical long-run house price equation:

$$p = \frac{\alpha_0}{\alpha_2} + \frac{\alpha_1}{\alpha_2} y + \frac{\alpha_3}{\alpha_2} hh - \frac{1}{\alpha_2} s + \text{other determinants} \quad (5)$$

Assuming that the demand for housing rises proportionately to the number of households (so that $\alpha_3 = 1$), we can simplify the long-run house price equation (5) as follows:

$$p = \frac{\alpha_0}{\alpha_2} + \frac{\alpha_1}{\alpha_2} y - \frac{1}{\alpha_2} ln\left(\frac{S}{HH}\right) + \text{other determinants} \quad (6)$$

Equation (6) is the long-run house price relationship estimated in the IHM.[22]

An important implication for affordability can be highlighted from this empirical long-run house price equation. As discussed before, demographic approaches rely on the assumption that any increase in housing supply had to be matched by an increase in the number of households (the need) to restore equilibrium (*S*=*HH*).

But in the IHM, this assumption leaves house prices unchanged. Moreover, it does not ensure that affordability remains constant unless the long-run elasticity of prices to income α_1/α_2 is estimated to be one. That is, the ratio price-to-income is constant over time only if α_1/α_2=1 for a given value of other variables in the house price equation.

However, α_1/α_2 is estimated to be about 2.5 in the IHM. This means that the income elasticity of housing demand α_1 is higher than the price elasticity of housing demand α_2, which is estimated to be about –0.4 in the IHM (as described in previous Section 2.3.1). Consequently, the income elasticity of housing demand α_1 is estimated to be about one in the IHM.

These results, in line with Meen et al. (2005) and most econometric time-series studies, have important implications. They imply that existing households demand a higher quantity of housing services than they currently hold as their income rises. Some may buy a second home. Others may buy a bigger house in a better neighborhood. Some may move from renting to owning and so on.

Therefore, only matching supply to the number of households (the need) over time implies worsening affordability, unless other variables operate in the house price equation (Meen et al., 2008). For that reason, supply equals demand rather than need in the IHM.

[22] See Meen et al. (2008) for a similar demonstration.

2.4 Other implications of using the IHM for supply gap estimations

The implications of selecting the appropriate affordability price targets on supply gap estimates are examined in Section 2.4.1. Section 2.4.2 discusses the simplifying assumption that we are forced to make in the IHM regarding the supply of housing services.

2.4.1 Impacts of affordability target choices when assessing supply gaps

The IHM allows to estimate the required level of additional housing units to make projected house prices hit predefined targets. Simulations can be conducted for an infinity of different scenarios.

As such, the IHM doesn't know what an "affordable market" is, i.e., what house price level would signal that there is enough supply. To estimate a supply gap, we need to give the model explicit house price targets. The key challenge in determining meaningful and relevant house price targets is that there exists no fundamental, objective definition of an "affordable" market. It will always be based on a set of assumptions and/or arbitrary policy objectives.

The magnitude of the supply gap can be drastically different depending on:

- the gap between projected house prices and the house price targets and
- the time horizon (target date) to reach these house price targets

Depending on the selected targets, the number of additional units isn't necessarily going to be realistic or even desirable from the perspective of building capacities, allocation of economic resources, public finances, etc. For some extreme scenarios, the required level of additional housing units to make house prices hit predefined targets can also imply an unrealistically high share of unoccupied housing units.[23]

That explains why selecting the appropriate affordability price targets when assessing supply gaps is crucial.

2.4.2 Assumption that the supply of housing services is a fixed proportion of the stock of housing units

Accounting for increased demand for housing services from existing households is crucial when estimating supply gaps with predefined affordability price targets. Ideally, the IHM would include the "stock of housing services" instead of the stock of housing units as a determinant of prices. However, data exists only for the number of dwellings.

There are no official estimates of the supply of housing services that can be used in a cointegrating time-series price model. As a result, the IHM relies on the simplifying assumption that the supply of housing

[23] It is important to note that the share of unoccupied units includes second homes. Although second homes are not explicitly modeled in the IHM, the model implies more second homes with lower prices. This distinction is important.

services is a fixed proportion of the stock of housing units, even if, in reality, the stock of housing services likely changes relative to the number of units over time (Meen et al., 2008).

Since the IHM is based on an empirical exercise (coefficients are derived from econometric estimations based on historical data) to capture the past relationships between key variables, all simulations performed in the IHM implicitly assume that new housing units built over the projected period reflect past experiences (on average over the historical period) both in terms of the types of units constructed and their impact on house prices.

From an econometric point of view, the elasticity of real prices to the housing stock in the IHM is potentially underestimated since we can't directly account for the stock of housing services in the price model. As a result, the impact of additional increases in housing supply on affordability may be underestimated in the IHM. In this regard, the sensitivity scenario explored in Chapter 4, Section 4.1.1, where the responsiveness of households to lower house prices is reduced, provides a magnitude of this underestimation.

Using an imperfect variable for the housing stock is a compromise we deem appropriate to make in order to use a model which accounts for the increased demand from both existing households and new households being formed when estimating the impact of additional supply on house prices.

2.5 Potential future improvements of the IHM

The IHM was built in a way that can easily be extended by integrating more blocks of equations to reflect other elements of the economy. As with any other models, the IHM isn't set in stone and will continue to be enhanced. Some potential future improvements include:

- developing and integrating a complete endogenous economic block of equations within the IHM
- breaking down Canada into more regions (i.e., individual results for more CMAs)
- explicitly modeling second homes, vacancies, conversions and demolitions within the IHM so that these variables respond to changes in prices and other economic factors when performing shock scenarios
- estimating the effective housing stock, which converts housing stock units to capture housing quality and quantity of housing services
- making continuous econometric/modeling/technical enhancements that will improve the current key components of the IHM

Chapter 3: Exploring the central properties of the IHM through 2 projection scenarios

This chapter explores the central properties of the IHM through two specific projection scenarios:

- the base projection scenario, what we call the business-as-usual scenario and
- an alternative scenario in which supply is exogenously increased (beyond business-as-usual) to achieve predefined affordability price targets over the next decade

Section 3.1 provides important notes with regards to this scenarios analysis. Section 3.2 presents the business-as-usual scenario. Section 3.3 presents the alternative scenario, i.e., the “additional-supply” scenario.

3.1 Caveats when performing projections and alternative scenarios with the IHM

The IHM is designed to provide a consistent structure for forecasting and shock scenario analysis. It captures key relationships between key variables and their respective determinants.

This makes the IHM a useful tool for thinking in a more consistent way when simulating the impact of demographic, economic and policy shock scenarios. However, as with any other model, the IHM is a simplification of complex realities and is only meant to guide, not to dictate projections.

As a result, projections are always produced using a combination of simulations and judgments. The judgment part is key as it helps to reduce the risk that the IHM doesn’t adequately capture short-term developments.

The IHM is also not meant to be used blindly. The user needs to understand and be able to explain any projection scenarios generated by the IHM and the main transmission channels of a given shock scenario through the rest of the model.

The challenge when running shock scenarios is to make sure that the appropriate variable (the right trigger), in conjunction with other variables sometimes, is shocked with the appropriate corresponding transmission channels in the rest of the model. Sometimes, the variable to be shocked is not directly within the IHM, but alternative methods can be used to replicate the shock scenario in order to explore a specific question.

Moreover, the IHM relies on an empirical exercise to capture the past relationships between key variables. But there is an important caveat to this. It assumes that the parameters estimated will continue to hold in the future while many unexpected future factors and policies can affect these coefficients.

Finally, the IHM currently produces projections until 2043. Projecting key variables over 20 years is useful to simulate the effects of different scenarios, but it is important to keep in mind that the prediction errors can be quite important when projecting over such a long-time horizon.

Therefore, point estimates generated by the IHM over such a long period must be taken for what they are: a support to think in a more consistent way when assessing different scenarios (including the business-as-usual scenario). They aren't providing exact predictions.

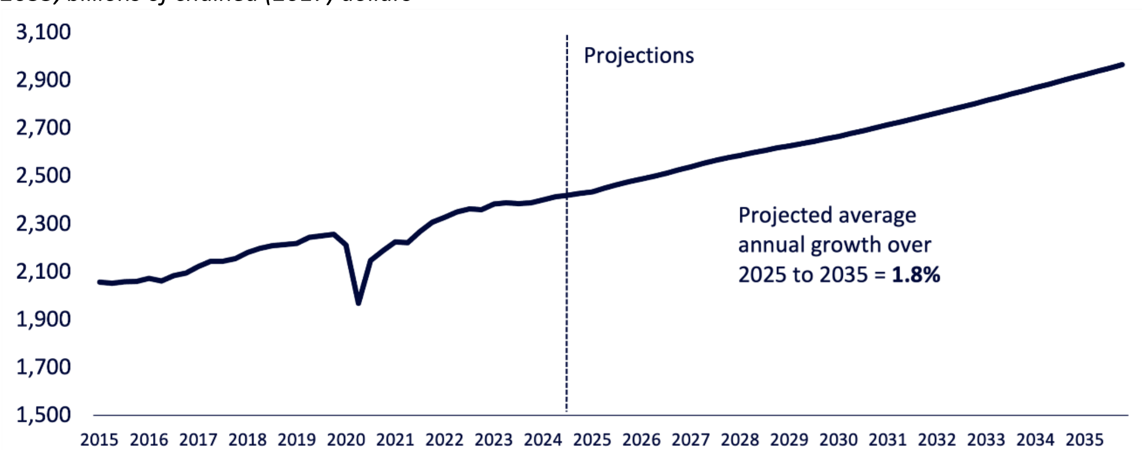
3.2 Business-as-usual scenario

As with any model, the IHM requires a base scenario from which different shock scenarios can be performed. In this exercise, we call it the business-as-usual scenario.[24] It should be stressed that the official projections published in CMHC's Housing Marlet Outlook (HMO) report are based on different models and data than the IHM. They include adjustments based on local market intelligence and other considerations at the time of producing the projections. Results provided in this section are solely based on the IHM and differ from the HMO.

3.2.1 Economic projections

The economic projections underlying the business-as-usual scenario reflect CMHC's macroeconomic projections as based on the information available by the end of January 2025. In this scenario, the Canadian gross domestic product (GDP) is projected to rise by around 1.8% annually over 2025 to 2035 (Figure 3.1).

Figure 3.1: Canada - Historical and projected gross domestic product (GDP), business-as-usual, 2015 to 2035, billions of chained (2017) dollars



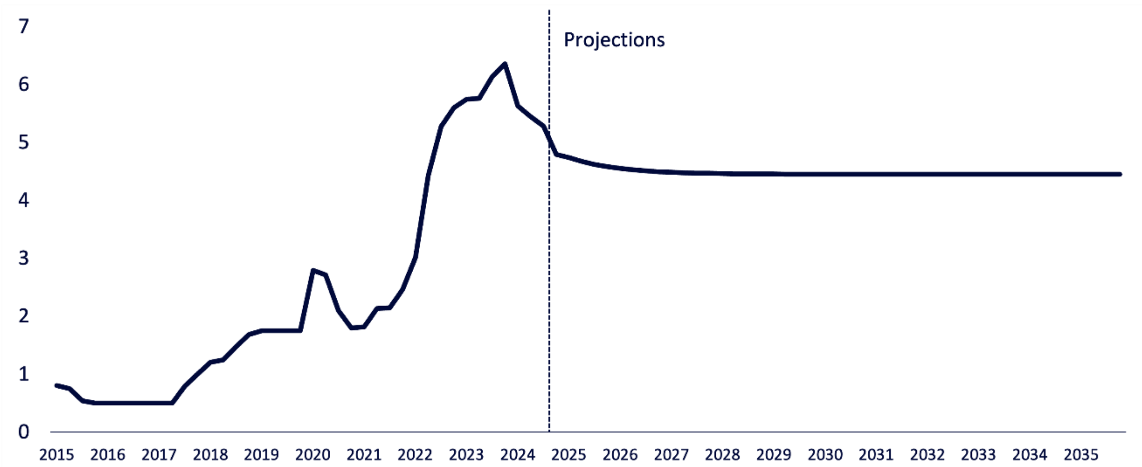
Source: Statistics Canada, CMHC calculations.

The 5-year fixed discounted mortgage rate[25] is projected to decrease in 2025, following the normalization of short- and long-term bond yields. It then stabilizes at around 4.5% over the medium and long-term horizons (Figure 3.2).

[24] The business-as-usual scenario presented in this document was constructed in January 2025.

[25] The 5-year fixed discounted mortgage rate is the most common mortgage in Canada. The discounted (contracted) rate considers discounts negotiated to the conventional (posted) rate. Most mortgages in Canada pay a discounted rate (CMHC, 2021 Mortgage Consumer Survey Results, 2021).

Figure 3.2: Canada - Historical and projected 5-year fixed discounted mortgage rate, business-as-usual, 2015 to 2035, %

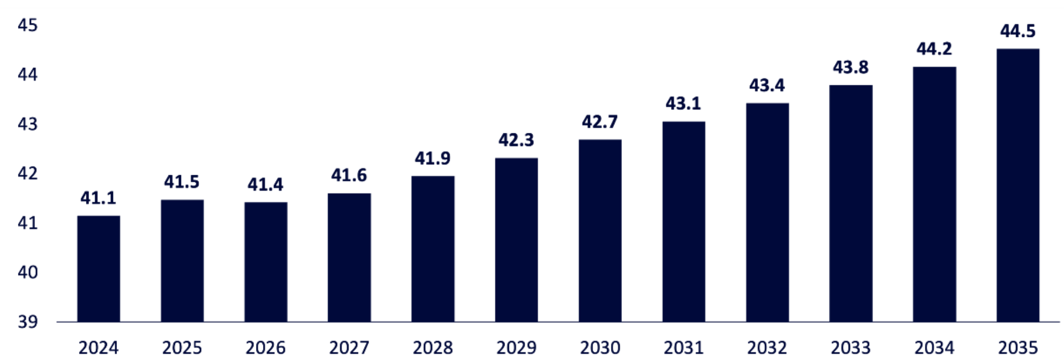


Source: Tangerine, CMHC calculations.

3.2.2 Demographic projections

In this business-as-usual scenario, the Canadian population reaches nearly 45 million by 2035 relative to just over 41 million in 2024 (Figure 3.3). This population projection reflects data from Statistics Canada and includes policy changes announced in 2024 to reduce immigration.[26]

Figure 3.3: Canada - Projected population, business-as-usual, 2024 to 2035, millions



Source: CMHC calculations.

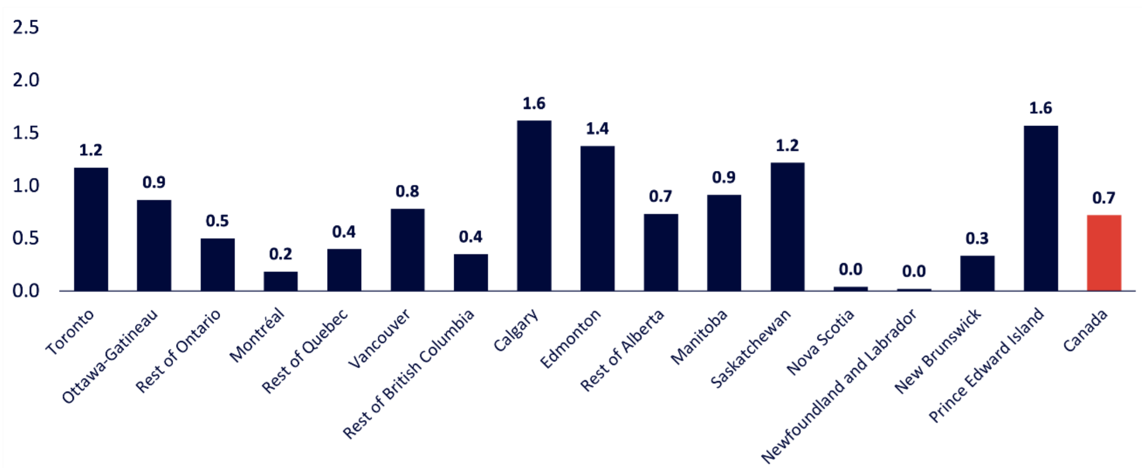
[26] While the composition of the population reflects the Statistics Canada M1 scenario, the level of population is developed by CMHC.

Figure 3.4 below reports the average annual population growth over 2024-2035 for Canada and the 16 regions. There is heterogeneity in population growth over the projection period. Immigration mostly flows to Canada's major cities, with Toronto, Vancouver, and Montréal receiving half of the international migrants.

Birth, death and international migration rates are exogenous in the IHM, but not population mobility between regions which depends on relative housing and economic conditions.

Canadians moving from expensive regions leads to proportionately greater increases in population in regions such as Prince Edward Island and Saskatchewan, for example. The overall population grows at 0.7% annually, on average, over 2024 to 2035, with Calgary, Edmonton, Prince Edward Island, and Toronto leading.

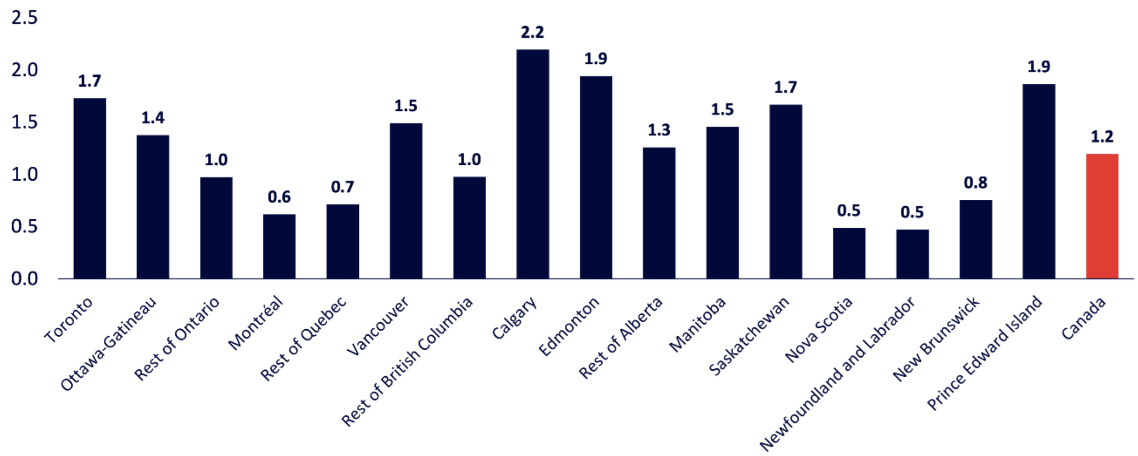
Figure 3.4: Canada and 16 regions - Projected average annual growth rate of the population, 2024 to 2035, business-as-usual, %



Source: CMHC calculations.

Figure 3.5 reports the average annual growth of the number of households over the period 2024-2035 for Canada and the 16 regions. Since population projections feed into household projections, heterogeneity in household projections across regions is similar to that of population projections.

Figure 3.5: Canada and 16 regions - Projected average annual growth rate of the number of households, 2024 to 2035, business-as-usual, %

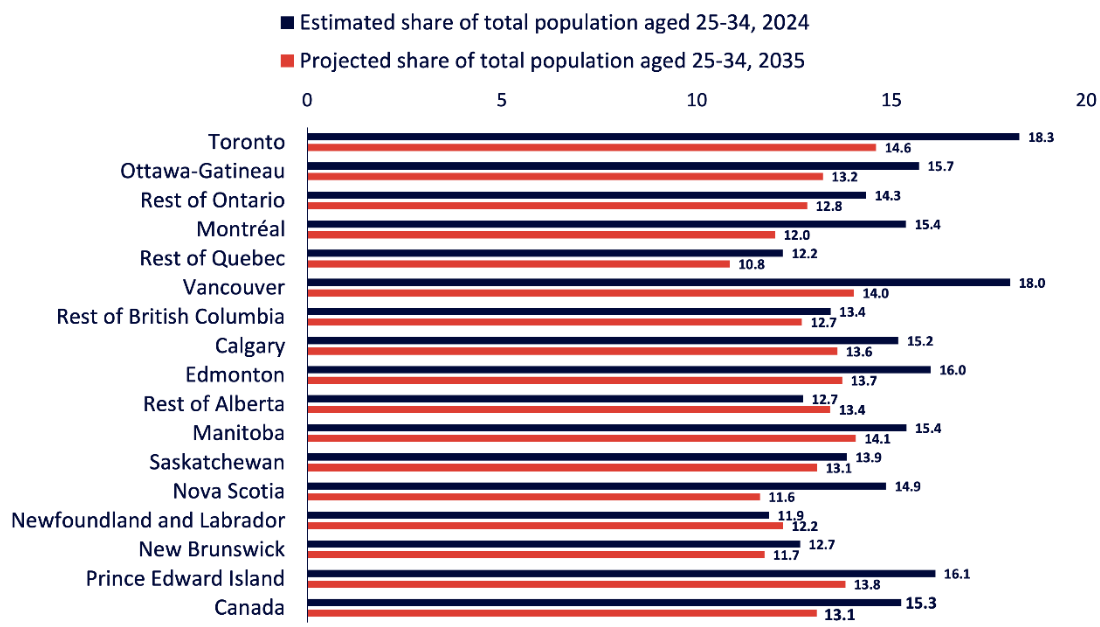


Source: CMHC calculations.

The share of total population aged 25-34, a key demographic group supporting new housing demand,[27] is projected to decrease in Canada over the next decade (Figure 3.6). This is particularly evident in Toronto and Vancouver where the aging of the population is significant.

[27] The period during which adults are the most likely to become households.

Figure 3.6: Canada and 16 regions - Projected share of total population aged 25-34, 2024 and 2035, business-as-usual, %

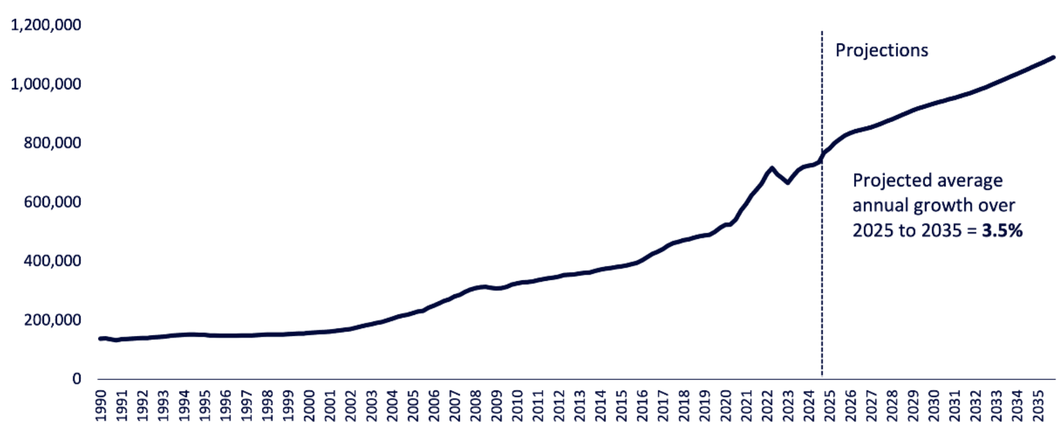


Source: CMHC calculations.

3.2.3 Housing projections

The long-run path of average house prices in the IHM depends on several factors: household income, the stock of housing, the number of households, the share of population aged 25-34 and the housing user cost of capital. For Canada as a whole, the average annual growth rate of nominal house prices from Q3 2024 to Q4 2035 is 3.5% (Figure 3.7).

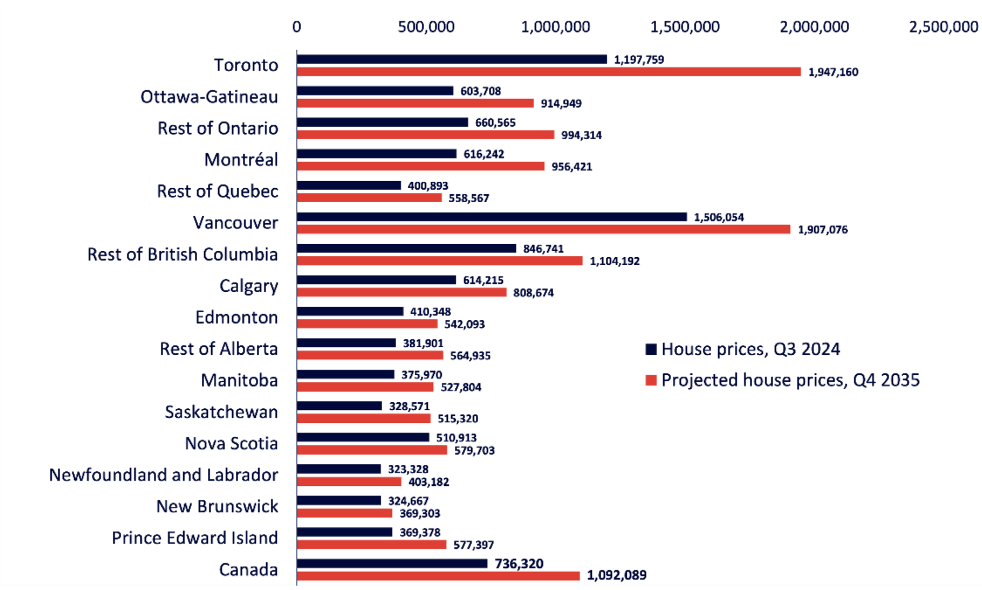
Figure 3.7: Canada - Historical and projected average house prices, business-as-usual, Q1 1990 to Q4 2035, $



Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.8 shows that house prices will increase over the next decade in all 16 regions. For example, the average house price in Toronto will increase from $1.2 million to reach close to $2 million in 2035.

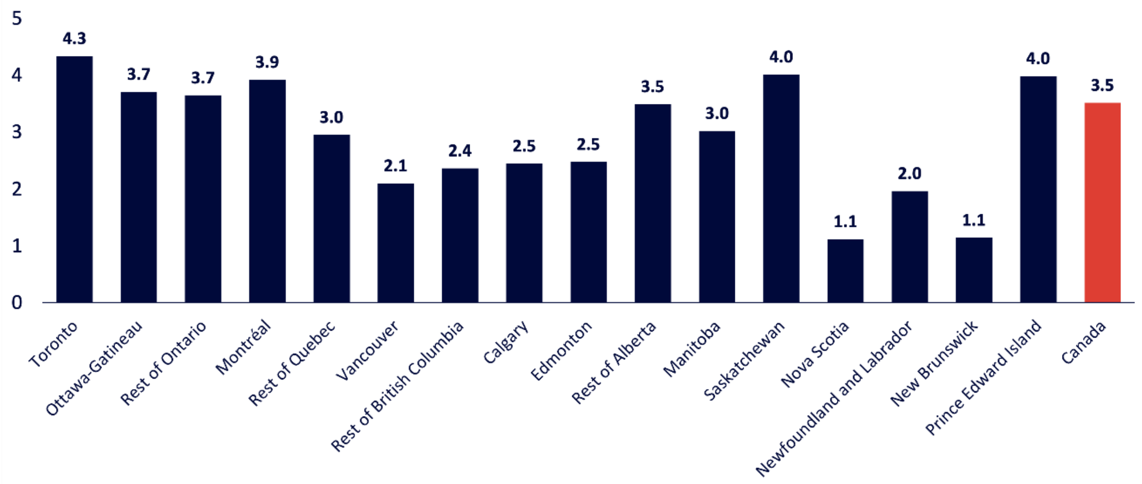
Figure 3.8: Canada and 16 regions - Projected average house prices, 2024 and 2035, business-as-usual, $



Source: CMHC calculations.

The average growth of house prices varies across the 16 regions (Figure 3.9). Price growth is strongest in Ontario, Quebec and the Prairies and the weakest in Atlantic provinces.

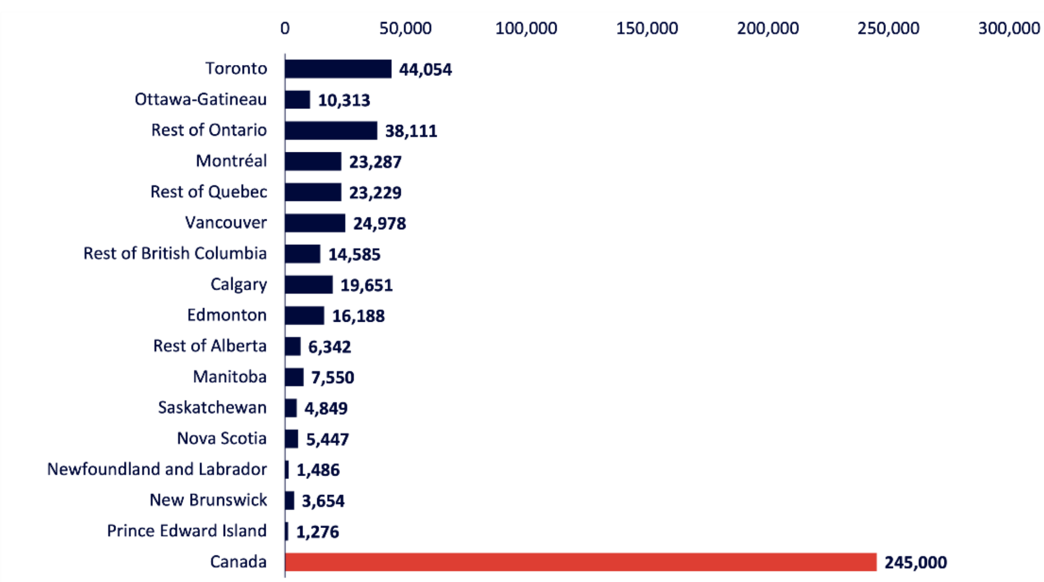
Figure 3.9: Canada and 16 regions - Projected average annual growth rate of average house prices, 2024 to 2035, business-as-usual, %



Source: CMHC calculations.

Projected housing starts generated by the housing starts model within the IHM under the business-as-usual scenario are reported in Figure 3.10 below. The business-as-usual scenario assumes that the level of housing starts of 245,000 units will be maintained over 2025 to 2035, which is higher than the recent historical average observed over the period 2015-2023 (225,000 units).

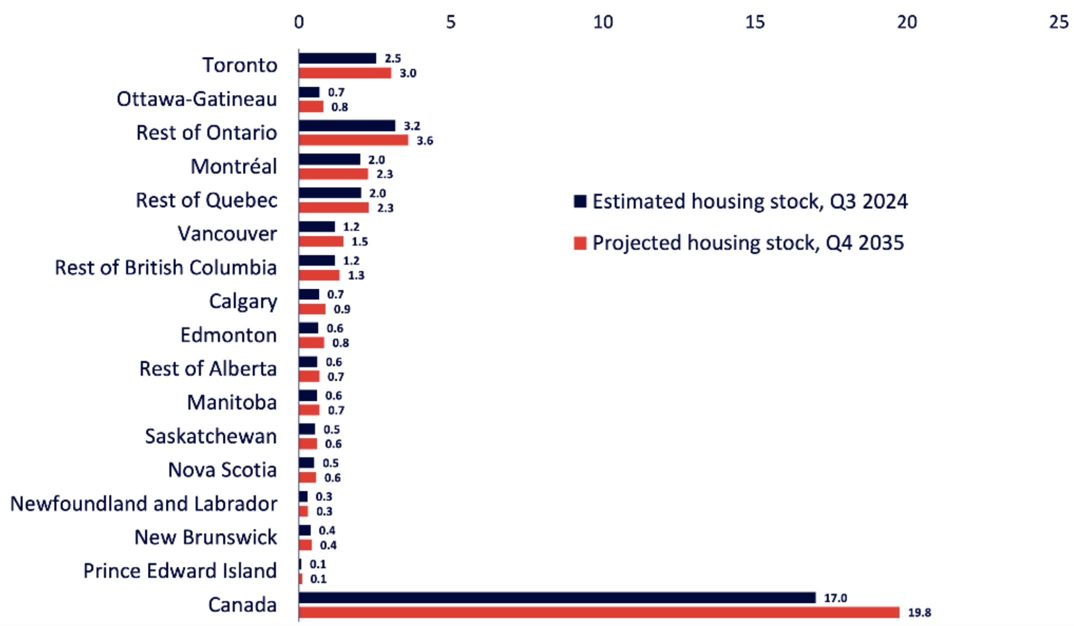
Figure 3.10: Canada and 16 regions – Projected average annual housing starts, 2025 to 2035, business-as-usual



Source: CMHC calculations.

With this projection of housing starts, the stock of housing in Canada would reach 19.8 million units in Q4 2035, relative to 17.0 million units in Q3 2024 (Figure 3.11). Under the current version of the IHM, the net additions to the housing stock equal total housing starts.

Figure 3.11: Canada and 16 regions – Projected housing stock, Q3 2024 and Q4 2035, business-as-usual scenario, millions



Source: CMHC calculations.

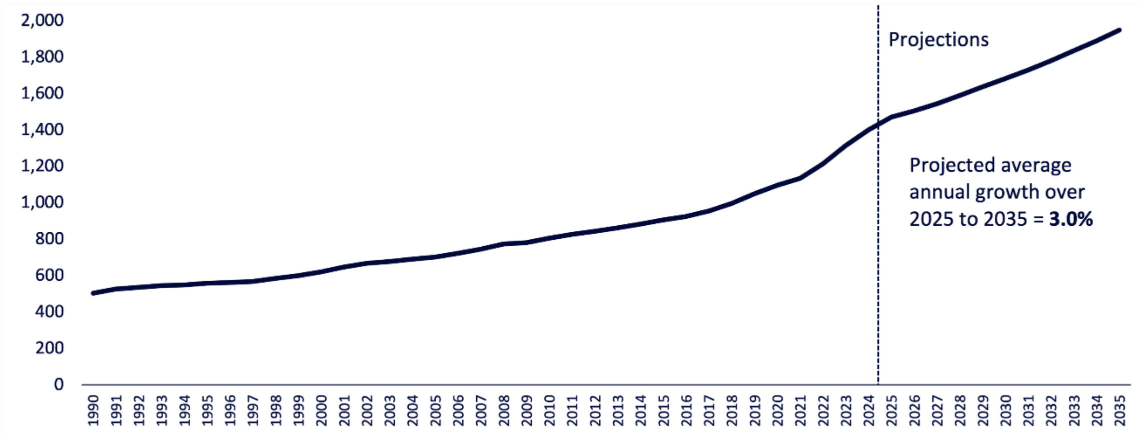
The future path of average rents is projected separately from house prices in the IHM. Both respond to changes in supply and demand and to each other. But their paths can diverge because they react differently to, for example, interest rates.

It should be stressed that the data on rents and house prices are different concepts. Unlike average house prices which instantly reflect the transactional value of properties that were sold, the average rents variable in the IHM capture the cost of all units, i.e., the contractual rent of currently occupied units, and the listed rent of vacant units.

As only a fraction of rental units turns over to new tenants each year, changes in listed rents have a limited impact on overall rent measures in the short-term.

Under the business-as-usual scenario, average rents are projected to increase by about 3% from around $1,400 today to over $1,900 by 2035 (Figure 3.12).

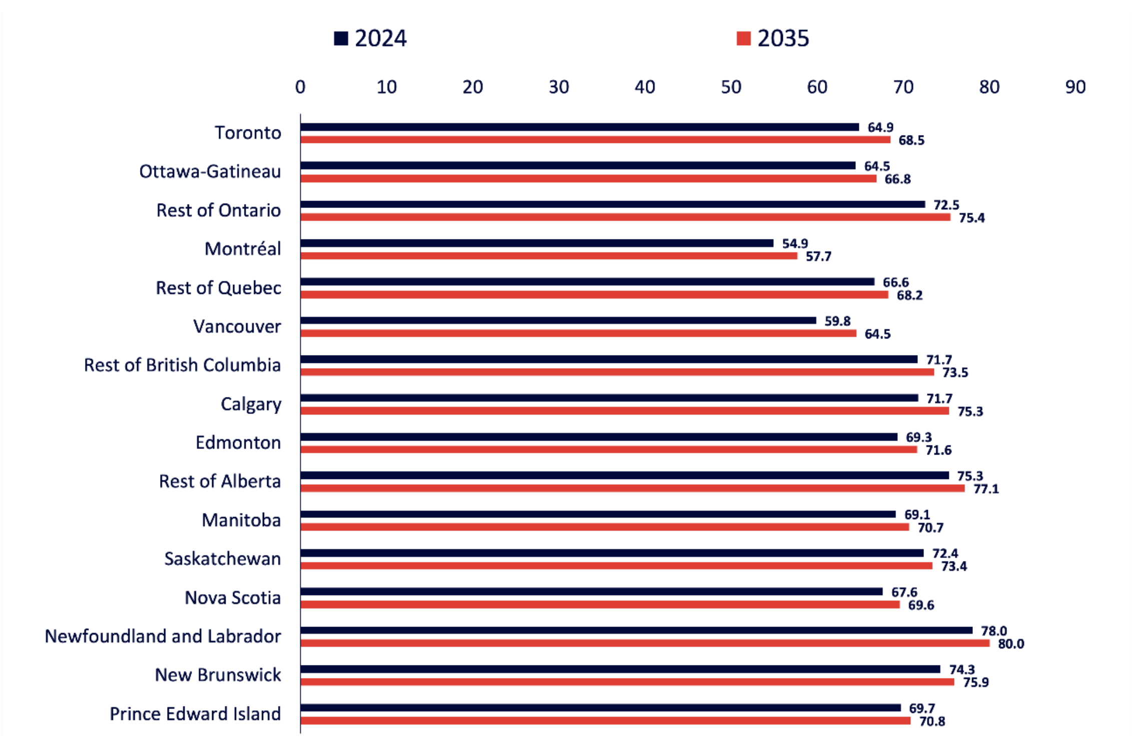
Figure 3.12: Canada - Historical and projected average rents, business-as-usual, 1990 to 2035, $



Source: CMHC calculations.
Note: Average rent of purpose-built private rental units (apartments and rows, all bedroom types). This is a different rent measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Changes in ownership costs relative to rents affect in turn ownership and renting rates in the IHM, which also depend on other economic factors, such as income, unemployment rate and credit constraints. Given the changing patterns of rents and house prices over the projected period, ownership rates are projected to slightly increase in 2035 relative to 2024 under the business-as-usual scenario (Figure 3.13).

Figure 3.13: 16 regions - Projected ownership rates, 2024 and 2035, business-as-usual, %



Source: CMHC calculations.

3.3 Scenario with additional supply: restoring the pre-pandemic level of affordability

The alternative scenario is one in which housing supply is exogenously increased (beyond business-as-usual) to restore by 2035 the levels of affordability observed just before the COVID pandemic. This is an evolution from the initial report released in 2022. The changes in the approach to "restoring affordability" and resulting affordability targets are detailed in Section 3.3.1. The results from this scenario are presented in Section 3.3.2.

3.3.1 Defining affordability

3.3.1.1 Changing our aspiration

The IHM allows to derive net additions to the housing stock that are consistent with various levels of affordability goals. Choosing the appropriate affordability targets when assessing supply gaps is crucial. Simulations can be conducted for an infinity of different scenarios. As such, the IHM doesn't know what an "affordable market" is, i.e., what house price level would signal that there is enough supply. To estimate a "supply gap", we need to give the model explicit house price targets.

The key challenge in determining meaningful and relevant house price targets is that there exists no fundamental, objective definition of an "affordable" market. It will always be based on a set of assumptions and/or arbitrary policy objectives. The magnitude of the supply gap can be drastically different depending on:

- the gap between projected house prices and the house price targets and
- the time horizon (target date) to reach these house price targets

In the prior analytical framework used to support the initial report released in 2022, the approach was to quantify the supply needed to restore the homebuying affordability from the early 2000s by 2030.

However, for some regions that have already experienced many years of housing affordability erosion, bringing affordability back to levels last observed two decades ago is too ambitious, especially after the post-pandemic price surge. COVID significantly changed the affordability landscape across the country while Toronto and Vancouver face more structural affordability challenges that require more time to address.

Moreover, for expensive regions like Toronto and Vancouver, bringing affordability back to levels last observed in 2003-2004 would imply a significant decrease in their respective house prices. Therefore, under such an unrealistic scenario, the required level of additional housing units in 2030 to make house prices hit the predefined affordability price target in these expensive regions would imply an unrealistically high share of unoccupied housing units[28]. For these reasons, the aspiration to restore affordability has been changed to levels seen just prior to the pandemic.

Furthermore, the 2030 timeline is now too short. Selecting a longer time horizon to reach affordability price targets generate more plausible results, in terms of the number of additional housing units required each

[28] It is important to note that the share of unoccupied units includes second homes. Although second homes are not explicitly modeled in the IHM, the model implies more second homes with lower prices. This distinction is important.

year to achieve this target and the path of house prices. Consequently, the target year has been pushed further, from 2030 to 2035.

Finally, the results are now presented as a change in how many housing starts are required per year rather than as a cumulative total to ease comparison with current and potential rates of housing construction.

3.3.1.2 Changing our homebuying affordability metric

As mentioned above, there exists no universal definition of an affordable market. In economy-wide analyses a common convention is to compare the monthly cost of purchasing an average home to the average or median income.

Our previous approach was based on a comprehensive metric of homebuying costs that included parameters for qualifying for a mortgage, such as the borrowing capacity of an average-income household. Unfortunately, house prices have risen to such an extent in our most expensive cities that the average household would not qualify to buy the average home under current mortgage rules, and that metric has become obsolete.

We therefore adapted how we measure homebuying affordability. We got rid of the Gross Debt Service (GDS) requirements and other mortgage rules and use a more generic concept, closer to a price-to-income ratio (or "homebuying affordability ratio"), while also accounting for the impact of changes in mortgage rates and homeowner expenses.

This new metric is presented in detail in Appendix 9. It allows us to better monitor homebuying affordability over time in all regions. Interpretation remains the same: the higher the ratio, the less affordable the market is.

3.3.1.3 New affordability targets

Changing our aspiration for affordability to match pre-pandemic levels and the use of a more suited affordability metric leads to new affordability targets for the "additional-supply" scenario. Table 3.1 highlights that there has been substantial loss of affordability in Ontario, British Columbia, Quebec and Nova Scotia as well as losses elsewhere between 2019 and 2024.

Table 3.1 also shows the level of affordability we aim to return to in the IHM (i.e., the targeted ratios in the third column). Rather than being government targets, they illustrate what would be required to regain lost affordability. In general, we aim to return to levels of affordability at which adjusted house prices (homebuying affordability ratios) are:

1. no higher than 30% of gross household income or
2. no higher than its 2019 level in the more unaffordable regions

Hence, in British Columbia, parts of Ontario, and Montréal, we aim at only returning to affordability levels of 2019 (higher than 30%). Many parts of Canada – the Prairies and parts of the Atlantic – were relatively affordable in 2019 with affordability ratios less than 30% but have now breached that level and increased housing supply will move them back to the 30% threshold.

The targeted ratios in 2035 are our interpretation of what might be a realistic level of affordability. They are meant to be illustrative. In turn, where these ratios are projected to be in 2035 in our business-as-usual scenario (the ratio in the 4th column), compared to the aspiration (targeted ratios in the 3rd column), is central to understanding the size of the supply gap in each region.

For instance, some regions see their affordability improve between 2024 and 2035 even in the business-as-usual scenario, particularly Vancouver, the Rest of British-Columbia and Nova Scotia.

In cases where the ratio is already below the 30% threshold in 2035 in the business-as-usual scenario, then no additional supply is required. This includes Edmonton, New Brunswick and Newfoundland and Labrador, where no additional supply is required since they are projected to build sufficient housing to maintain their relative affordability over the next decade.

For the rest of Quebec, the ratio is slightly above 30% in the business-as-usual scenario in 2035, but it goes below 30% in the “additional-supply” scenario without the need to increase supply beyond business-as-usual. As discussed later in the scenario with additional supply, more population from the rest of Quebec moves to Montréal because there is more housing built in Montréal to restore the affordability lost since 2019.

Calgary, the rest of Alberta, Saskatchewan, Manitoba, Nova Scotia and Prince Edward Island require additional supply beyond business-as-usual to move them back to the 30% threshold by 2035, which is higher than the ratios these regions had in 2019.

The regions for which the pre-pandemic levels of affordability are matched in the “additional-supply” scenario are Toronto, Ottawa-Gatineau, the rest of Ontario, Montréal, Vancouver and the Rest of British Columbia. Their ratio in 2019 was equal or above the 30% threshold.

Table 3.1: Canada and 16 regions - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, 2019, 2024 and Q4 2035 (projected and targeted ratios), %

	Ratio in 2019	Ratio in 2024	Targeted ratio in Q4 2035*	Projected ratio in Q4 2035 in business-as-usual
Toronto	59	74	59	79
Ottawa-Gatineau	30	44	30	44
Rest of Ontario	33	50	33	49
Montréal	34	48	34	48
Rest of Quebec	24	34	30	32
Vancouver	71	99	71	83
Rest of British Columbia	47	64	47	57
Calgary	27	38	30	36
Edmonton	26	31	30	30
Rest of Alberta	25	31	30	34
Manitoba	27	34	30	33
Saskatchewan	26	29	30	32
Nova Scotia	26	49	30	41
Newfoundland and Labrador	23	31	30	28
New Brunswick	20	34	30	27
Prince Edward Island	24	34	30	39
Canada**	39	54	41	53

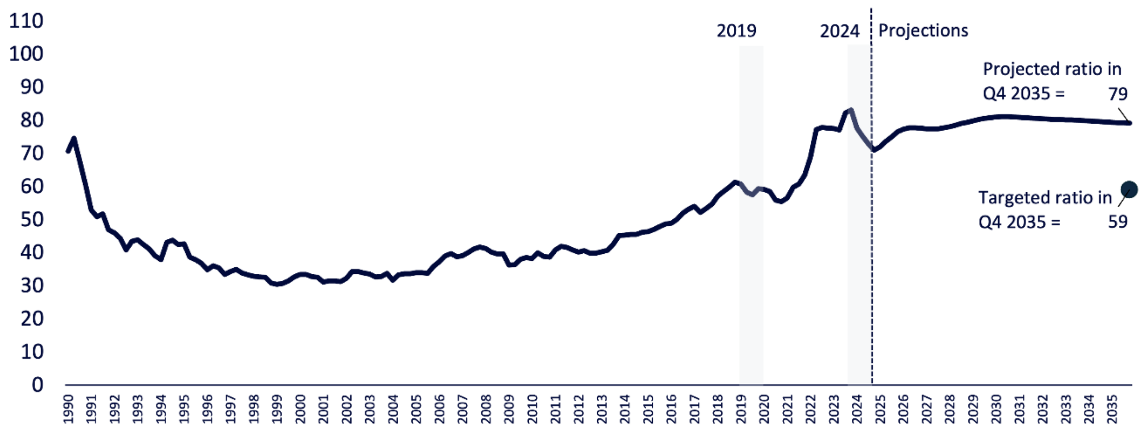
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.
Note: Average house price-to-average gross household income ratio, with an adjustment factor to account for mortgage rates and monthly homeowner expenses (estimations of property taxes, utilities, maintenance and insurance).
*The target for the model is that by 2035 the adjusted housing price metric should be no higher than 30% of gross household income where this is still realistic, or no higher than its 2019 level in the most expensive regions.
**The IHM generates results for 16 regions which together fully cover the 10 Canadian provinces. Results provided at the national level consist of a weighted average of these 16 regions.

Historical and projected homebuying affordability ratios up to 2035 for each individual region and Canada are reported in Figure 3.14 to Figure 3.30. These figures are very useful in visualizing the deterioration in housing affordability that many regions across the country have experienced since 2019.

As discussed later in Section 3.3.2.1, the loss in affordability since 2019 in Montréal, Ottawa-Gatineau, the rest of Ontario and Nova Scotia, for example, leads to more housing being needed there.

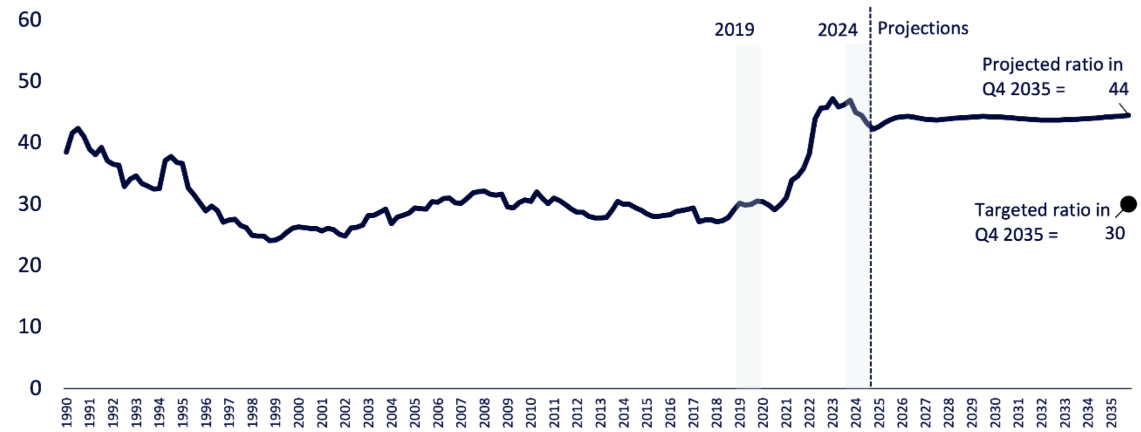
By illustrating where affordability ratios are projected to be in 2035 in the business-as-usual scenario relative to the targeted ratios (the aspiration), these figures are also very useful to understand the number of additional units required (beyond business-as-usual) in each region to restore 2019 affordability levels by 2035.

Figure 3.14: Toronto - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



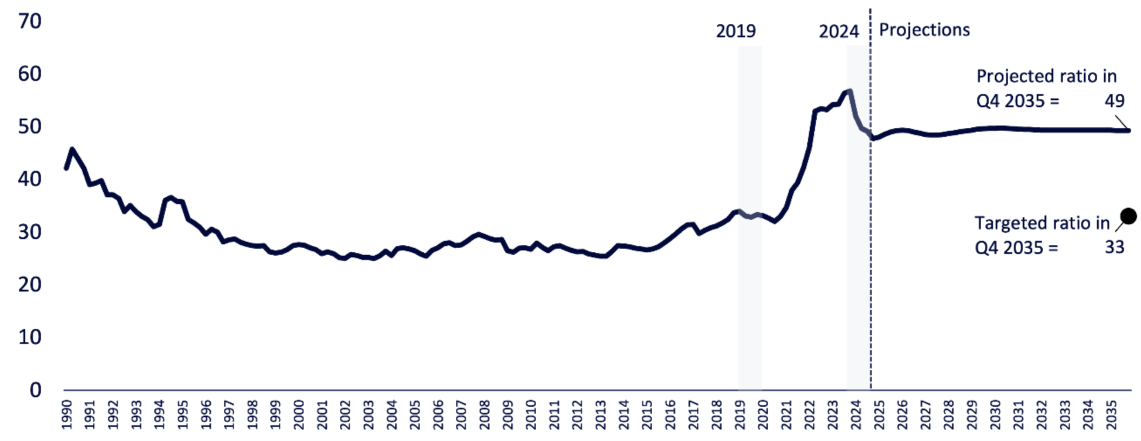
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.15: Ottawa-Gatineau - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



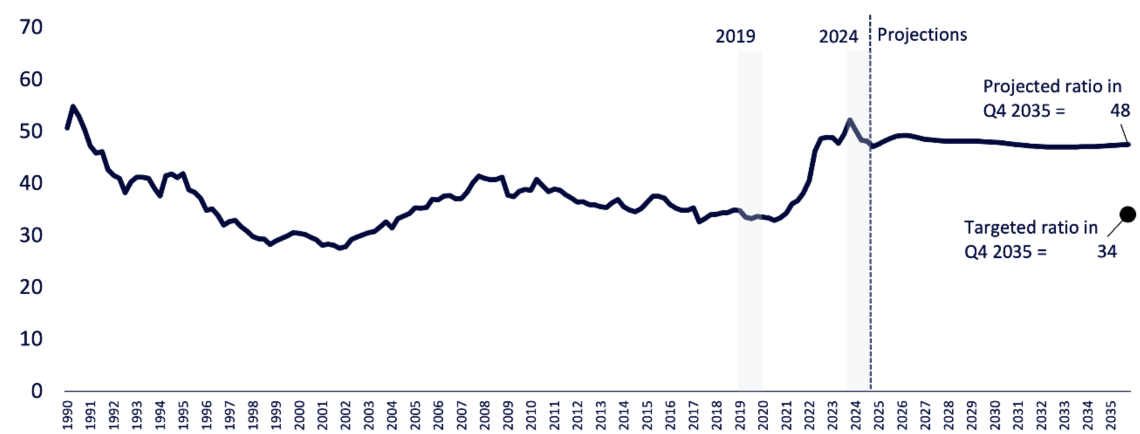
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.16: Rest of Ontario - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



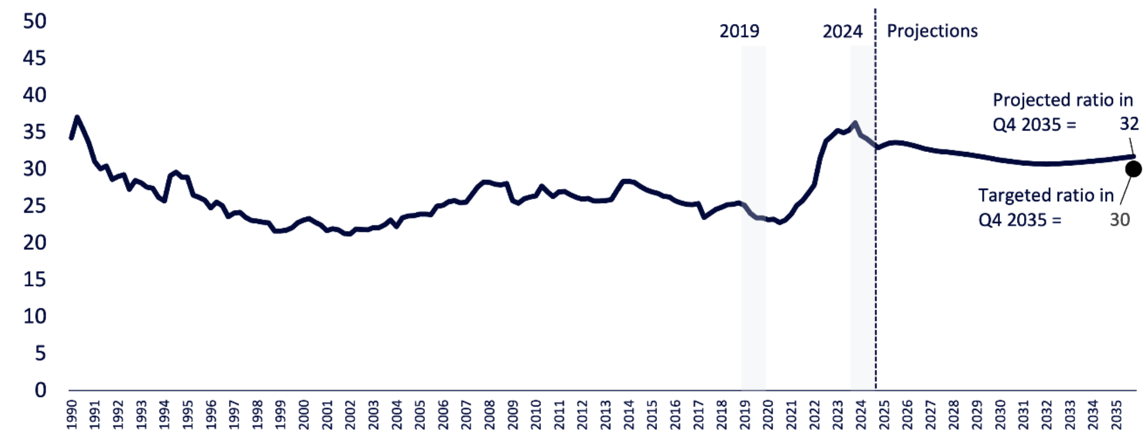
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.17: Montréal - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



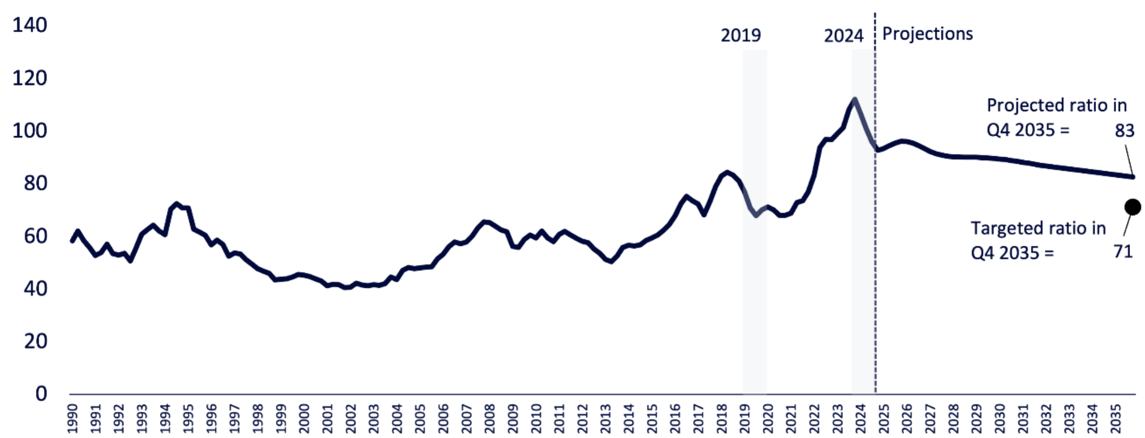
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.18: Rest of Quebec - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



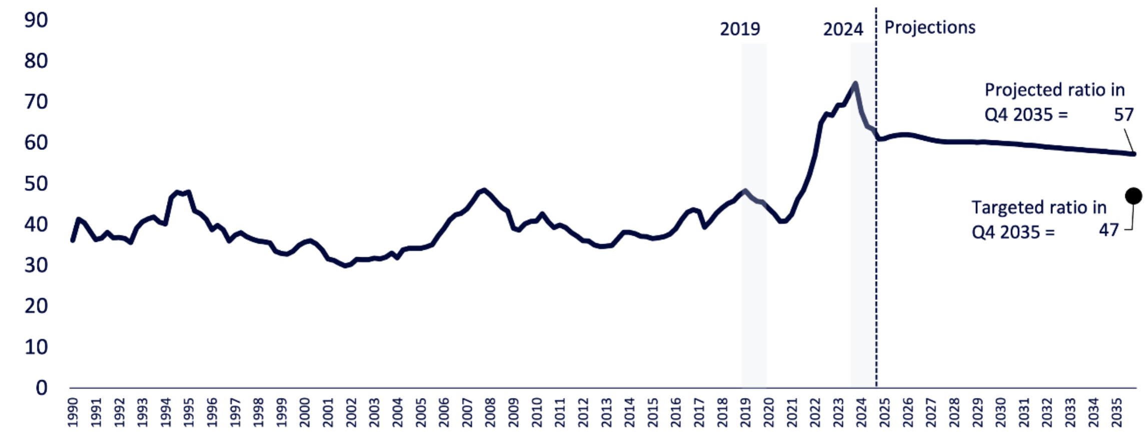
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.19: Vancouver - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



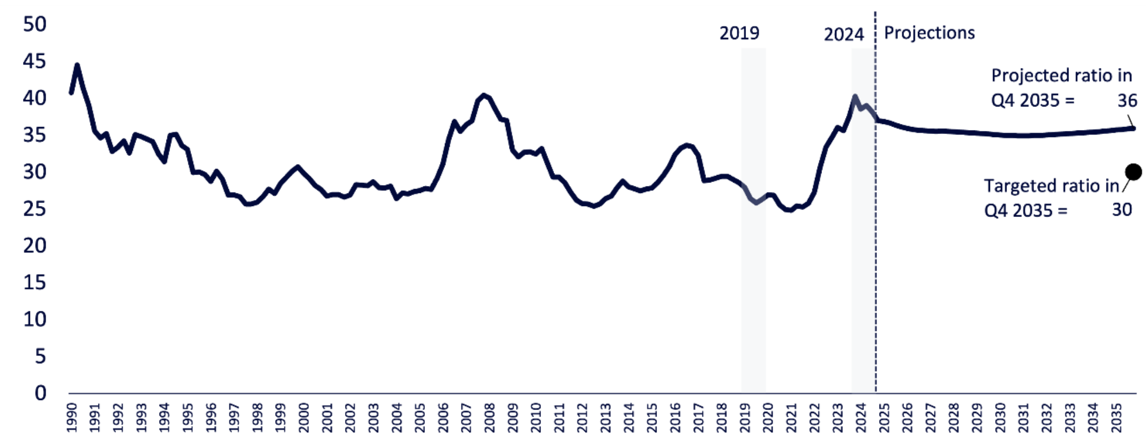
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.20: Rest of British Columbia - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



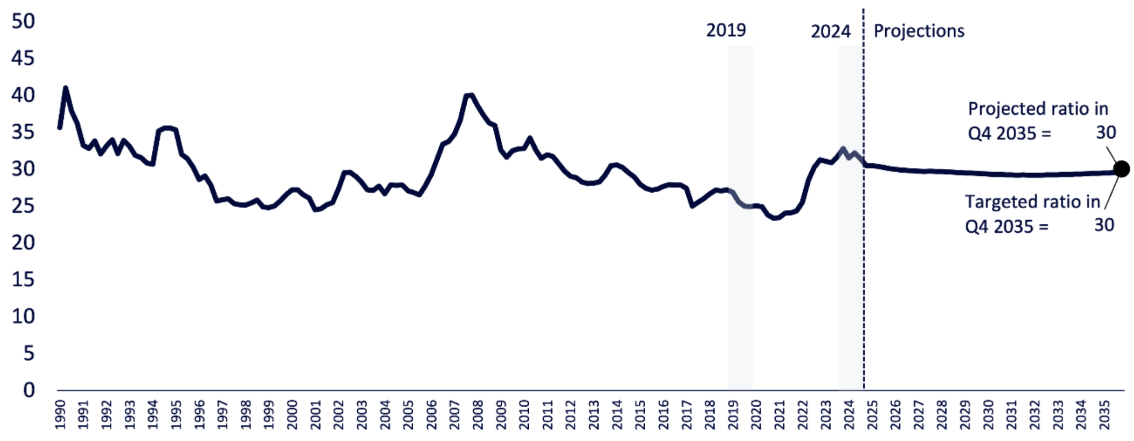
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.21: Calgary - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



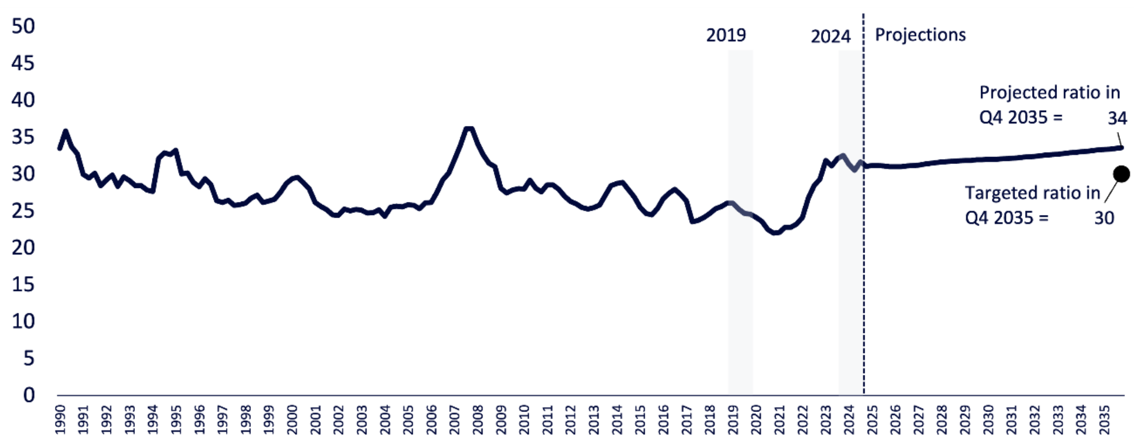
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.22: Edmonton - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



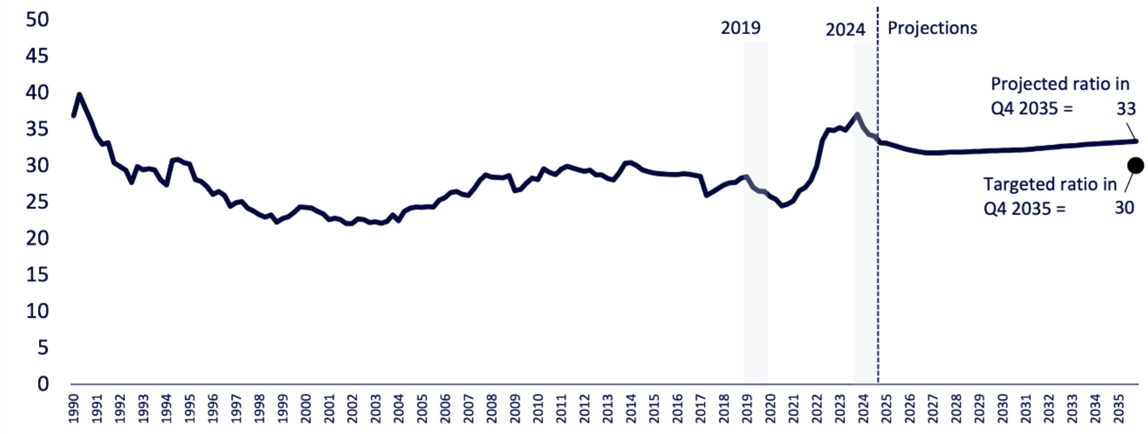
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.23: Rest of Alberta - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



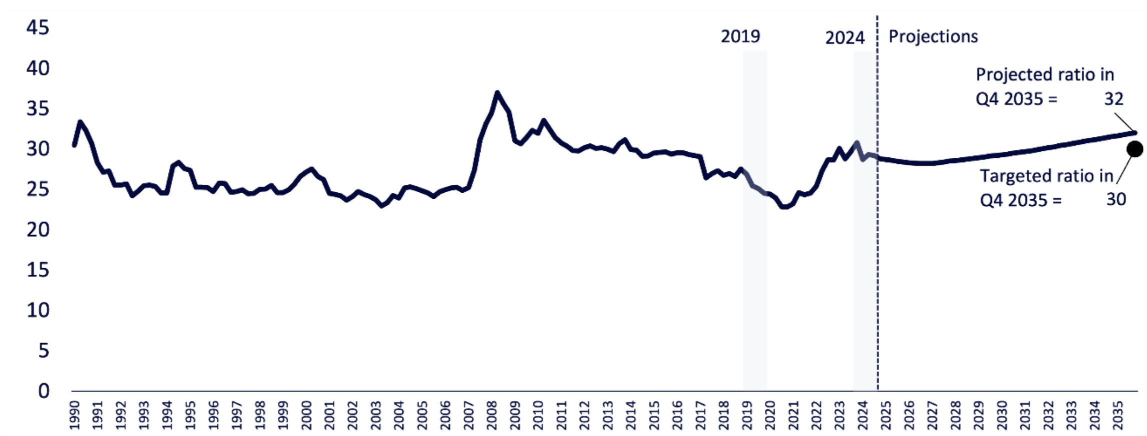
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.24: Manitoba - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



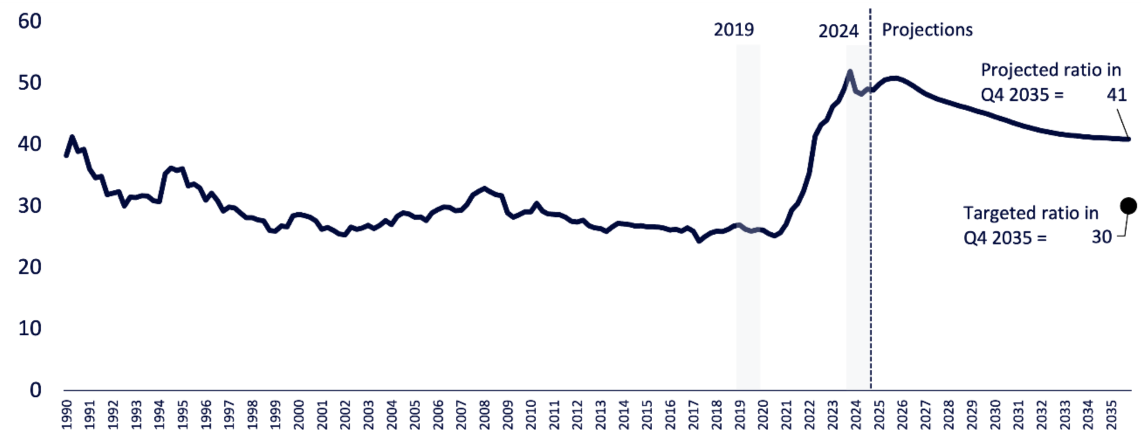
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.25: Saskatchewan - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



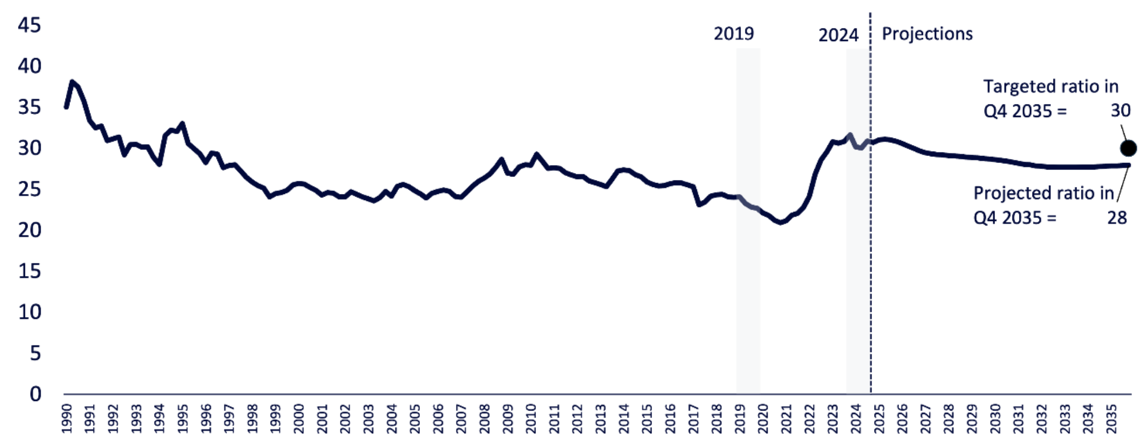
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.26: Nova Scotia - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



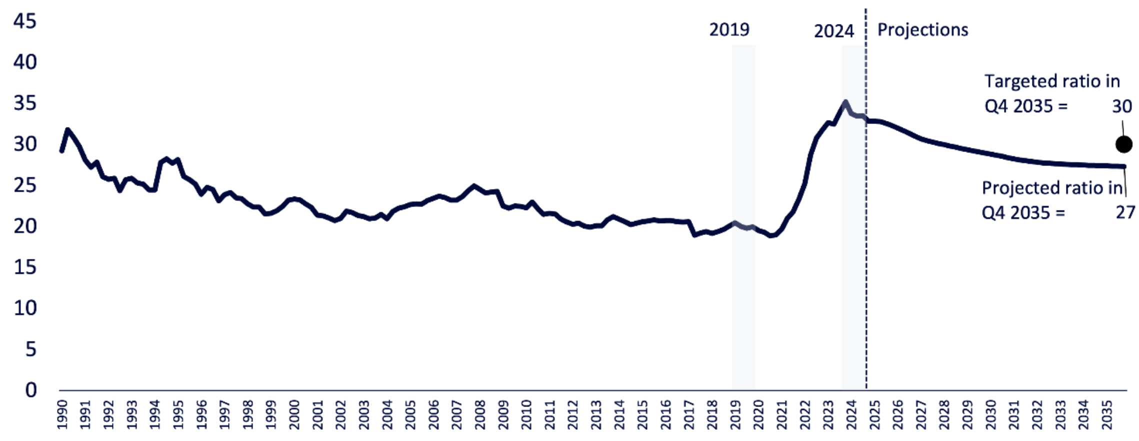
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.27: Newfoundland and Labrador - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



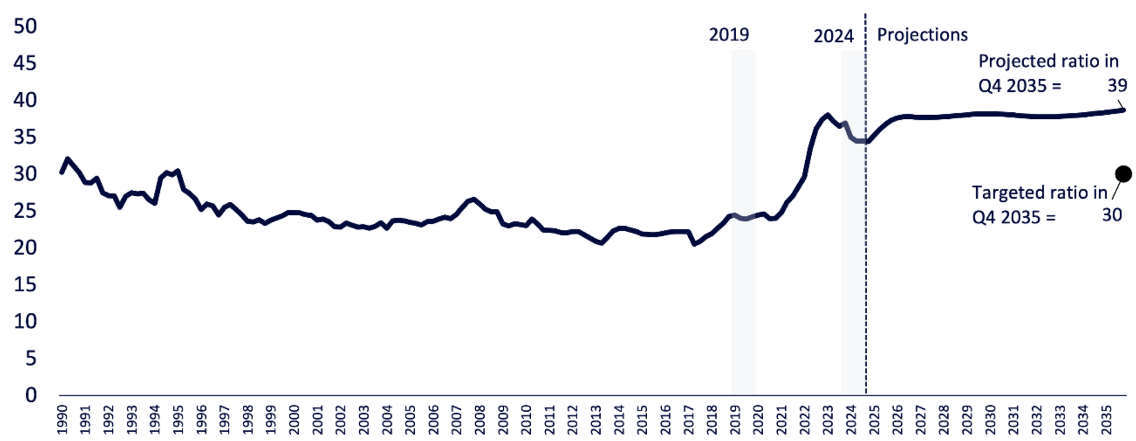
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.28: New Brunswick - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



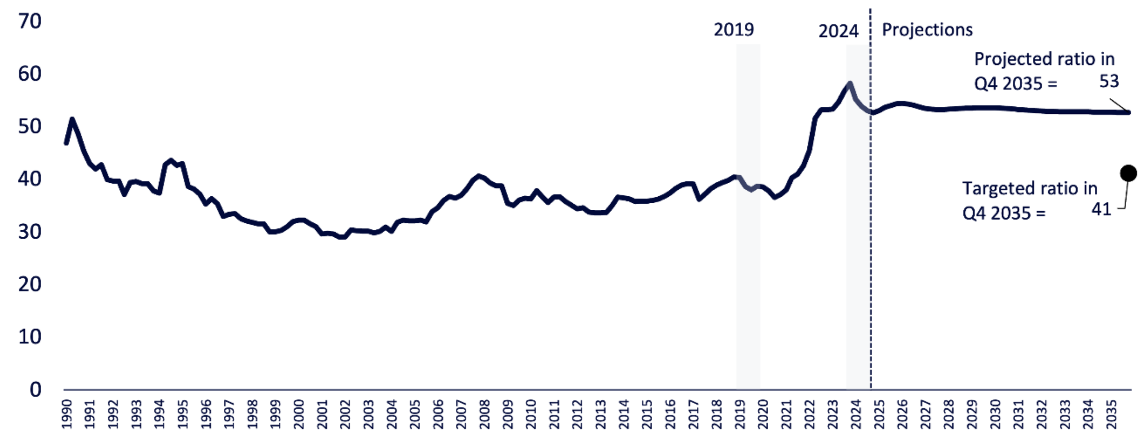
Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.29: Prince Edward Island - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

Figure 3.30: Canada - Historical and projected homebuying affordability ratios: house price-to-income, adjusted for mortgage rates and homeowner expenses, business-as-usual, Q1 1990 to Q4 2035, %



Source: CMHC calculations based on data from CMHC, Statistics Canada, Oxford Economics and the Bank of Canada.

3.3.1.4 How supply is increased in the IHM when performing an "additional-supply" scenario

In the scenario with additional supply to restore 2019 affordability levels by 2035, the government is assumed to have the capacity to significantly increase housing supply like a policy instrument to meet predefined affordability price targets.

In the IHM, this means that housing supply is exogenously increased (beyond business-as-usual) in all 16 regions according to their respective predefined affordability price targets. That is, the housing starts model is muted and not part of the long-run adjustment process in the housing system of the IHM.

In other words, following the shock on housing supply, feedback effects from the overall model (like changes in house prices) on housing starts are shut off. This is what allows to isolate the impact of additional supply on house prices and quantify a "supply gap".

It must be stressed that the purpose of performing such a scenario is to estimate the number of units that would theoretically be required to reach predefined affordability price targets (the aspiration).

In reality, housing supply responds to changes in house prices. Lower house prices provide a disincentive to build new houses and have a negative influence on new residential investment, which lowers housing starts. These interactions are properly captured by the IHM, when conducting "real-life" economic, demographic and policy shock scenarios.

Therefore, when conducting scenarios other than "supply gaps", housing supply is endogenous and part of the long-run adjustment process in the IHM housing system. Such a scenario is presented in Chapter 4, Section 4.2, which explores the impact of improving productivity in the construction industry, including the dampening effect of lower prices on the incentive to build more housing.

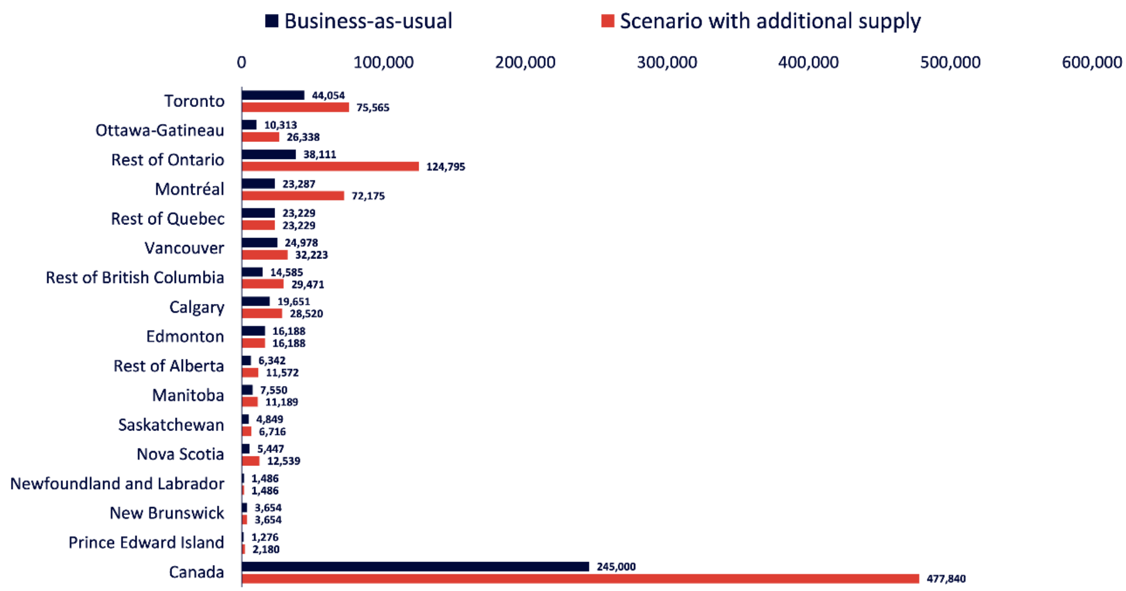
3.3.2 Results from the “additional-supply” scenario and comparison with the business-as-usual scenario

3.3.2.1 How much supply is required to restore the pre-pandemic level of affordability by 2035

Based on our simulations, the estimated level of annual housing starts required to return to pre-pandemic levels of affordability by 2035 is about 478,000. For comparison, the business-as-usual scenario implies an average of 245,000 housing starts annually over the period 2025-2035 (Figure 3.31).

This means that Canada must almost double the current pace of annual housing starts over the next decade to achieve housing affordability last seen in 2019. This increase in housing starts is ambitious, but seems to be within the realm of possibility[29].

Figure 3.31: Canada and 16 regions - Projected annual housing starts, business-as-usual and scenario with additional supply, 2025 to 2035



Source: CMHC calculations.

The rate of increase in housing starts required varies across the country with sizeable increases required in areas such as the rest of Ontario, Ottawa, Montréal and Nova Scotia (Figure 3.32). This reflects the sharp loss of affordability since the pandemic discussed in the previous Section 3.3.1.3.

In some areas of Canada, such as Edmonton, New Brunswick and Newfoundland and Labrador, no additional supply is required since they are projected to build sufficient housing to maintain their relative affordability over the next decade.

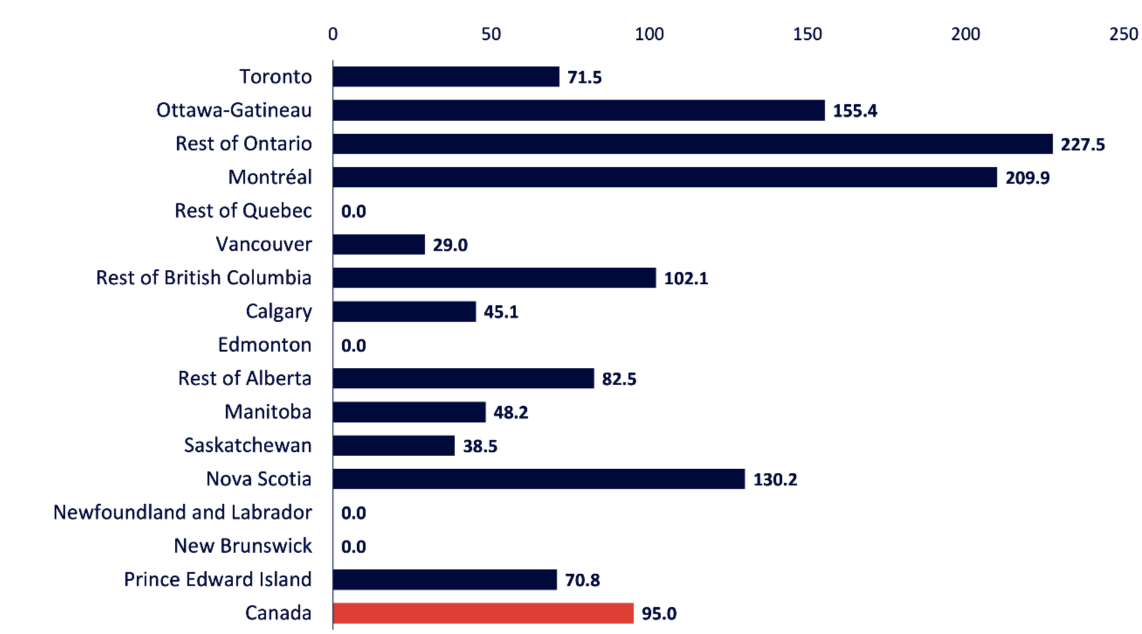
[29] See The Housing Observer of CMHC, *What is Canada’s potential capacity for housing construction?* (May 2024)

The case of the rest of Quebec is more complicated. The homebuying affordability ratio is slightly above the 30 per cent threshold in the business-as-usual scenario in 2035, which indicates the need for more supply.

However, meeting the affordability target in Montréal in the scenario with additional supply implies a significant increase in housing supply, which encourages migration from the rest of Quebec to Montréal.

This migration outflow is so large that no extra supply (beyond business-as-usual) is then required in the rest of Quebec, where the price target is met simply because prices are pushed lower due to the weaker demand. Without this migration component, the required increase in projected annual housing starts (beyond business-as-usual) in the rest of Quebec to reach its affordability target would have been about 30%.

Figure 3.32: Canada and 16 regions - Required increase (beyond business-as-usual) in projected annual housing starts to achieve housing affordability last seen in 2019, 2025 to 2035, %



Source: CMHC calculations.

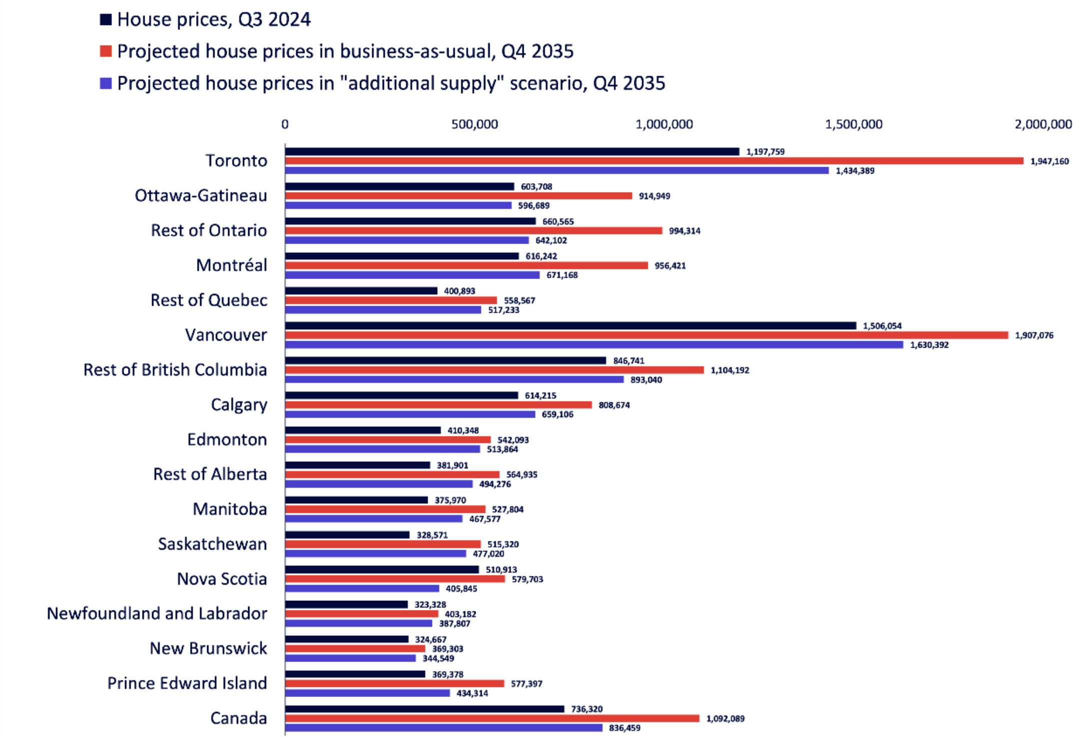
3.3.2.2 Impacts of additional supply on average house prices

The increase in supply to restore 2019 affordability levels in the next decade would result in a significant reduction in the national average annual house price growth between 2025 and 2035, from 3.5% in the business-as-usual scenario to 1.1% in the "additional-supply" scenario (Figure 3.33 and Figure 3.34).

This scenario would significantly reduce the growth of house prices relative to business-as-usual in Montréal, Toronto, British Columbia, Calgary and Prince Edward Island. It even leads to price declines relative to today's levels in regions that experienced a sharp price increase since 2019, such as Nova Scotia, Ottawa-Gatineau, and rest of Ontario.

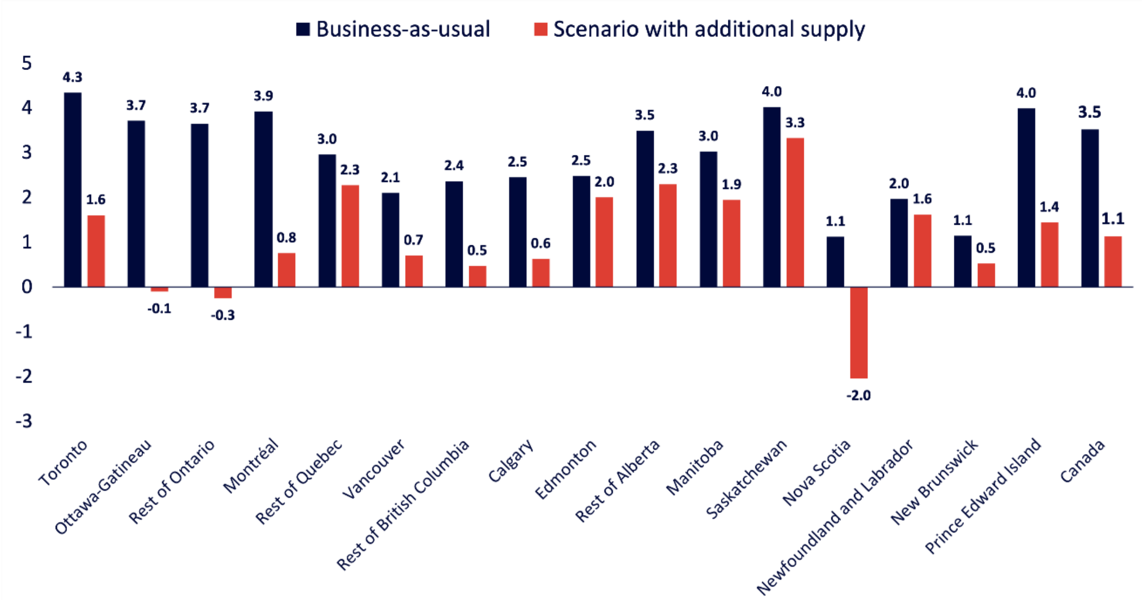
Other regions, such as Newfoundland and Labrador, New Brunswick and the Prairies (excluding Calgary) only see a small reduction in their price growth relative to business-as-usual. Since these regions are relatively more affordable today, tight affordability goals have not been set for them.

Figure 3.33: Canada and 16 regions - Projected average house prices, business-as-usual and scenario with additional supply, 2024 and 2035, $



Source: CMHC calculations.

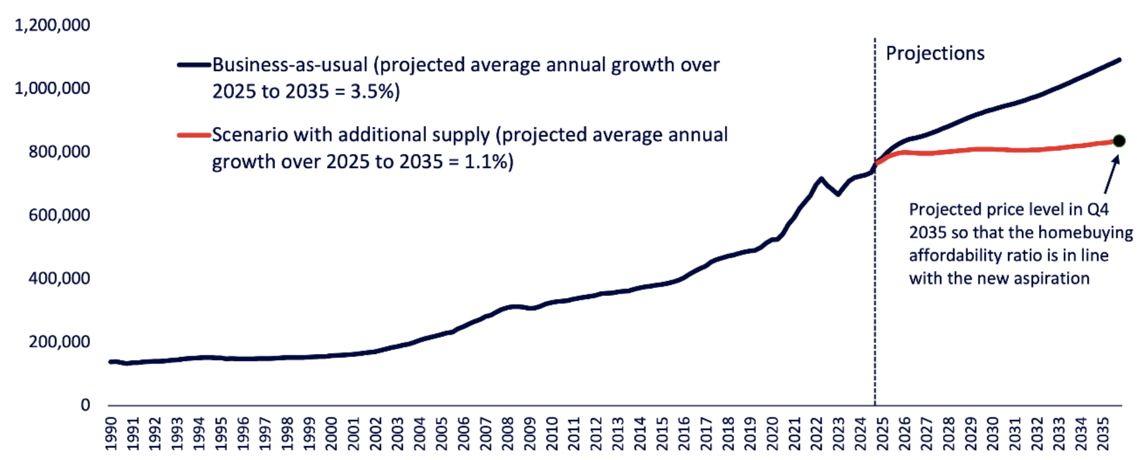
Figure 3.34: Canada and 16 regions - Projected average annual growth rate of average house prices, 2024 to 2035, business-as-usual and scenario with more supply, %



Source: CMHC calculations.

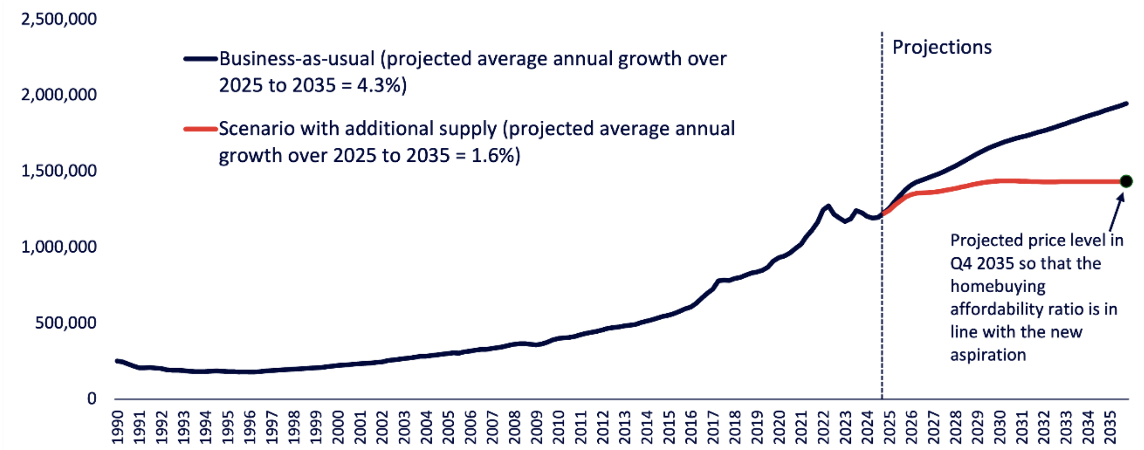
For illustration purposes, historical and projected average house prices up to 2035 under the business-as-usual and "additional-supply" scenarios for Canada and the 6 largest CMAs are reported in Figure 3.35 to Figure 3.41.

Figure 3.35: Canada - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



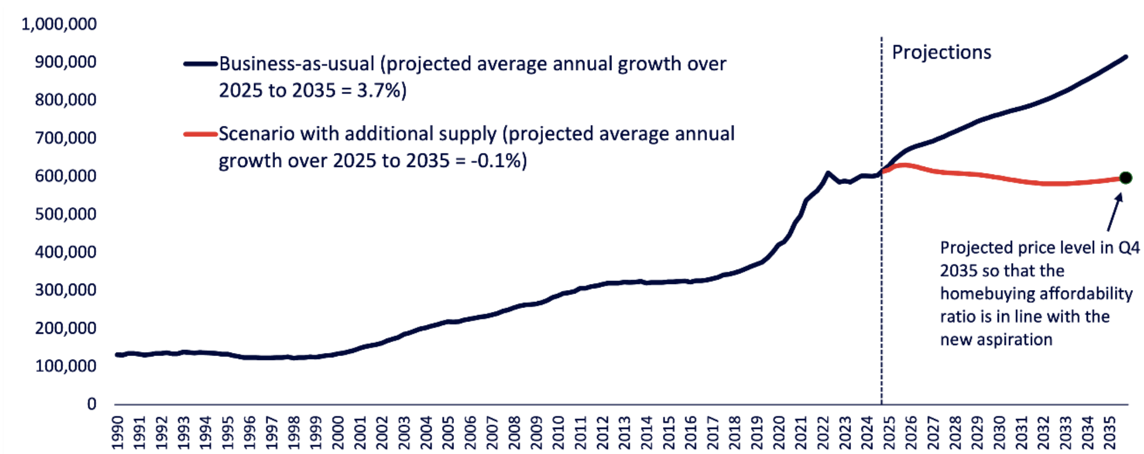
Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.36: Toronto - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



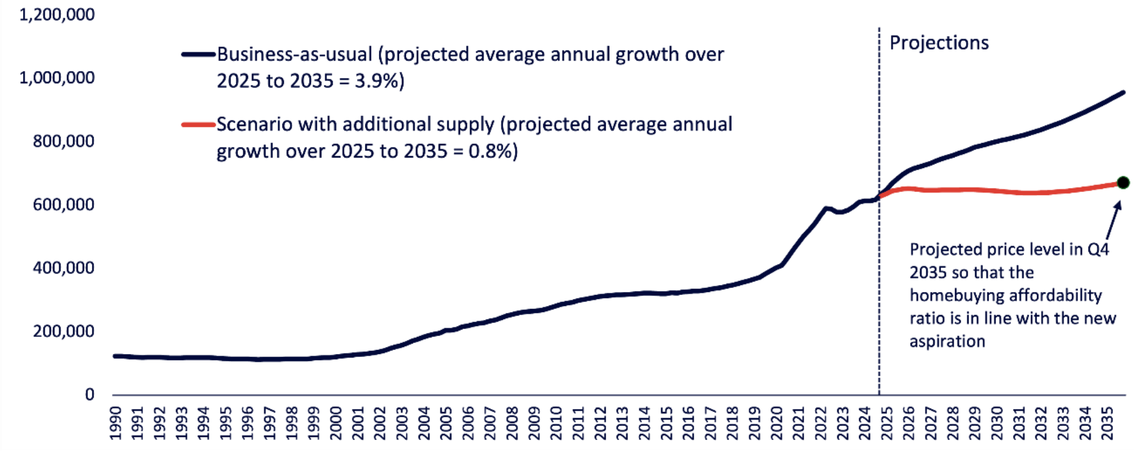
Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.37: Ottawa-Gatineau - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



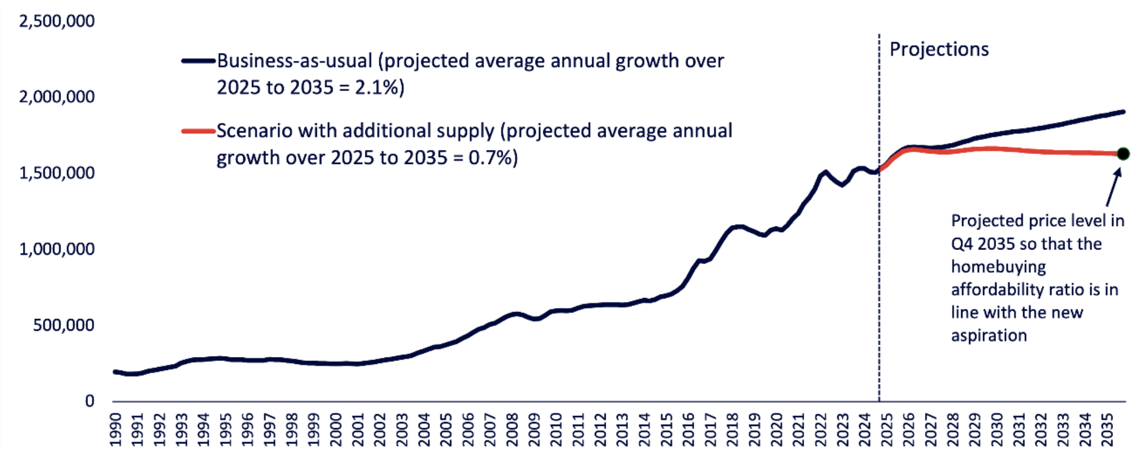
Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.38: Montréal - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



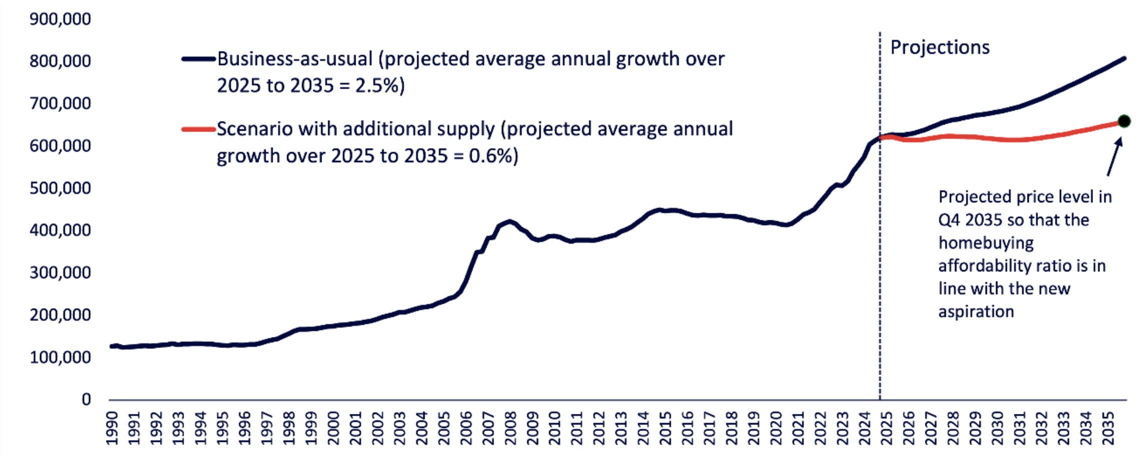
Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.39: Vancouver - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



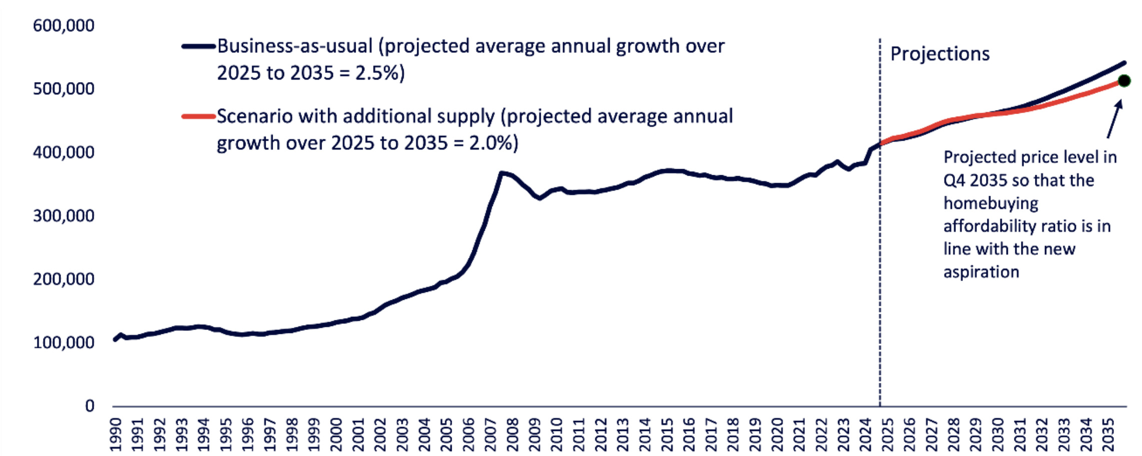
Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.40: Calgary - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

Figure 3.41: Edmonton - Historical and projected average house prices, business-as-usual and scenario with additional supply, Q1 1990 to Q4 2035, $



Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

3.3.2.3 Impact of additional supply on population mobility

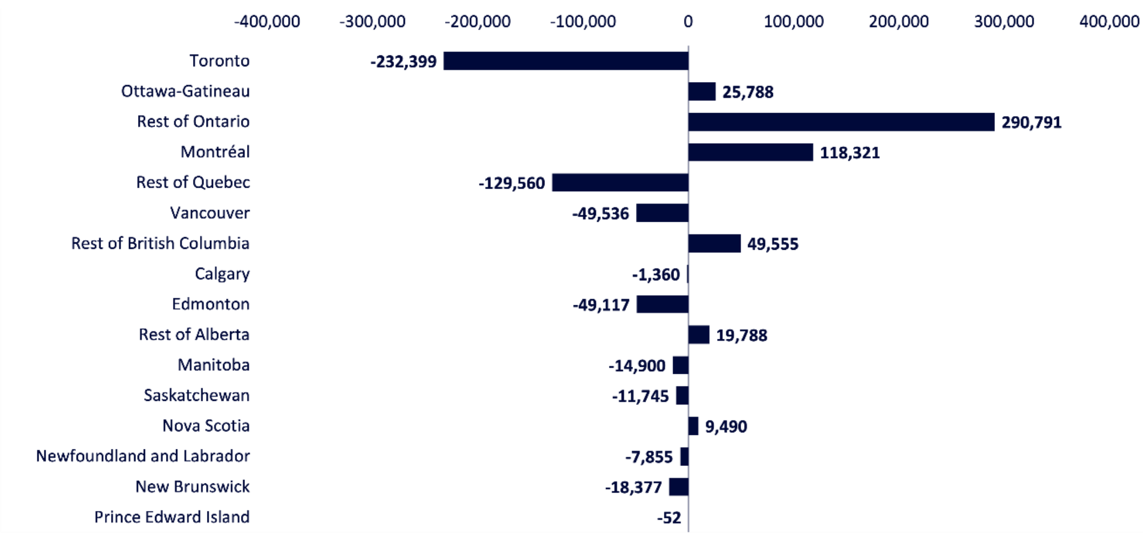
Levels of unaffordability vary greatly across regions, and so do price targets to restore the pre-pandemic level of affordability by 2035. Therefore, reaching the affordability price targets in each region implies different magnitude of increases in housing supply across regions (unbalanced expansion), as we saw in previous Section 3.3.2.1. This unbalance creates important changes in relative house prices between regions, which impacts significantly inter-regional migration flows.

The population mobility induced by relative price changes is particularly important between large metro areas and the rest of their province as relative price changes are important in determining short-distance moves, which is supported by the inter-regional migration model within the IHM. This results in significant differences in population between the business-as-usual scenario and the scenario with additional supply (Figure 3.42).

Greater supply of housing in the rest of Ontario to restore lost affordability leads to some households leaving Toronto for the rest of Ontario to benefit from reduced prices and increased housing availability.

A roughly similar pattern holds for Vancouver and the rest of British Columbia. In Quebec, as discussed earlier in Section 3.3.2.1, more population move to Montréal in the scenario with additional supply as more housing in Montréal is built to restore the affordability lost since 2019. There is less change in Alberta because there were less changes in prices and rents from the pre-pandemic period.

Figure 3.42: 16 regions - Projected difference in population between "additional-supply" and business-as-usual scenarios, 2035



Source: CMHC calculations.

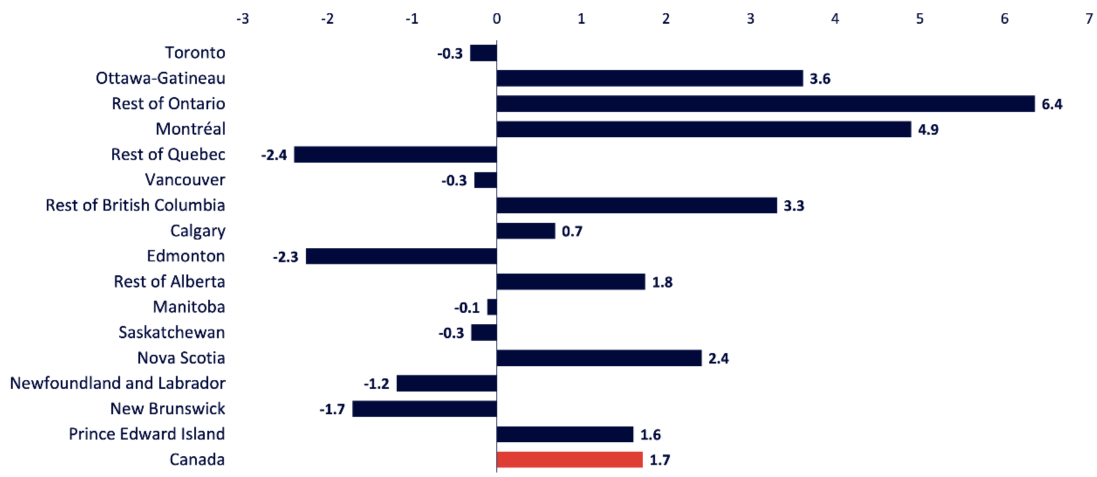
3.3.2.4 Impacts of additional supply on the number of households

As pointed out before in Section 2.3.1.2, an important elasticity in the IHM when estimating the required level of housing supply is the price elasticity of household formation (i.e., the responsiveness of household formation to a change in house prices), which is part of the household formation model.

In response to the increase in housing supply to achieve housing affordability last observed in 2019, the reduction in house prices (and consequently the improvement in affordability) influences positively the decisions of individuals to form households via the positive effect on headship rates.

This key mechanism in the IHM increases the number of households in 2035 by about 2% nationally (or about 400,000 households) relative to business-as-usual (Figure 3.43).

Figure 3.43:** Canada and 16 regions **- Projected difference in the number of households between "additional-supply" and business-as-usual scenarios, 2035, %



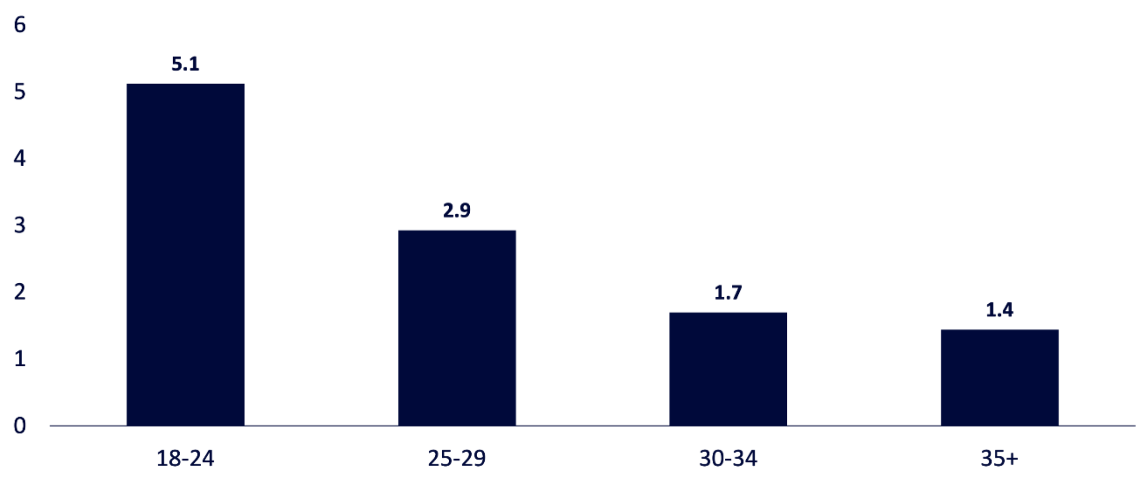
Source: CMHC calculations.

As discussed previously in Section 1.7.2.1, the household formation model within the IHM determines household formation probabilities (headship rates) at a very detailed level for a broad range of groups of individuals.

To illustrate this important element of granularity built into the IHM, Figure 3.44 reports the increase (in %) in the national number of households by age group in the scenario with additional supply relative to business-as-usual.

The results clearly show how the underlying microstructure of the household formation model, where different individual types respond differently to changes in housing and economic factors (as a result of the nonlinearity of the probit regression function), allows the IHM to properly capture the fact that younger age groups have overall lower probabilities to form households, but benefit the most from improvements in affordability.

Figure 3.44: Canada - Projected difference in the number of households between "additional supply" and business-as-usual scenarios, by age group, 2035, %



Source: CMHC calculations.

Because of the impact on population mobility between regions induced by the scenario with additional supply (which affects certain age groups more than others), the estimated impacts on the number of households by age group can be counterintuitive when we look at the results at a more regional scale.

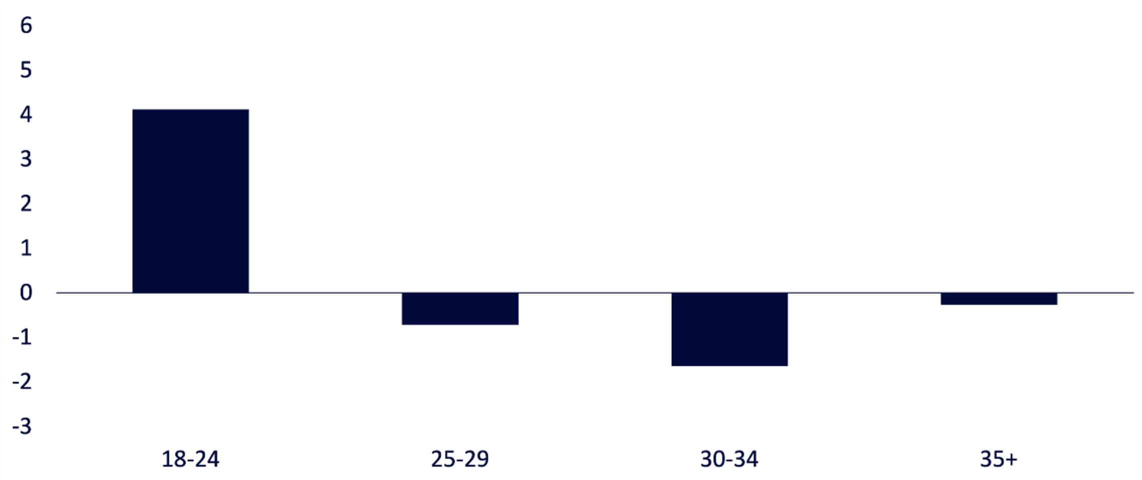
This is the case for Toronto (Figure 3.45). As discussed before, the greater supply of housing in the rest of Ontario to restore lost affordability since 2019 leads households leaving Toronto for the rest of Ontario to take advantage of lower prices. This results in a decrease of 0.3% in the total number of households in Toronto in 2035 in the scenario with additional supply relative to business-as-usual.

While the number of households aged 18-24 is higher in the scenario with additional supply relative to business-as-usual (as younger age groups benefit the most from improvements in affordability), the number of households in older groups is lower. The 25-34 age group is more negatively impacted as people in this group are more likely to move from one region to another, which is well captured by the IHM.

As seen in Figure 3.46, movers from 25 to 34 years of age represent the higher share of movers. The IHM takes this age distribution of movers into consideration when redistributing total movers into movers by age.[30]

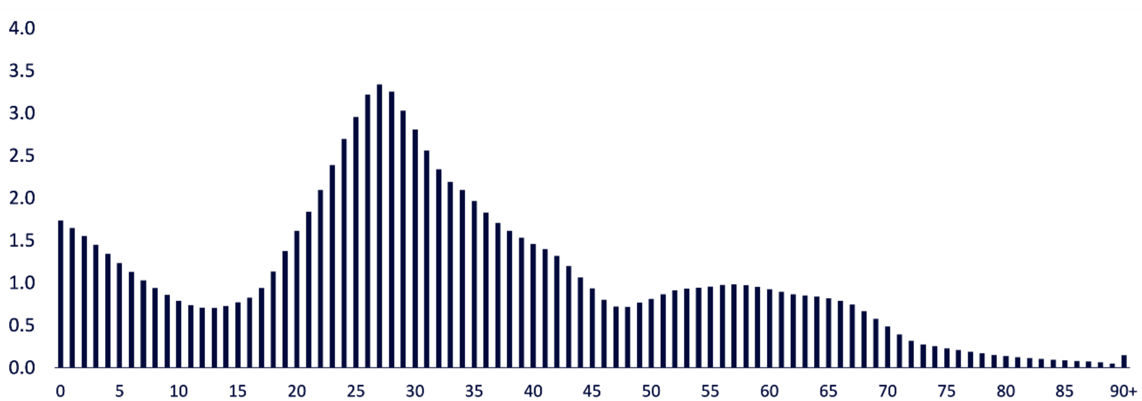
[30] The complete approach to break down inter-regional migration flows by age is detailed in Appendix 3.

Figure 3.45: Toronto - Projected difference in the number of households between "additional supply" and business-as-usual scenarios, by age group, 2035, %



Source: CMHC calculations.

Figure 3.46: Toronto - Share of out-migrants from Toronto by age, average from 2019-2020 to 2021-2022, %



Source: Statistics Canada, CMHC calculations.

3.3.2.5 Impacts of additional supply on average rents

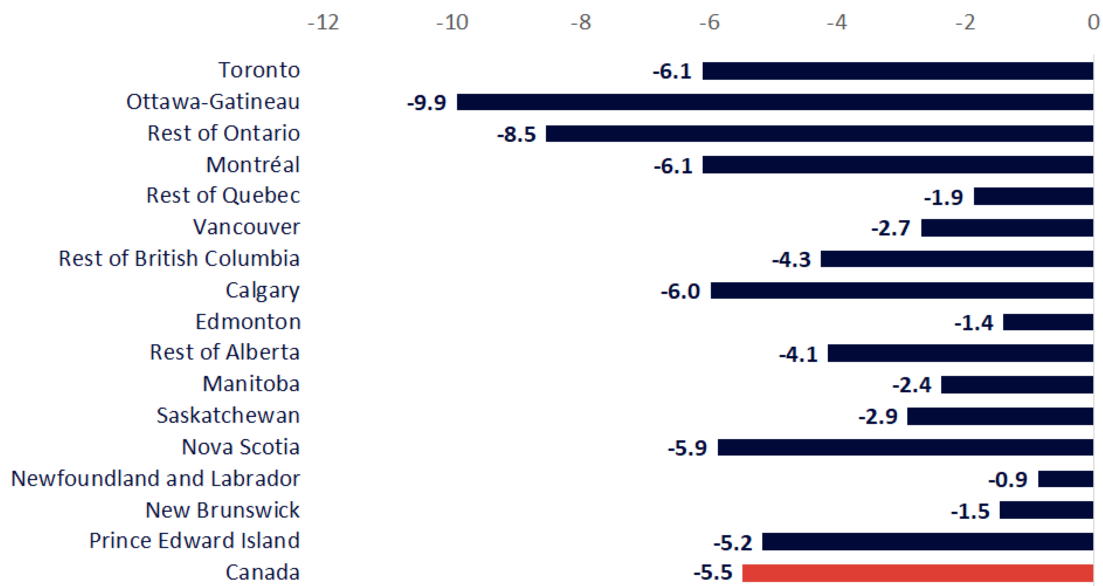
While affordability targets for the IHM model are primarily based on house prices, the framework also captures rental market conditions. The significant increase in housing supply to restore the pre-pandemic level of homebuying affordability also impacts rents, which is reported in Figure 3.47. As we can see, the negative impact on rents is larger in regions where the increase in supply is more significant.

It should be remembered that while average rents and prices both respond to changes in supply and demand and to each other in the IHM, they are based on different concepts. Average house prices instantly reflect the transactional value of properties that were sold. It isn't the case for average rents in the IHM since they capture the cost of all units, i.e., the contractual rent of currently occupied units, and the listed rent of vacant units.

As only a fraction of rental units turns over to new tenants each year, changes in listed rents have a limited impact on overall rent measures in the short-term.

Therefore, changes in home prices and rents are not directly comparable, which explains why the impact on rents is smaller in the scenario with additional supply relative to the impact on prices. While CMHC has started to report rents on turnover of units to reflect market transactions, these are currently insufficient for modelling.

Figure 3.47: Canada and 16 regions - Projected difference in rents between "additional-supply" and business-as-usual scenarios, 2035, %

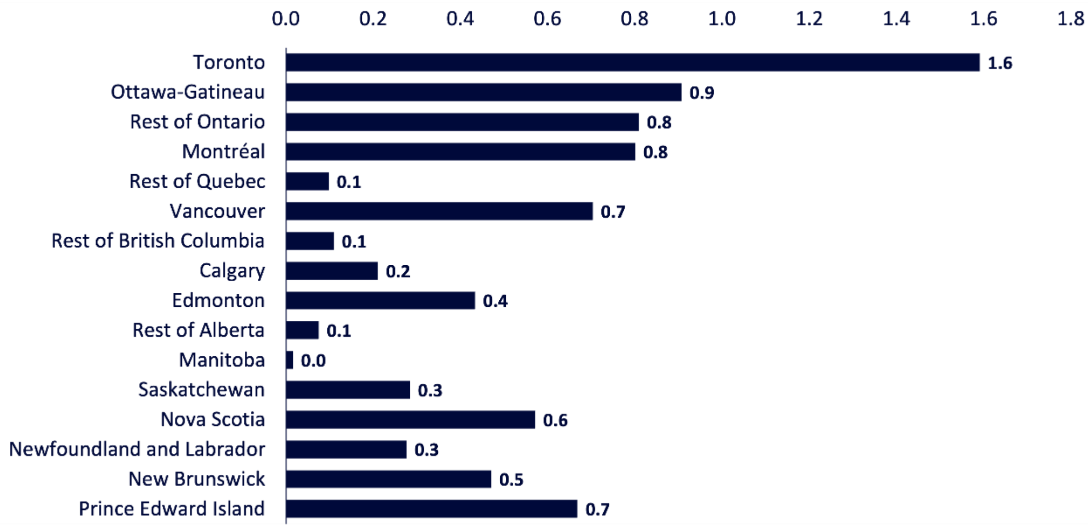


Source: CMHC calculations.

3.3.2.6 Impacts of additional supply on ownership rates

The significant increase in housing supply to lower the growth of house prices so that pre-pandemic levels of affordability is reached by 2035 leads to some renters moving to homeownership, which affects positively ownership rates in the scenario with additional supply relative to business-as-usual (Figure 3.48).

Figure 3.48: 16 regions - Projected difference in ownership rates between "additional-supply" and business-as-usual scenarios, 2035, p.p.



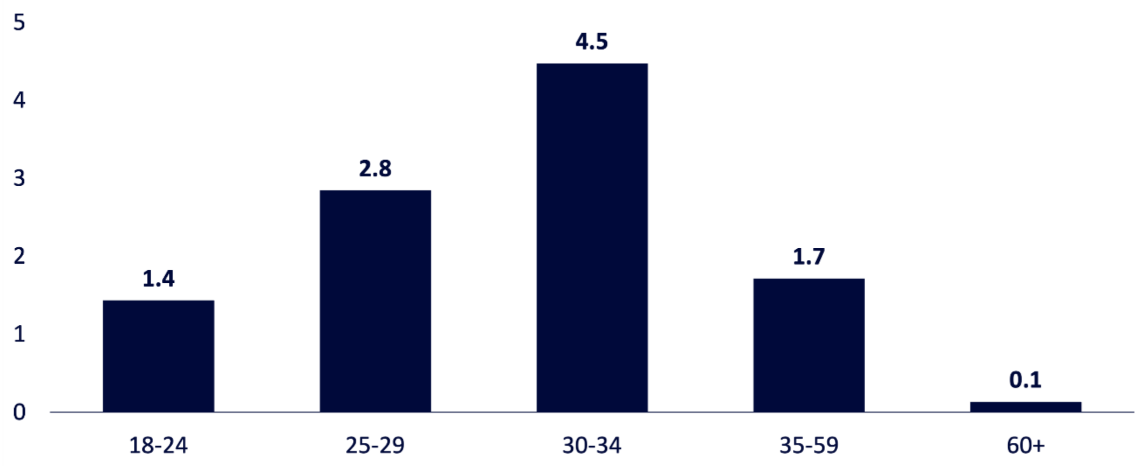
Source: CMHC calculations.

As mentioned previously, the tenure choice model within the IHM determines ownership probabilities at a very detailed level for a broad range of groups of households.

To illustrate this important element of granularity built into the IHM, Figure 3.49 and Figure 3.50 report the projected increase in ownership rates in Toronto in 2035 for different household groups (broken down by age group and income quintile) in the scenario with additional supply relative to business-as-usual. Figure 3.51 reports the projected ownership rates for different household groups in Toronto in 2035 in the business-as-usual and the "additional-supply" scenarios. These figures indicate that most increases in ownership rates induced by the scenario with additional supply occur for higher income quintiles[31] and younger households. As expected, middle-aged households respond less while the oldest household group virtually doesn't respond at all.

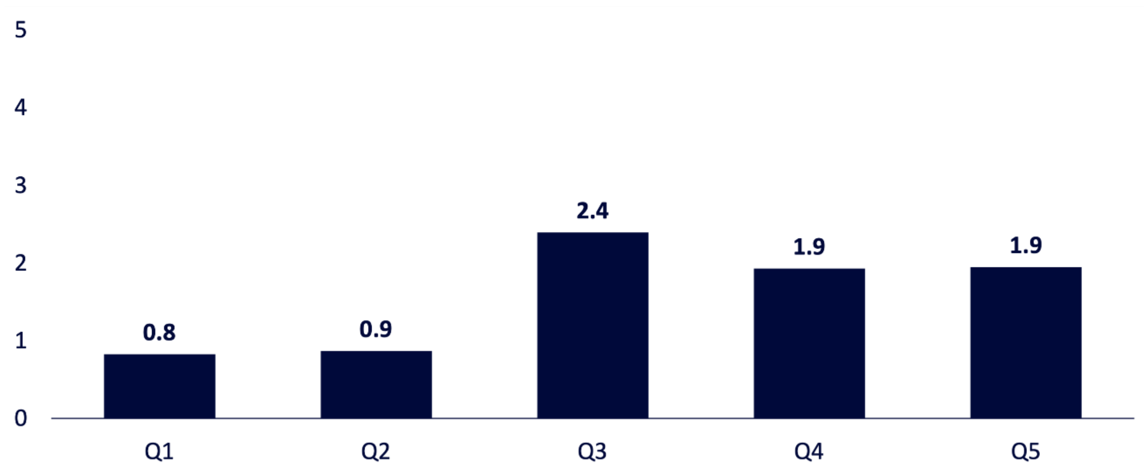
[31] Income quintiles are calculated separately for each age group. It does not correspond to the position in general income distribution.

Figure 3.49: Toronto - Difference in ownership rates between "additional-supply" and business-as-usual scenarios, by age group, 2035, p.p.



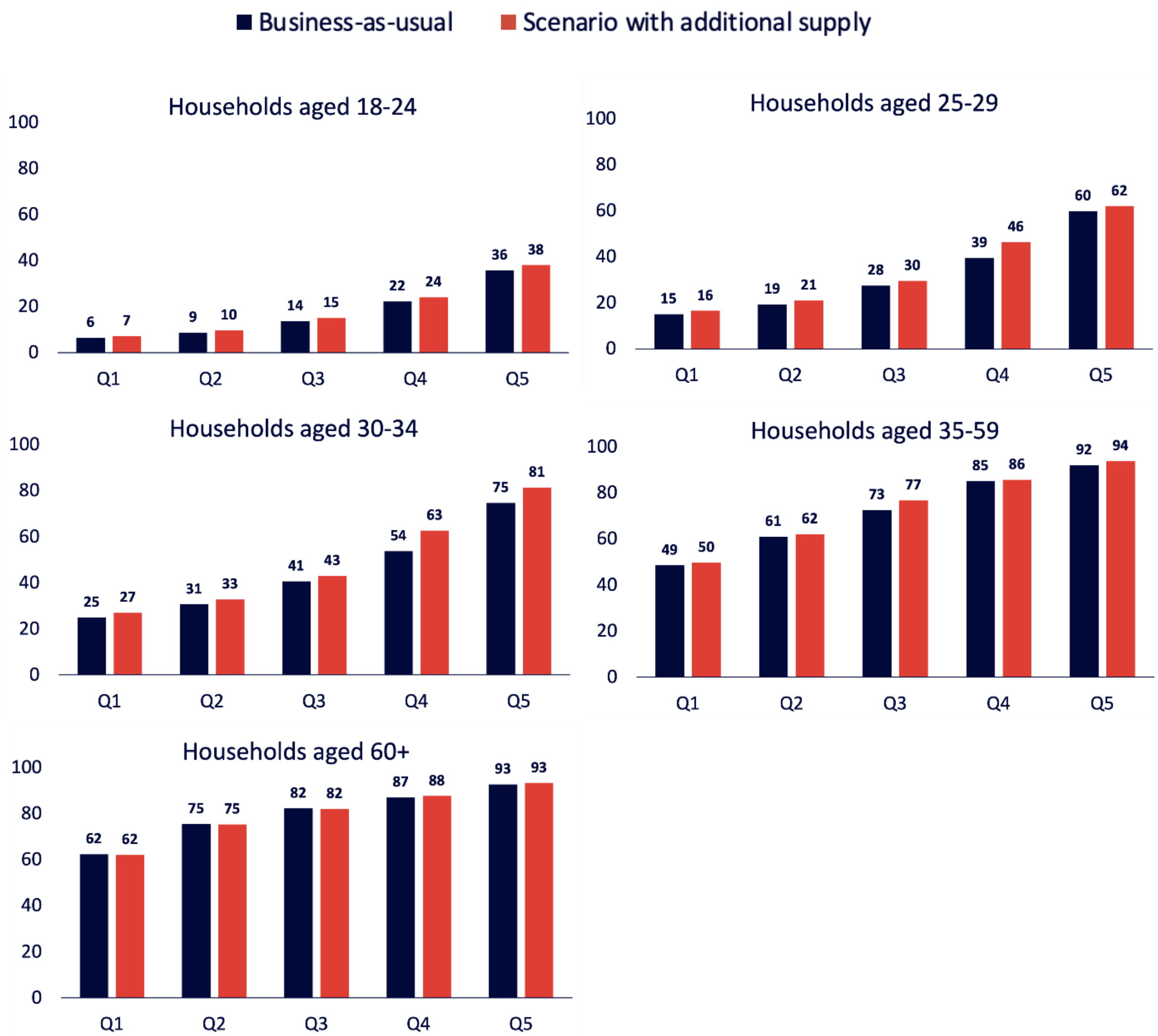
Source: CMHC calculations.

Figure 3.50: Toronto - Difference in ownership rates between "additional-supply" and business-as-usual scenarios, by household income quintile, 2035, p.p.



Source: CMHC calculations.

Figure 3.51: Toronto - Projected ownership rates for different household groups, by age groups and income quintiles, business-as-usual and scenario with additional supply, 2035, %



Source: CMHC calculations.

3.3.2.7 Impacts on households with different income levels

While much of the modelling is based on a single index value or mean value for core variables like prices and incomes, there is a need to be able to describe the impact of changing affordability conditions for households at different income levels.

One approach to evaluate the needs or impacts at various income levels would seem to be estimating a "supply gap" for different household incomes such that the overall supply gap in a given geography would be the sum of the additional units needed to achieve affordability for income group A, for income group B, C, and so on. However, housing markets don't operate in silos.

A lack of supply at any price point impacts the market as a whole. No price segment is exclusive to specific households. As such, housing supply cannot be expanded in a manner exclusively targeted to particular income groups, so estimating a “supply gap” by income doesn’t make sense.

Instead, the approach taken is to evaluate how total additional housing supply may impact households at different points in the income distribution, primarily by describing how their “options” have changed. In particular, we monitor the share of the ownership and rental housing markets that would be “qualifiable” (in the case of ownership) or “affordable” (in the case of rental) for them.

As additional supply is added to the market, there are changes throughout the house price (and rent) distributions. For instance, a larger proportion of units becomes qualifiable or affordable with a lower income level. These changes depend on the shape of the price and rent distributions.

Appendix 9 describes in detail how we make use of several simplifying assumptions in order to describe how changing supply might result in changing outcomes for households at various income levels.

The extent to which households at different income levels can buy a housing unit is assessed by comparing the projected maximum purchase price a household could qualify for given different income percentiles with the projected price distribution in the business-as-usual and “additional-supply” scenarios.

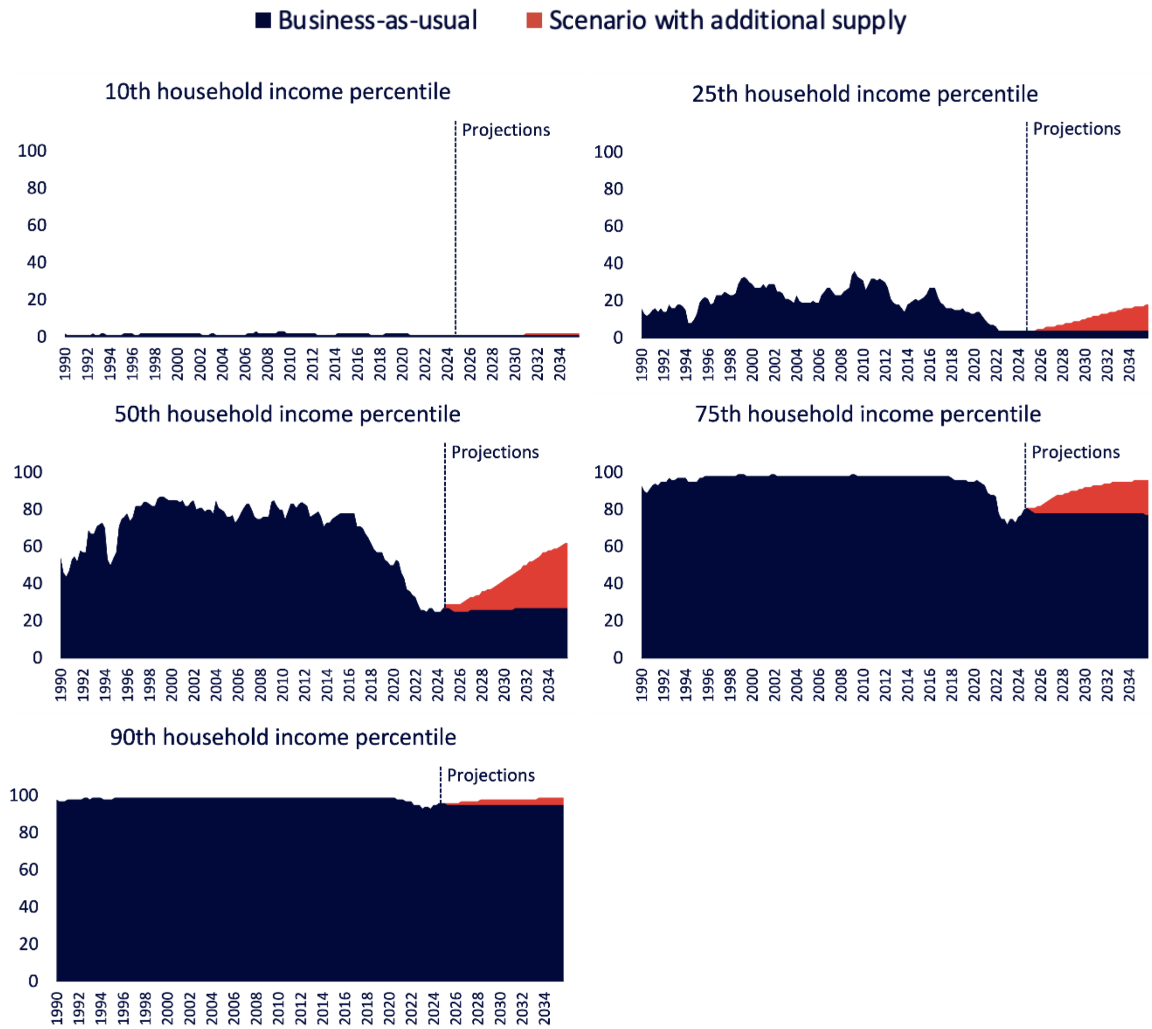
An example of the results generated by this exercise is illustrated in Figure 3.52 for Ottawa-Gatineau. It shows the historical and projected proportion of units in the ownership market that are attainable (“qualifiable”) for households at different income percentiles in the business-as-usual compared to the “additional-supply” scenarios from 1990 to 2035.

As expected, the scenario with additional supply leads to a much larger proportion of attainable units over 2025 to 2035 for households earning the 25^{th}, 50^{th} and 75^{th} income percentiles. The proportion of attainable units for these households in 2035 is close to what it was in 2019, before affordability started eroding significantly.

The proportion of attainable units in the ownership market for a household earning the 10^{th} income percentile (first figure from the left) remains very low under the scenario with additional supply. However, homebuying affordability for these low-income households has always been very low as most of these low-income households are living in the rental market.

In contrast, the proportion of attainable units in the ownership market for households earning the 90^{th} income percentile has always been very high (last figure), despite the sharp increase in housing costs since the pandemic.

Figure 3.52: Ottawa-Gatineau - Historical and projected proportion of housing units that are attainable in the ownership market for households at different income levels, business-as-usual and scenario with additional supply, 1990 to 2035, %



Source: CMHC calculations.

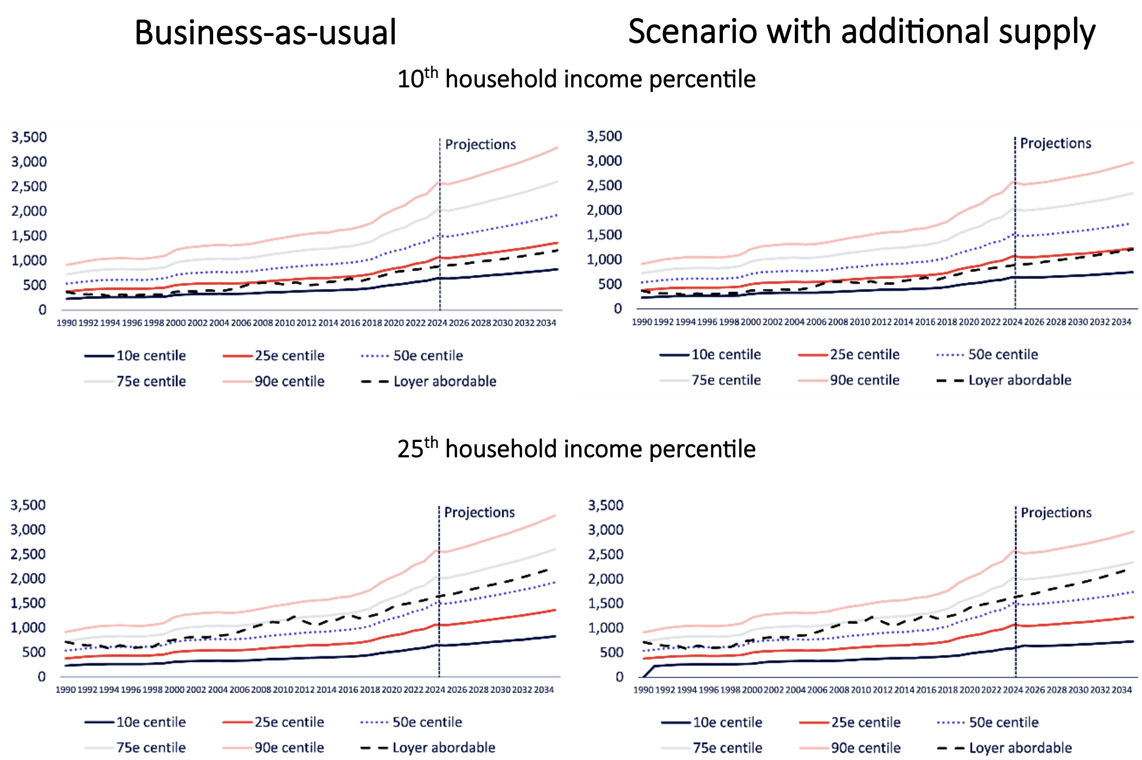
The extent to which households at different income levels can afford to rent units is assessed by comparing the maximum rent a household should not exceed given its income level (using the basic 30% standard) at different income percentiles with the projected rent distribution in the business-as-usual and "additional-supply" scenarios.

An example of the results generated by this exercise is illustrated in Figure 3.53 for Ottawa-Gatineau. The black dotted line in each figure represents the maximum rent a household earning the Xth income percentile should not exceed (i.e., 30% of their gross income).[32]

As can be seen, for households earning the 10th and 25th income percentile, the scenario with additional supply relative to business-as-usual leads to a larger proportion of rental units being priced below levels attainable. That is, the maximum affordable rent for these households gets higher up the rent distribution.

Results are exclusively illustrated for households earning the 10th and 25th income percentile as the maximum "affordable" rent for households earning the 50th income percentile in Ottawa-Gatineau is already higher than the rent at the 90th percentile of the rent distribution.

Figure 3.53: Ottawa-Gatineau - Historical and projected proportion of rents that are affordable for households at different income levels, business-as-usual and scenario with additional supply, 1990 to 2035, %



Source: CMHC calculations.

[32] It should be mentioned that the IHM does not distinguish between social and private rentals.

3.3.2.8 Distributing projected additional housing starts required to restore affordability by tenure

This section describes how we make use of several simplifying assumptions and results generated by the tenure choice model to break down additional housing starts estimates by tenure.

First, it should be stressed that when supply is exogenously increased in the IHM, no assumption is made on the composition of supply in the model, i.e. ownership vs. rental units. However, the demand for ownership and rental housing is projected in the tenure choice model based on house prices, rents and other economic factors over the projection horizon. It is then assumed that these additional housing units should be distributed according to this future projected demand.

Consequently, the important assumption (and caveat) is that all housing units have the same impact on house prices. In fact, since the IHM relies on an empirical exercise (coefficients are derived from econometric estimations based on historical data) to capture the past linkages between key variables, all simulations performed in this document implicitly assume that the new housing supply built over the projection horizon reflects past experiences (on average over the historical period). This is both in terms of the types of units constructed and their impact on house prices.

As noted in the previous Section 3.3.2.5, the significant increase in housing supply required to restore homebuying affordability to levels seen just prior to the pandemic in both sectors in 2035 leads to some renters moving to homeownership, which affects positively ownership rates in the scenario with additional supply relative to business-as-usual.

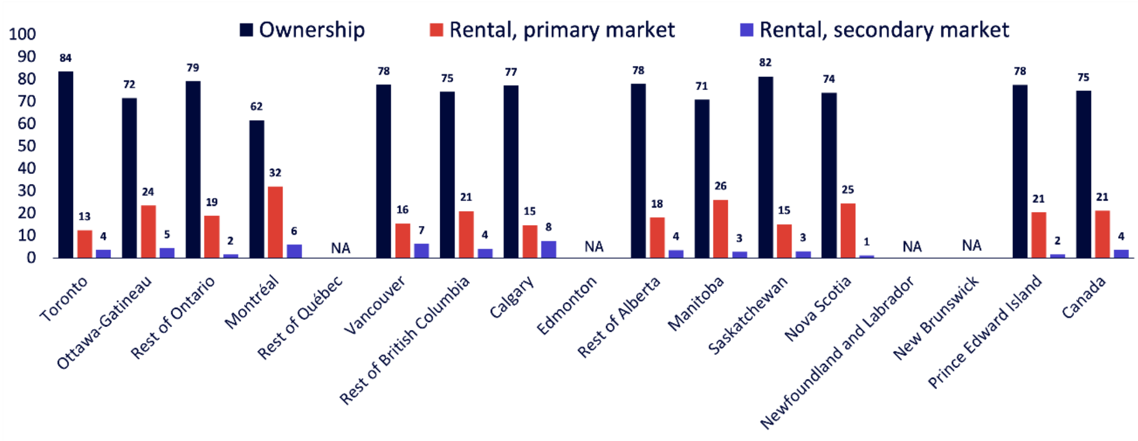
The resulting projected ownership and renting rates from the tenure choice model for the business-as-usual and “additional-supply” scenarios allow us to break down the housing stock by tenure in 2035 under both scenarios by matching the distribution of the housing stock between the owner-occupied and rental sectors to the projected ownership and renting rates. By doing so, vacancies are assumed to be distributed the same way.

Then, the difference in the housing stock in 2035 between the “additional-supply” scenario and business-as-usual scenario in the ownership and rental sectors gives directly the distribution of the additional housing starts (beyond business-as-usual) required to restore the pre-pandemic level of affordability in both sectors in 2035 (Figure 3.54)[33].

Because housing starts are a flow, and the ownership housing stock is large, the small rise in ownership rates implied by the scenario with additional supply has a sizeable impact on how additional housing starts are distributed toward homeownership until 2035.

[33] The shares of rented dwellings that are part of a condominium in all rented dwellings from the 2021 census are used to break down additional housing starts required between the secondary and primary rental markets.

Figure 3.54: Canada and 16 regions - Projected shares of total additional annual housing starts (beyond business-as-usual), 2025 to 2035, by tenure, %



Source: CMHC calculations.

Chapter 4: Further scenarios

Although the IHM is significantly more complex than the prior analytical framework, it is still an oversimplification of reality. While many key elements of reality can be directly determined within the model as endogenous variables, others have to be treated as independent of the rest of the model (i.e., not determined within the structure of the model) or simply ignored, because, for example, the data is not available.

Therefore, point estimates generated by the IHM must be taken for what they are: a support to think in a more consistent way when assessing the effects of different scenarios. They are not providing exact predictions.

This fourth chapter explores how sensitive the results presented in Section 3.3 are when the responsiveness of households to lower house prices and to higher income are reduced in the IHM (Section 4.1). These two key elasticities of housing demand have important implications on the estimated number of units required to achieve predefined affordability price targets in the future (see Section 2.3).

To illustrate how the IHM can be used to conduct a broader range of economic, demographic and policy shock scenarios, the impact on affordability of improving productivity in the construction industry is also described in this fourth chapter (Section 4.2).

In the shock scenario performed in Section 3.3, the government is assumed to have the capacity to significantly increase housing supply like a policy instrument to meet predefined affordability price targets. Unlike this scenario, the one explored in Section 4.2 can be seen as a “real-life” scenario in the sense that the increase in productivity that leads to lower prices has a dampening effect on the incentive to build more housing.

4.1 Sensitivity scenarios

Two sensitivity scenarios are performed in this section to explore how sensitive results presented in Section 3.3 are. We focus on the impact from reducing the responsiveness of households to lower house prices and to higher income. To do so, two key elasticities of housing demand in the IHM are reduced:

- the price elasticity of housing demand (Section 4.1.1) and
- the income elasticity of housing demand (Section 4.1.2)

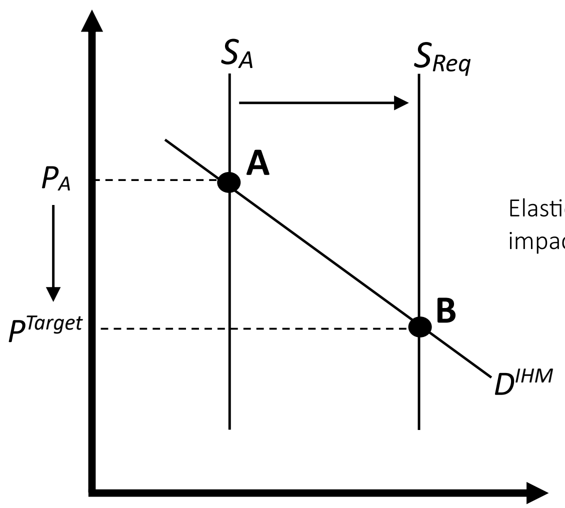
4.1.1 Reducing the responsiveness of households to house prices

As explored in detail in previous Section 2.3.1, when housing supply is increased to reach a predefined affordability price target in the IHM, the rise in housing demand induced by lower house prices considers the:

- increased demand for housing by existing households, via the price elasticity of housing demand ($-\alpha_2$ defined in Section 2.3.1.1) and
- increased demand for housing by new households being formed, via the price elasticity of new household formation ($-\theta_2$ defined in Section 2.3.1.2)

Abstracting away population mobility, the sum of these two key price elasticities of housing demand represents the elasticity of the demand curve in the IHM (Figure 4.1).

Figure 4.1: Supply and demand dynamic implied by the IHM

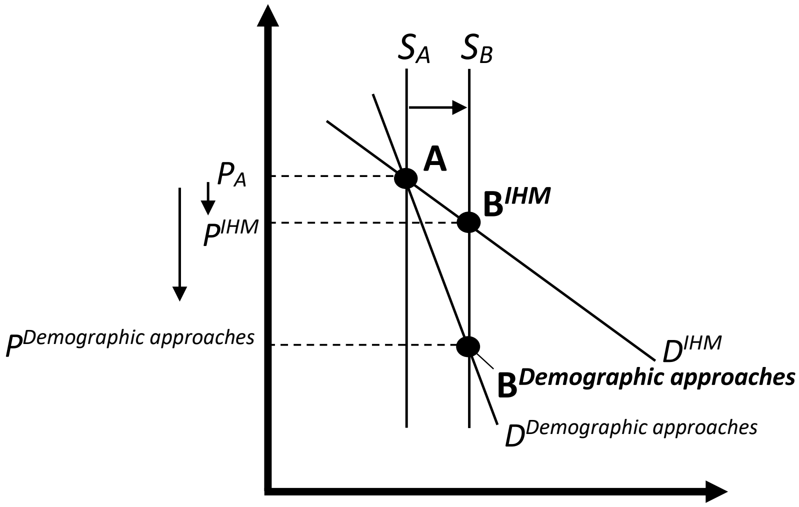


Elasticity of the demand curve in the IHM, abstracting for the impact on inter-regional migration flows $= -(\alpha_2 + \theta_2)$

As discussed in Section 2.2.1, by accounting for the increased demand from both existing households and new households being formed (i.e., supressed households) when estimating the impact of additional supply on house prices, a more elastic demand curve is assumed by the IHM (D^{IHM}) relative to demographic approaches ($D^{Demographic\ approaches}$ on Figure 4.2).

Therefore, for the same increase in housing supply from S_A to S_B (Figure 4.2), the IHM implies a smaller decrease in house prices relative to demographic approaches. As a result, the net addition to the housing stock to meet the predefined affordability price target is larger in the IHM.

Figure 4.2: Dynamics between IHM and demographic approaches



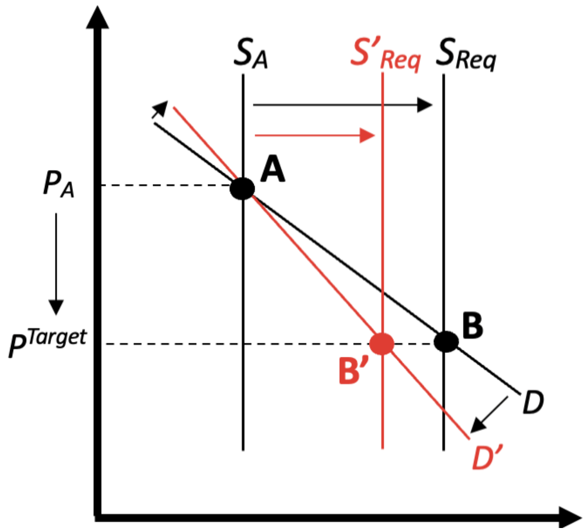
If the price elasticity of demand currently estimated in the IHM is too large, then the responsiveness of existing households and new households being formed to lower prices would be lower in reality and less housing would need to be built relative to the "additional-supply" scenario presented in Section 3.3.

To explore this idea, we can artificially lower the price elasticities of housing demand by existing households and new households being formed to their minimum value we can expect from a statistical point of view. That is, using the normal distribution and the standard error of the estimated econometric coefficients corresponding to $-\alpha_2$ and $-\theta_2$, we reduce these two key parameters to their lowest plausible levels with 95% confidence.

Essentially, a lower price elasticity of demand in the IHM makes the demand curve less elastic (red demand curve D' on Figure 4.3). That is, as supply increases from the supply curve S_A to the red supply curve S'_{Req} (Figure 4.3), the increase in housing demand by existing households and new households being formed given lower house prices is reduced.

For that reason, it requires fewer additional supply units (difference between B' and **B** on Figure 4.3) to reach the predefined affordability price target P^{Target}.

Figure 4.3: Reducing the responsiveness of households to prices in the IHM[34]

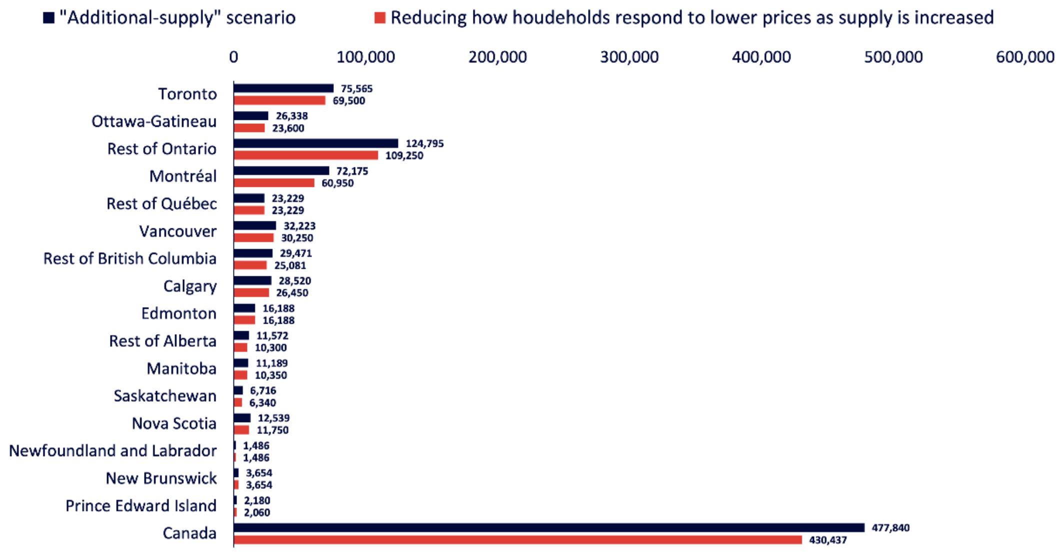


Reducing in the IHM the responsiveness of existing households and new household being formed to lower house prices to its lowest plausible level decreases by 10% the national level of annual housing starts required to restore the pre-pandemic level of affordability, from about 478,000 units to 430,000 units over 2025 to 2035 (Figure 4.4).

Consequently, it reduces how much additional annual housing starts (beyond business-as-usual) are required by 20%, from around 233,000 units to 185,000 units nationally over the same period (Figure 4.5). While this is a large difference in absolute terms, the underlying theme of the need for more housing supply remains intact.

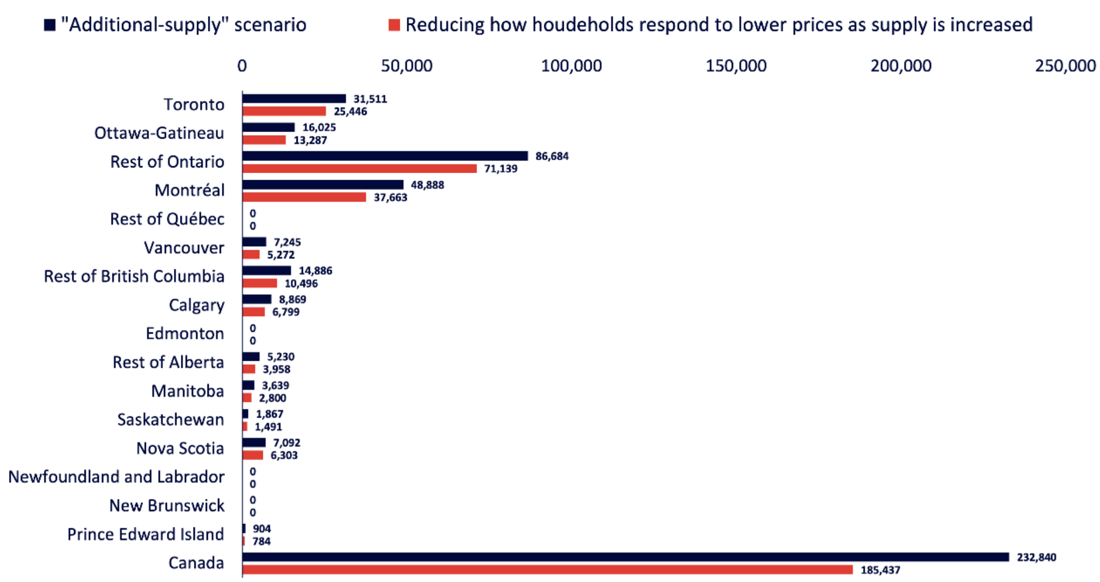
[34] Reducing the responsiveness of households to house prices also increases the projected house prices in the business-as-usual scenario. As a result, the reduction in the level of housing starts required to restore 2019 affordability levels from making the demand less elastic is mitigated, with the consequence of producing counterintuitive results for some regions. For that reason, the mitigating factor has been removed by adjusting a few parameters in the IHM, so that the projected house prices in business-as-usual are not affected from reducing the responsiveness to prices for all 16 regions. That is, the "pivot point" of the demand curve has been set at point **A** in Figure 4.3 for all regions.

Figure 4.4: Canada and 16 regions - Impact of reducing price responsiveness: projected annual housing starts, 2025 to 2035



Source: CMHC calculations.

Figure 4.5: Canada and 16 regions - Impact of reducing price responsiveness: projected additional annual housing starts (beyond business-as-usual), 2025 to 2035



Source: CMHC calculations.

4.1.2 Reducing the responsiveness to income

As discussed in Section 2.3.2, existing households demand more housing services than they currently hold as their income rises, an effect incorporated in the IHM. Technically speaking, this effect stems from the fact that the income elasticity is higher than the price elasticity of demand. As a result, only matching supply to the number of households (the need) over time implies higher prices and worsening affordability, unless other variables operate.

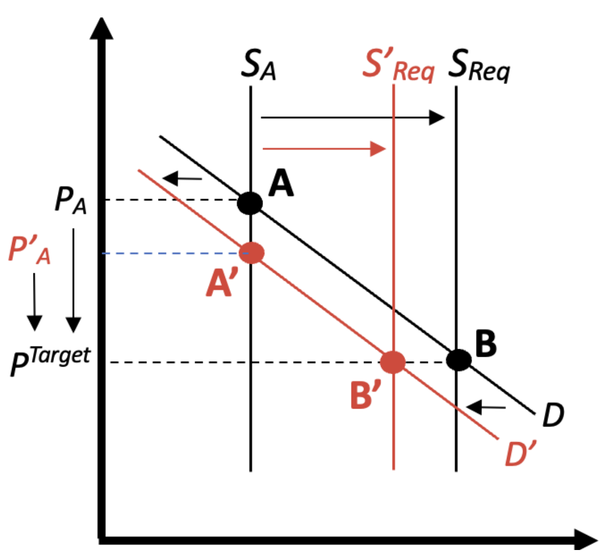
If the income elasticity of demand currently estimated in the IHM is too large, then the responsiveness of households to higher income would be lower in reality and less housing would need to be built relative to the “additional-supply” scenario presented in Section 3.3.

To examine this idea, we can artificially lower this responsiveness in the IHM to the minimum value we can expect from a statistical point of view. That is, using the normal distribution and the standard error of the estimated econometric coefficients corresponding to the income elasticity of demand, we reduce it to its lowest plausible levels with 95% confidence.

Essentially, a lower income elasticity of demand implies a lower increase of housing demand by existing households as their income rises. That means a movement of the demand curve to the left relative to the base model in the IHM, i.e., from *D* to *D’* (Figure 4.6).

This lower demand for housing reduces the projected prices in business-as-usual in 2035, from P_A to P'_A and the new equilibrium in business-as-usual goes from **A** to **A’**. For that reason, reducing the responsiveness to income decreases the number of additional supply units required to reach the predefined affordability price target P^{Target} (difference between **B’** and **B** on Figure 4.6). Housing supply increases from S_A to S'_{Req}.

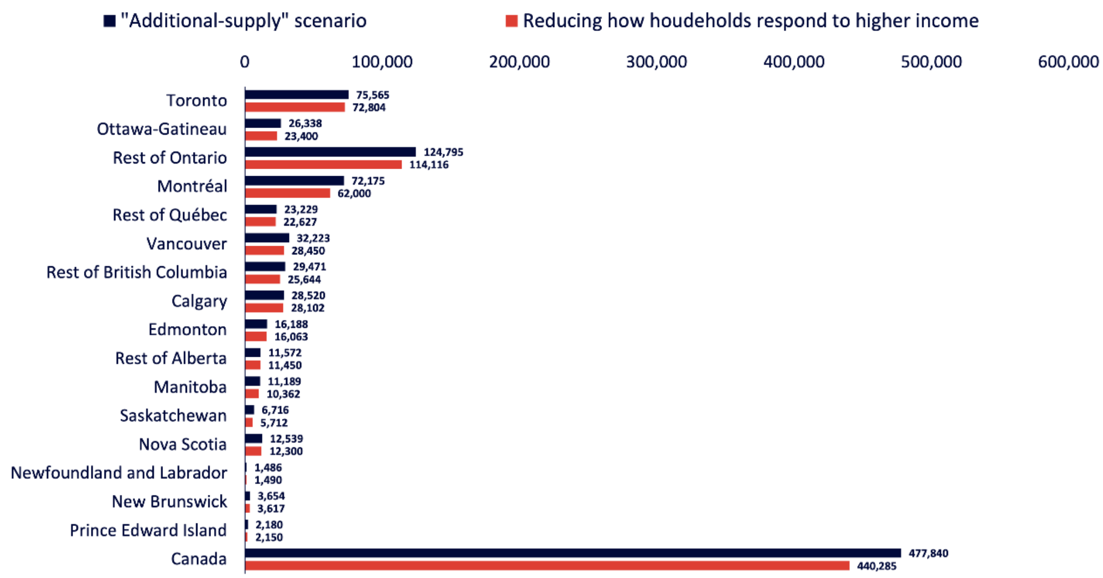
Figure 4.6: Reducing the responsiveness of households to income in the IHM



Reducing in the IHM the responsiveness of households to higher income to its lowest plausible level decreases by 8% the national level of annual housing starts required to restore the pre-pandemic level of affordability, from about 478,000 units to 440,000 units over 2025 to 2035 (Figure 4.7).

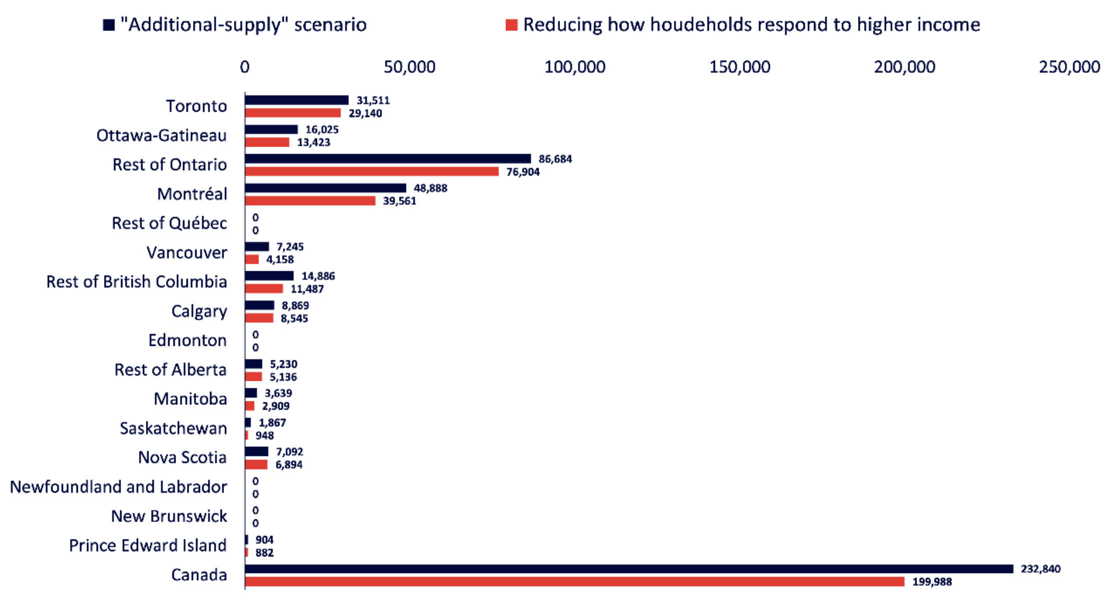
Consequently, it reduces how much additional annual housing starts (beyond business-as-usual) are required by 14%, from around 233,000 units to 200,000 units nationally over the same period (Figure 4.8).

Figure 4.7: Canada and 16 regions - Impact of reducing responsiveness to income: projected annual housing starts, 2025 to 2035



Source: CMHC calculations.

Figure 4.8: Canada and 16 regions - Impact of reducing responsiveness to income: projected additional annual housing starts (beyond business-as-usual), 2025 to 2035



Source: CMHC calculations.

4.2 Improving productivity in the construction industry

4.2.1 The IHM is much more than a supply gap model

As mentioned in the introduction of this document, the IHM is a reliable and consistent integrated framework designed for forecasting and shock scenario analysis. The IHM can be used to perform a broad range of different economic, demographic and policy shock scenarios to support other functions at CMHC.

To illustrate potential uses, we simulate in Section 4.2.3 the impact on affordability of improving productivity in the construction industry. This shock scenario represents only one example of many simulations that can be conducted with the IHM in order to examine key demographic, economic and policy questions.

In reality, several exogenous variables can be shocked within the IHM to assess the effect of alternative scenarios. For example, the IHM can be used to explore the impact on housing and demographic variables from changes on:

- mortgage rules, like increasing the maximum amortization period from 25 to 30 years, reducing insurance premiums for developers, etc.
- immigration rates (at a very granular level and both permanent and non-permanent), which impacts the growth in young Canadians, the number of households that can form, and the number of future internal migrants[35]
- economic variables that feed many equations in the IHM, such as mortgage rate, short-term interest rate, unemployment rate, GDP, income, etc.
- and many more

The challenge when running shock scenarios is to make sure that the appropriate variable (the right trigger), in conjunction with other variables sometimes, is shocked with the appropriate corresponding transmission channels in the rest of the model. Sometimes, the variable to be shocked is not directly within the IHM, but alternative methods can be used to replicate the shock scenario in order to examine a specific question.

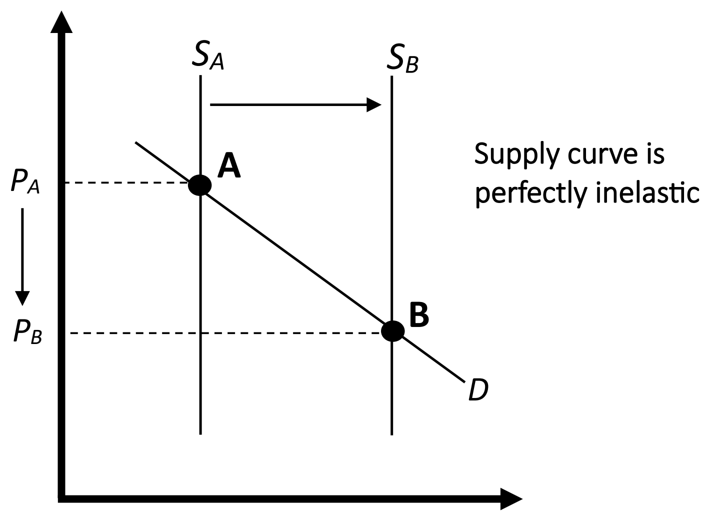
4.2.2 Difference between the productivity shock and "additional-supply" scenarios

The "additional-supply" scenario explored in Section 3.3 assumes that the government has the capacity to significantly increase housing supply like a policy instrument to meet predefined affordability price targets.

[35] There is an important element of heterogeneity in the population model built into the IHM, which is the differential exposure to international immigration. For that reason, when performing shocks on immigration rates, the population changes more in centers that are more exposed to immigration, like Toronto, Vancouver, and Montréal and in younger age groups as immigrants are typically in the first-time homebuyer's bracket.

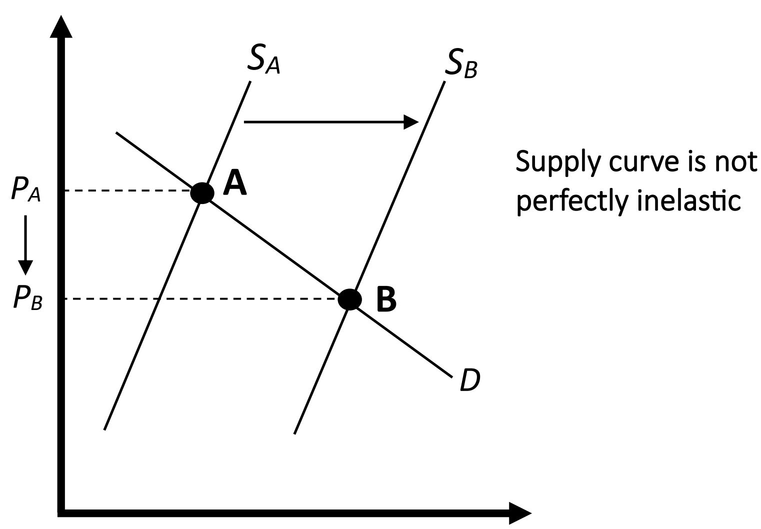
In such a scenario, the housing supply curve is perfectly inelastic (Figure 4.9) because housing supply is exogenously increased so that the housing starts model in the IHM is muted and not part of the long-run adjustment process in the housing system of the IHM.

Figure 4.9: Scenario where supply is exogenously increased



However, when shocking a determinant of housing starts in the IHM, they react to changes in other variables following the shock, including changes in house prices. Therefore, increases in productivity leading to lower prices would have a dampening effect on the incentive to build more housing in the IHM. This dampening effect on housing starts and house prices is reflected by the non-perfectly inelastic supply curve in Figure 4.10.

Figure 4.10: Scenario where the productivity is increased



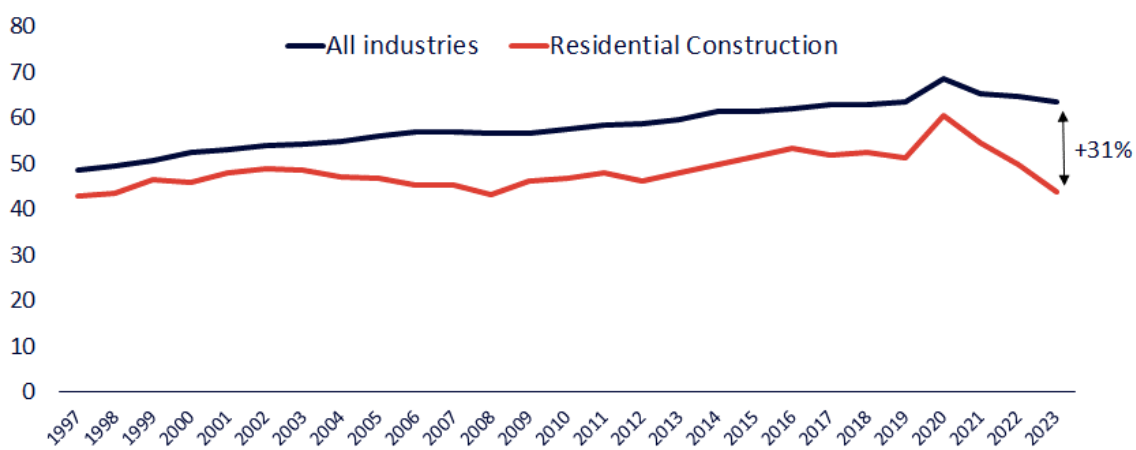
4.2.3 Impact of improving productivity in the construction industry

An improvement in productivity would imply more housing being constructed with the same number of workers. Since productivity is not explicitly modeled in the housing starts model built within the IHM, we implement an equivalent negative shock on the cost of labour, a key determinant of housing starts.

To illustrate the potential benefits of improving productivity, we look at the impacts of:

- a 10% increase in the productivity of the construction industry and
- a 31% increase in the productivity of the construction industry to match the average level of productivity across all industries (Figure 4.11)

Figure 4.11: Canada, labour productivity in the residential construction sector and all industries, $/hour



Source: Statistics Canada.

The 10% and 31% productivity improvements from the current workforce would respectively increase the national level of housing starts by about 7% and 21% over 2025 to 2035 relative to the business-as-usual scenario. This represents an average of 262,000 and 296,000 housing starts annually over the same period relative to an average of 245,000 units in business-as-usual (Figure 4.12).

The national level of housing stock would be higher by 1% (or about 190,000 units) and 3% (or about 520,000 units) respectively relative to the business-as-usual scenario in 2035 (Figure 4.13).

As expected, the higher level of housing supply would reduce the growth in house prices in both scenarios. The national level of average house prices would decline by 2% and 6% respectively relative to business-as-usual in 2035 (Figure 4.14).

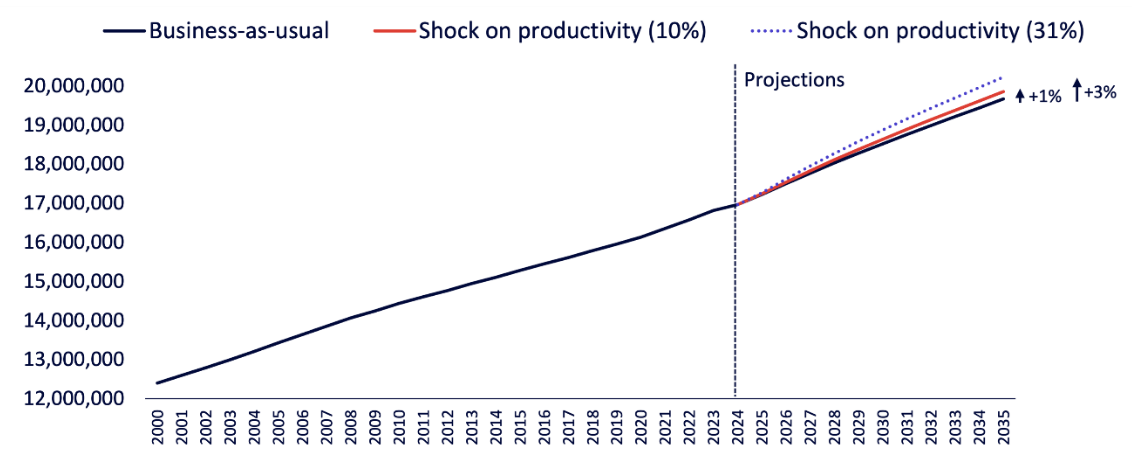
Since the IHM is an equilibrium framework, this reduction in house prices relative to business-as-usual would lower the level of investment in residential construction, as lower house prices provide a disincentive to the residential construction sector to build more housing.

Therefore, while housing supply is higher, house prices are lower, which maintains housing starts to a lower level than they would be without the decrease in house prices. This dampening effect on housing starts and house prices is taken into account in results presented below.

Figure 4.12: Canada, historical and projected housing starts over 2000 to 2035, business-as-usual, shock on productivity (10%) and shock on productivity (31%)

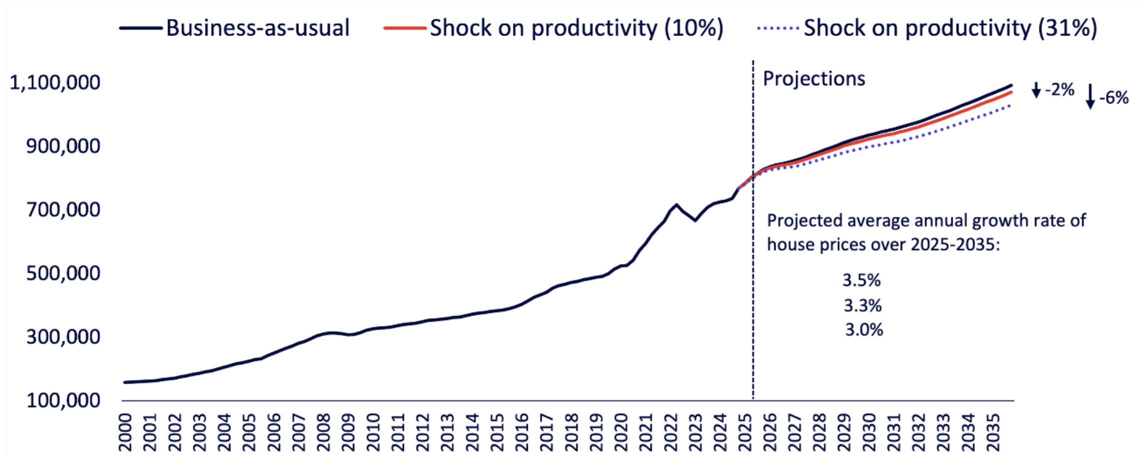
Source: CMHC calculations.

Figure 4.13: Canada, historical and projected housing stock over 2000 to 2035, business-as-usual, shock on productivity (10%) and shock on productivity (31%)



Source: Statistics Canada, CMHC calculations.

Figure 4.14: Canada, historical and projected average house prices over 2000 to 2035, business-as-usual, shock on productivity (10%) and shock on productivity (31%), $



Source: CMHC calculations.
Note: Average house prices ($) represent the average price of a fixed basket of residential properties with changes in value based on a CMHC repeat sales price index. This is a different price measure than projected in the CMHC Housing Market Outlook (HMO) publication.

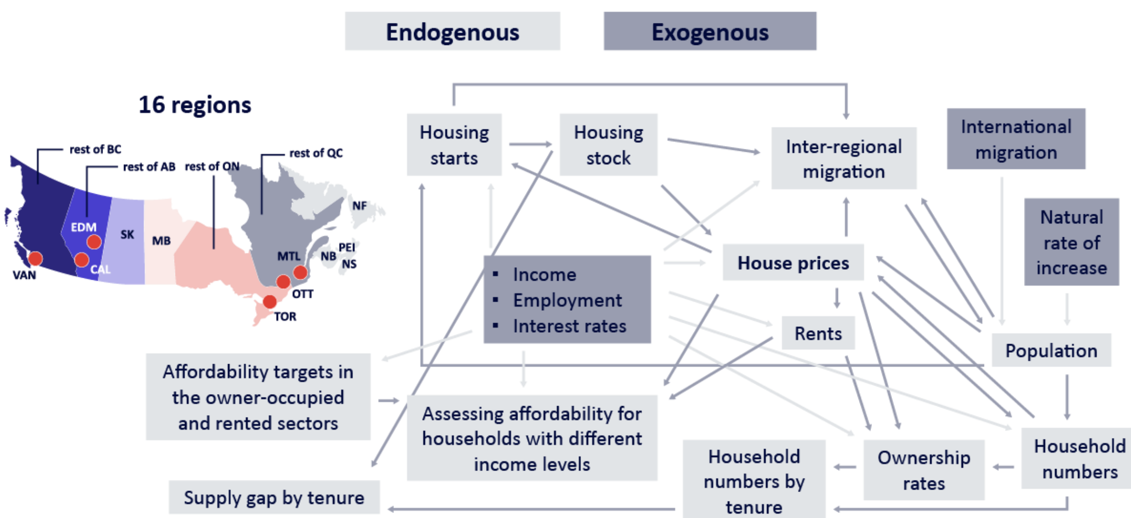
Appendices: Sub-models of the IHM

The appendices describe the sub-models underlying the IHM (illustrated in Figure A):

- house price model (Appendix 1)
- housing starts model (Appendix 2)
- inter-regional migration model (Appendix 3)
- population framework (Appendix 4)
- household formation model (Appendix 5)
- tenure choice model (Appendix 6)
- rent model (Appendix 7)
- exogenous economic variables (Appendix 8)

This Appendix also discusses in more detail the affordability targets developed in the owner-occupied and rental sectors, the attainable targets by income percentile and the distribution of prices, rents and income that allows to assess how additional supply impacts affordability across the income distribution (Appendix 9).

Figure A: Flow chart of the IHM: relations between endogenous and exogenous variables



Appendix 1: House price model

The house price model identifies the relationship between housing stock, number of households, income, mortgage rates, taxes, policy, share of total population aged 25-34 and house prices. This is a dynamic relationship that projects house prices for a given level of those core fundamental determinants.

The price model is central to the IHM's simulation properties when performing projections and economic, demographic and policy shock scenarios. This appendix describes the house price model.

A1.1 Model theory

Households in our model have preferences over two goods, housing stock (*S*) and a numeraire consumption good (*C*). They solve a utility maximization problem each period by choosing how much housing and other goods to consume given the cost of housing (*HC*) and their income (*Y*):

$$\max U_t(S_t, C_t) \ s.t. HC_t S_t + C_t = Y_t \tag{1.1}$$

Once maximized, we assume a downward sloping demand curve exists for the representative household (*REP_HH*), which relates the number of units demanded (D^{REP_HH}) to house prices (*P*), user cost of capital (*UCC*), budget represented as income (*Y*), and a measure of credit restriction (*CR*), more precisely, the maximum mortgage amortization period:

$$D^{REP\_HH} = f(Y_t, P_t, UCC_t, CR_t) \tag{1.2}$$

Multiplying the representative household's demand curve for housing by the number of households gives the aggregated housing demand (*D*), which is dictated by its traditional fundamental determinants:[36]

$$D_t = HH_t \cdot f(Y_t, P_t, UCC_t, CR_t) \tag{1.3}$$

Assuming that the relationship between fundamental determinants of housing demand in equation (1.3) is a specification that is additive in logarithms and that the demand for housing rises proportionately to the number of households ($\alpha_3 = 1$), we can express the aggregated long-run housing demand as:

$$d_t = (\alpha_0 + \alpha_1 y_t - \alpha_2 p_t - \alpha_4 ucc_t + \alpha_5 cr_t) + hh_t \tag{1.4}$$

[36] Like most modern aggregated housing demand models, we justify aggregation by appealing to monocentric city models. Typically (see either Muth, 1969 or Capozza & Helsley, 1989 for example), new units built in response to a change in demand occur at the boundary of the city. Consumers prefer units close to the downtown core as they reduce costly commutes to work and amenities but are willing to trade off commute time for a larger house and more consumption. Finally, monocentric city models assume constant utility across the city so that all citizens are indifferent between moving between locations. This implies that if house prices increase in one part of the city, they increase in all parts of the city. Therefore, it is reasonable to estimate an aggregated demand curve, and that a sufficient increase in supply can reduce house prices by making the trade-off between space and distance more favourable.

with lower case letters denoting variables in log-form and α_i representing coefficients associated with demand fundamental determinants. Market equilibrium implies the following:

$$d_t = (\alpha_0 + \alpha_1 y_t - \alpha_2 p_t - \alpha_4 ucc_t + \alpha_5 cr_t) + hh_t = s_t \tag{1.5}$$

If we assume that all the economic determinants inside the bracket in equation (1.5) have no long-run influence on housing demand, then the equation would reduce to:

$$\ln\left(\frac{S_t}{HH_t}\right) = \alpha_0 \tag{1.6}$$

In this case, the housing stock-to-household ratio is constant in the long run and planning residential construction by targeting a constant housing stock-to-household ratio would be appropriate.[37] However, the economic fundamental determinants in the above specification do have a long-term influence on housing demand and house prices, so meeting affordability targets requires incorporating economic factors into the analysis.

Solving equation (1.5) for house prices, we can express the fundamental house price level as:

$$p_t^* = \frac{\alpha_0}{\alpha_2} + \frac{\alpha_1}{\alpha_2} y_t - \frac{1}{\alpha_2} ln\left(\frac{S_t}{HH_t}\right) - \frac{\alpha_4}{\alpha_2} ucc_t + \frac{\alpha_5}{\alpha_2} cr_t \tag{1.7}$$

Given we expect the theory to hold in the long-term but not in every period, we then assume the following empirical cointegration relationship of house prices in the IHM:

$$p_t = \underbrace{\theta_0 + \theta_1 y_t + \theta_2 ln\left(\frac{S_t}{HH_t}\right) + \theta_3 ucc_t + \theta_4 cr_t}_{p_t^*} + ect_t \tag{1.8}$$

where θ_i are reduced form coefficients. The error term ect captures the percentage deviation of the observed house prices (p) from their fundamental level (p^*) which is not explained by the fundamental determinants of house prices. Therefore, in every period, house prices deviate from their fundamental levels by the percentage amount ect, but these deviations are expected to vanish in the medium-term.

The house price model in the IHM takes a log-log form. This assumption is typical of this literature and provides reasonable fit and estimation accuracy. The log-log form also allows for easy retrieval of core elasticities. Moreover, house prices and income (more precisely the disposable income per household) are expressed in real terms by deflating them with the Consumer Price Index, CPI.[38]

Our treatment of the housing user cost of capital (*UCC*) follows Poterba (1984) and Meen (2008) and includes the nominal mortgage rate (*r*), depreciation rate (δ) which is the observed share of units removed

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[37] This has important implications for the statistical properties of the housing stock-to-household ratio. If indeed the long-run influence from all economic determinants in the bracket is statistically insignificant for the house price—and housing demand—then this ratio should exhibit temporary deviations around a constant in the long-term. However, if any of these determinants does have a long-term influence on housing demand, then this ratio will be non-stationary. For this reason, we treat this ratio as potentially non-stationary in our statistical analysis and estimation.

[38] We use the CMHC repeat sales price index as our measure of prices. The CMHC repeat sales price index is a Case-Shiller type index (Case & Shiller, 1987) that attempts to measure the true increase in housing prices by comparing the change in price of units that have sold at least twice within the sample period. This intends to control for changes in quality and composition of the housing stock that aren't captured in the average resale price.

from the housing stock each year, and property taxes (*PT*). These are offset by the expected gains in house prices ($\dot{P}^e$), capturing the asset feature of housing (see equation 1.9 below).[39]

To reflect expected gains, we use adaptive expectations in which households' expectations of future price changes are solely based on past price changes. For our purpose, we assume that households extrapolate average price gains of the last five years into the future.

The literature supports this view that households' expectations regarding future house price growth are adaptive (see Himmelberg, Mayer & Sinai, 2005 and Glaeser & Nathanson, 2017). Our choice of five years is typical in the literature (see Duca, Muellbauer, & Murphy, 2021).

Authors typically place a weight (λ) on the appreciation term in the user cost of capital specification, as homeowners either can't fully capture price appreciation due to transaction costs at the time of sale or incomplete attention. We follow Meen (2008) and apply a weighting factor of 0.3 to the appreciation term (λ = 0.3).[40]

$$UCC = \left[r - \lambda \cdot \dot{P}^e + \delta + PT\right] \tag{1.9}$$

where:

e = superscript representing an expected value

($\dot{}$) = rate of change of a variable

A1.2 Estimation methodology

House prices, housing stock, the number of households, income and the housing user cost of capital are integrated variables. They exhibit stochastic trends over time. This means that for a long run relationship to exist, a stable relationship that ensures balanced growth must exist. This is known as a cointegrating vector.[41]

We estimate our house price equation in two parts following the method developed by Engle & Granger (1987). The first assumes that the fundamental determinants and house prices in equation (1.7) above share a long run, cointegrating relationship.

Engle & Granger (1987) demonstrated that in the presence of a cointegrating vector, Ordinary Least Squares (OLS) estimator is super consistent, converging to the true value at a faster rate than the usual rate even in

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[39] This specification preserves the ability to incorporate the user cost into the regression in logarithms. Meen notes that the logarithmic form produces observed reactions to changes in rates, smaller changes have larger impacts at low user costs.

[40] A value of zero for λ in equation (1.9) implies that only nominal interest rates affect demand as the capital gains element drops out of the equation. A value of one implies that only real interest rates matter. An intermediate value means that both real and nominal interest rates matter (Meen et al., 2008).

[41] We performed tests to ensure that the model variables follow a unit root process. We also conducted a Johansen test with the model variables before estimation to ensure that our model captures one cointegrating vector. We conducted post-hoc cointegration panel test on the long-run residuals as well. Results from those tests suggest that the variables selected are appropriate to include in a cointegrating regression, and the intended cointegrating equation likely exists.

the presence of substantial serial correlation in the errors and correlation across variables (Campbell & Perron, 1991).

However, in finite samples, the OLS procedure can lead to severe biases which often decrease only slowly with the sample size (see Banerjee et al., 1986 cited by Campbell & Perron, 1991). The asymptotic distribution of the OLS estimates is impaired by the presence of serial correlation in the residual and the endogeneity of the regressors. Therefore, the OLS procedure is not recommended if someone wants to perform statistical inferences.

Because of these drawbacks of the OLS procedure, we use the Fully Modified OLS (FMOLS) approach developed by Phillips & Hansen (1990), which is a fully efficient estimation method for single cointegrating equations that accounts for these issues and provide optimal estimates so that we can perform inference and simulation as normal.

Ideally, we would like to estimate separate elasticities for every region but estimates on individual regions generated unusual parameter estimates for some key centers. To stabilize estimates and take advantage of information from geographically close locations, we use a panel extension of FMOLS (Phillips & Moon, 1999).

Notably, panel FMOLS enforces a homogeneous cointegrating vector, but allows for heterogeneity with deterministic regressors. We group geographically close regions into five panels: Ontario, Quebec, British Columbia, the Prairies, and Atlantic Canada. The regions are blocked as follows:

- Ontario: Toronto, Ottawa (including Gatineau, QC), and the rest of Ontario
- Quebec: Montréal and the rest of Quebec (excluding Gatineau)
- British Columbia: Vancouver and the rest of British Columbia
- Prairies: Calgary, Edmonton, the rest of Alberta, Manitoba, and Saskatchewan
- Atlantic Canada: Nova Scotia, New Brunswick, Newfoundland and Labrador, Prince Edward Island

We recognize that demographic factors likely impact the cointegrating vector without directly entering the cointegrating relationship. Thus, we include a demographic variable to measure the effect of exogenous changes in demography on the estimated relationship between prices, units demanded, user cost, and credit.

For this purpose, we use the share of the total population aged 25-34. A similar demographic choice was elected by Caldera & Johansson (2013). This is the age cohort where most households that eventually become homeowners buy their first house. Hence it acts as a good measure of potential homeowners. Other papers opt for exogenous immigration flows as a demographic measure (for example Webley, 2018).

Additionally, we add deterministic period dummies into the regression to control for different socio-economic regimes. We include a period dummy covering the oil-boom of 2006, the financial crisis of 2008 and 2009, the crisis recovery period from 2010 to 2013, the introduction of the OSFI B20 rules, and the COVID-19 pandemic.

The second step involves estimating an error correction model to capture the short run dynamics of house prices around their long run equilibrium value. Importantly, the error correction model captures rigidities in the housing market which prevent house prices from immediately adjusting to their fundamental long run value. Since purchasing housing involves a lengthy search process (Han & Strange, 2014), house prices can take a long time to return to their long-run fundamental value. It is therefore essential to model rigidities in real estate markets.

We follow second step of the two-step method proposed by Engle and Granger to estimate the error correction model, by taking the residuals from the long run equation (1.8) and placing them as a regressor in a panel regression of the first differences of the regressors from the long run equation and deterministic regressors:

$$\Delta p_t = \gamma ect_{t-1} + \beta_1 \Delta p_{t-1} + \beta_2 \Delta ln\left(\frac{S_t}{HH_t}\right) + \beta_3 \Delta ucc_t + \beta_4 \Delta cr_t + \beta_5 \Delta ratio25\_34_t + \delta + \epsilon_t \qquad (1.10)$$

The error correction model (1.10), estimated by OLS[42] in differences instead of levels, is appropriate for our application as serial correlation is a noted feature of housing markets (Mankiw & Weil, 1992, DiPasquale & Wheaton, 1994) and allows house prices to react to deviations from their fundamental levels (i.e., the lagged value of $ect = p - p^*$).

The coefficient γ, the error correction loading factor, measures how fast these deviations get resolved. It gives the "half-life" of a shock to house prices. An error correction model with a small loading factor implies a longer half-life. δ contains location fixed effects and period fixed effects.

A1.3 Key elasticities in the house price model

The price elasticity of housing demand and the elasticity of prices to income, two key long-run elasticities of the house price model, have respectively been discussed in Section 2.3.1 and Section 2.3.2 of Chapter 2.

The long-run elasticity of prices to the user costs (denoted by θ_3 in the empirical cointegration relationship 1.8), another key elasticity of the house price model, is estimated to be around –0.4, which is relatively high compared to the literature. Other estimates from Meen et al. (2005), Meen (2008), DiPasquale & Wheaton (1994) and Duca, Muellbauer, & Murphy (2011) generate estimates around –0.004 to –0.3.

However, it is worth noting that these other estimates are generated on data that ends before 2009. We believe that the period of low interest rates amplified the effect of the user costs on house prices, as changes in user costs have a higher impact when they are low (Himmelberg, Mayer, & Sinai, 2005). This can explain why the long-run elasticity of prices to the user costs of capital is high in the IHM.[43]

A1.4 Interconnections with other sub-models of the IHM when performing different projection scenarios

House prices are one of the core components of the broader model (the IHM). They are a direct input into every sub-model except for the demographic model, which they impact indirectly through inter-regional

[42] The cointegrating relationship (1.8) is the one of primary interest. As mentioned by Campbell & Perron (1991), if coefficients in this long-run relationship have optimal properties, the estimates of the coefficients (using OLS) in the short-run dynamic (1.10) should well behave.

[43] Note that the decision to include housing user cost of capital in logarithms implies that the effect of mortgage rates on prices is non-linear in the IHM.

migration. The flow chart of the IHM presented in Figure A in the Appendices preamble shows the centrality of the house price sub-model.

When performing projection scenarios, as prices increase in one region, starts increase, net migration decreases, household formation decreases, and homeownership decreases. The reduction in net inter-regional migration then indirectly leads to fewer births.

All these effects then impact prices, providing downward counterpressure on them through increased building activity and fewer households. Prices are also used to calculate user costs and rents within the IHM.

These interconnections set the base for dynamic relationships with feedback effects between house prices and other key variables in the IHM.

Appendix 2: Housing starts model

As mentioned in Section 1.4 of Chapter 1, unlike the model developed by Meen where housing supply is always treated as an exogenous policy variable, the IHM includes an explicit housing starts error correction model, which is central to the IHM's simulation properties when performing projections and economic, demographic and policy shock scenarios. This appendix describes the housing starts model.

A2.1 Model theory and approach

A2.1.1 Model theory: the stock-flow model

The stock-flow model is an analytical framework that allows to understand the dynamics of the housing market. It captures some unique characteristics of housing markets as it distinguishes between the 'stock' of existing houses, which changes relatively slowly over time, and the 'flow' of new construction, which can respond more quickly to market conditions.

This model helps in analyzing how different factors such as income, population, interest rates and construction costs can impact house prices and housing investment in residential construction.

On the supply side of the stock-flow model, housing stock slowly expands through new construction and gradually depreciates. New development is costly, time-consuming, and subject to supply constraints, e.g., regulatory and/or geographic constraints, labour costs. The supply of new houses comes from housing construction, which depends on house prices relative to the construction costs.

In the empirical literature, many authors estimate a stock-flow model with a demand equation (house price) and a supply flow equation (new housing construction). For the new housing construction equation, DiPasquale & Wheaton (1994) model the supply of new single-family housing as a function of house prices, price for land, costs of construction and interest rates.

Riddel (2004) models the housing stock in the supply equation, instead of the new construction, as a function of house prices, construction costs, short-term interest rates, GDP, and apartment vacancy rates. Caldera & Johansson (2013) model the real gross residential investment as a function of construction costs, house prices and the share of the population aged 25 to 44 years.

In contrast to previous authors, Mayer & Somerville (2000) consider that housing starts, being a flow variable, should be modelled as a function of flow variables (like changes in prices) rather than stock variables (like the level of prices). They therefore estimate a model where housing starts are function of changes in house prices, construction costs, and other socio-economic indicators.

A2.1.2 Modelling approach

Our empirical housing starts model is based on a micro-founded framework where housing suppliers optimize their profits.

We base our approach on housing market studies using the stock-flow approach (DiPasquale & Wheaton, 1994, Riddel, 2004 and Caldera & Johansson, 2013). We selected this approach because it provides a consistent framework that links new housing construction to its fundamental determinants based on economic theory. This approach therefore generates reliable long-term projections and allows to assess the effects of different economic, demographic and policy shock scenarios on housing supply.

In the supply equation of the stock-flow model, housing stock is rigid in the short run, while the flow of new residential construction reacts quicker to changes in economic conditions. Housing stock and new residential construction (C) are linked together through the capital accumulation identity. Housing stock (*S*) slowly depreciates over time at a rate δ and expands gradually with new construction C as follows:

$$\Delta S_t = C_t - \delta S_t \quad (2.1)$$

with *ΔS* representing the change in housing stock.

Profit maximization by housing suppliers under technological constraints provides an equilibrium relationship between new residential construction C (which we will refer to in the rest of this section as housing starts[44]), the lagged value of house prices (*P*) and other key determinants included in X. Thus, the fundamental level of housing starts can be expressed as:

$$C_t^* = f(P_{t-1}, X_t) \quad (2.2)$$

Assuming that the relationship between housing starts and their fundamental determinants in equation (2.2) is a specification that is additive in logarithms, we can represent the fundamental housing starts level as follows:

$$c_t^* = \beta_0 + \beta_1 p_{t-1} + \beta_2 x_t \quad (2.3)$$

with lower case letters denoting variables in log-form and β_i representing reduced form coefficients associated with fundamental determinants of housing starts.

Given that we expect the theory to hold in the long-term but not in each period, we assume the following relationship between the observed housing starts level and their fundamental level in period *t*:

$$c_t = c_t^* + ect_t \quad (2.4)$$

The error term ect captures the percentage deviation of the observed housing starts (c) from their fundamental level (c^*) which is not explained by the fundamental determinants of housing starts. Therefore, in every period, housing starts deviate from their fundamental levels by the percentage amount ect, but these deviations are expected to vanish over time.

To estimate such a relationship, we need to specify the elements of X in equation (2.3). In the empirical literature, X typically includes construction costs and other variables such as the lagged housing stock and demographic measures.

[44] Given that the purpose of our supply framework is to project housing starts and that housing starts and residential investment are closely related, we therefore model housing starts the same way as we would model the new residential investment, even though both variables are different by definition. Housing starts are the number of units in new residential construction projects that have begun during any particular time while the residential investment consists of the value of new construction and improvements (additions, alterations, and major structural replacements) to housing units.

Construction costs, including the cost of land, financing, labour and materials are among the main determinants used in the housing supply models. However, the lack of satisfactory data on land and construction costs led us to only include two variables in the model: the average hourly wage in the construction sector (*wage_cstr*) as a proxy for labour costs and the short-term interest rate (*st_r*) as a broad measure of the short-term financing costs faced by housing developers.

In addition to house price and the variables representing construction costs, the other determinant of the fundamental level of housing starts considered in our model is the lagged value of the population to housing stock ratio (*pop_stock_ratio*), which gives an indication on the state of the demographic pressure relatively to the existing housing stock. Hence, the long-run cointegrating housing starts equation for a pool of regions (*i*) can be represented as follows:

$$c_{i,t} = \beta_{i0} + \beta_1 p_{i,t-1} + \beta_2 st\_r_{i,t} + \beta_3 wage\_cstr_{i,t} + \beta_4 pop\_stock\_ratio_{i,t-1} + ect_{i,t} \quad (2.5)$$

with lower case letters denoting variables in log-form, except for the short-term interest rate and the population to housing stock ratio. Note that house prices, the short-term interest rate and the average hourly wage in the construction sector are expressed in real terms by deflating them with the CPI.

Housing markets adjust slowly and gradually to changes in market conditions due to rigidities that stem from economic, policy and geographic factors. It is important to use an error correction framework that accounts for these rigidities. This is particularly important for forecasting and shock scenario analysis.

Therefore, we estimate housing starts as an error correction model using the Engle-Granger two-step estimation procedure. We do this by incorporating the lagged value of the error term from the long-run equation (2.5) ($ect_{t-1} = c_{t-1} - c^*_{t-1}$) into the short-run equation (where regressors are expressed in first differences), allowing the model to correct any deviations from the long-run equilibrium. Housing starts dynamics can be specified by the following error correction equation:

$$\Delta c_{i,t} = \alpha_0 + \alpha_1 \Delta c_{i,t-1} + \alpha_2 \Delta p_{i,t-1} + \alpha_3 \Delta st\_r_{i,t-1} + \alpha_4 \Delta wage\_cstr_{i,t}$$
$$+ \alpha_5 outputgap_{i,t} + \sigma ect_{i,t-1} + \varepsilon_{i,t} \quad (2.6)$$

with $outputgap$ representing the output gap, which is calculated as the percentage difference between the GDP and its estimated potential. This variable is used as a broad indicator of the state of the economic activity.

The coefficient σ, the error correction loading factor, measures how fast housing starts approach their fundamental values. It gives the "half-life" of a shock to housing starts. An error correction model with a small loading factor implies a longer half-life.

The use of an error correction framework provides:

- a long-run (cointegration) relationship linking housing starts with their core economic and demographic determinants derived from economic theory and
- a short-run equation that allows housing starts to react to short-term shocks and deviations from their fundamental levels

A2.2 Estimation methodology

Our long-run housing starts relationship (2.5) assumes that there exists a cointegration relationship between housing starts and their fundamental determinates.[45] However, given the drawbacks described in Section A1.2 of using the OLS procedure to estimate a cointegrating equation, we use the Dynamic Ordinary Least Square (DOLS) approach suggested by Saikkonen (1991) and Stock & Watson (1993) and extended by Kao & Chiang (2000) for pooled estimations. This fully efficient estimation method asymptotically eliminates the effect of endogeneity on the distribution of the OLS estimator by augmenting the cointegration regression with a finite number of leads and lags of the change of the fundamental determinants.[46]

The panel of the 16 regions is estimated as a pool in both the long-run and the short-run equations.[47] This procedure ensures that the effects of the key determinants are considered for all regions, while estimated fixed effects allow to account for heterogeneity among the regions.[48]

A2.3 Key elasticities in the housing starts model and their implications

A very important coefficient in the housing starts model is the coefficient on the lagged value of real house prices (denoted by β_1 in the cointegrating housing starts equation 2.5), which represents the responsiveness of housing starts to price changes. This can be interpreted as the long-run price elasticity of new housing supply. This long-run elasticity is estimated at 0.75 and is statistically significant, which indicates the positive impact of house prices on the housing starts levels as higher house prices provide an incentive to build new houses.

This estimated long-run elasticity is close to the reported estimates in the literature. Caldera & Johansson (2013) estimate the long-run price elasticity of new housing supply in 21 OECD countries and find that the responsiveness of housing supply to price changes is relatively more flexible in North America, while it is more rigid in continental European countries and in the United Kingdom. Their estimates of this elasticity ranges between 0.15 in Switzerland and 2 in United States and at about 1.2 in Canada. DiPasquale & Wheaton (1994) estimate a price elasticity of single-family construction in the United States at around 1 to 1.2 depending on the model specification.

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[45] Finding evidence of such a cointegration relationship is crucial in our context. Our panel unit root tests show strong evidence of a cointegration relationship between housing starts and their determinants: the lagged value of real house price, the real short-term interest rate, the real wage in the construction sector and the lagged population to housing stock ratio. All estimated coefficients for these fundamental determinants are significant and have the expected sign according to the economic theory.

[46] There is still the issue (although less important) that the residuals are serially correlated, which also affects the asymptotic distribution of the OLS estimator. Hence, in order to compute asymptotically valid standard errors, we employ the HAC (Newey-West) covariance method to compute the long-run variance of the residuals in the DOLS estimation, so that we can perform inference and simulation as normal.

[47] The cointegrating relationship (2.5) is the one of primary interest. As mentioned by Campbell & Perron (1991), if coefficients in this long-run relationship have optimal properties, the estimates of the coefficients (using OLS) in the short-run dynamic (2.6) should well behave.

[48] Estimation of the model as a pool assumes elasticities with regards to independent variables are similar among all regions. This limits the model in the sense that some regions are more supply-constrained than others. Individual equations for each region could have captured this through differentiated elasticities. However, the introduction of fixed effects mitigates this caveat. It is also worth mentioning that we have estimated individual equations, but the results were not conclusive.

Another important long-run coefficient in the starts model is the coefficient on the real short-term interest rate (denoted by β_2 in the cointegrating housing starts equation 2.5). The estimate of this coefficient is significantly negative, indicating that financing costs influence negatively housing starts levels. This coefficient is estimated at –0.032, which means that a 1 percentage point increase in the real short-term interest rate lowers housing starts by 3.2%.

This coefficient is close to the reported estimates in the literature. Ball, Meen & Nygaard (2010) show the results of the estimation of this coefficient in equations similar to our housing starts model for the UK, United States and Australia. These estimates are negative and significant and range between –0.015 in Australia, –0.024 in the UK, and –0.039 in the United States.

Mayer & Somerville (2000) estimate a different model where housing starts are function of changes in exogenous variables, including interest rates (the real prime rate). They find that changes in real interest rates have a statistically significant effect on housing starts. Approximately, a 1 percentage point increase in interest rates lowers housing starts by about 2.5 to 4% depending on the model specification.

The long-run elasticity of housing starts to labour costs in the construction sector (denoted by β_3 in the cointegrating housing starts equation 2.5) is another key parameter. As expected, this elasticity is significantly negative in our estimations (at around –0.72), indicating that labour costs have a fundamental negative influence on housing starts, i.e., a 1% increase in the labour costs lowers housing starts by 0.72%.

For instance, this elasticity is particularly important in the scenario described in Section 4.2 of Chapter 4 where we explore the impact on affordability of improving productivity in the construction industry.

A2.4 Interconnections with other sub-models of the IHM when performing different projection scenarios

The housing starts model is fully integrated into the IHM when performing demographic, economic and policy scenarios over the projected period. First, the housing starts model uses projections produced by other sub-models as inputs such as house prices, population and some exogenous variables from the exogenous economic block, i.e., short-term interest rates and wages in the construction sector.

Secondly, the model's outputs, i.e., housing starts projections, determine the housing stock levels which feed into house prices and influence inter-regional migration flows by increasing availability. This, in turn, affects population and household formation projections.

Finally, housing starts projections combined to the outcomes generated by the tenure choice model (described in Appendix 6) allow to produce supply gaps by tenure. These interconnections set the base for dynamic relationships with feedback effects between housing starts and other key variables in the IHM.

Appendix 3: Inter-regional migration model

The inter-regional migration model allows to incorporate the effects of population mobility between regions with endogenous reactions to housing and economic factors. Each region in the IHM is therefore linked to other regions through inter-regional migration patterns. This key feature is highly important when performing projections and economic, demographic and policy shock scenarios. This appendix describes the inter-regional migration model.

A3.1 Stylized facts

A3.1.1 Inter-regional net migration becomes more negative as prices rise

The recent research of migration in Canada, Amirault, Demunnik, & Miller (2016) found that relative prices contributed little to the migration decisions of Canadians. The paper used a customized data set from the 2006 and 2011 census and matched the Canadian Real Estate Association MLS average price to geographies of interest as a measure for house prices.

For the period studied, house price dispersion in Canada was low, so it is unlikely that house prices played a large role in the migration decision of Canadians. Instead, in line with the canonical work in the migration literature (Blanchard & Katz, 1992), they found a large impact of economic considerations like employment or wages.

However, much has changed since 2011. House price growth accelerated across Canada, with much of this acceleration concentrated in Canada's major urban centers. Thus, price dispersion measured using a repeat sales index to ensure constant quality of house between regions has grown. The average ratio of prices between two regions rose from 1.03 in 2011 to 1.06 in 2021.

The grand mean ratio obscures the fact that much of the rapid price growth occurred in Toronto and Vancouver. Between 2011 and 2021, the average ratio of prices between Toronto and other regions increased from 0.85 to 1.42. Likewise, the average ratio for Vancouver increased from 1.23 to 1.72.

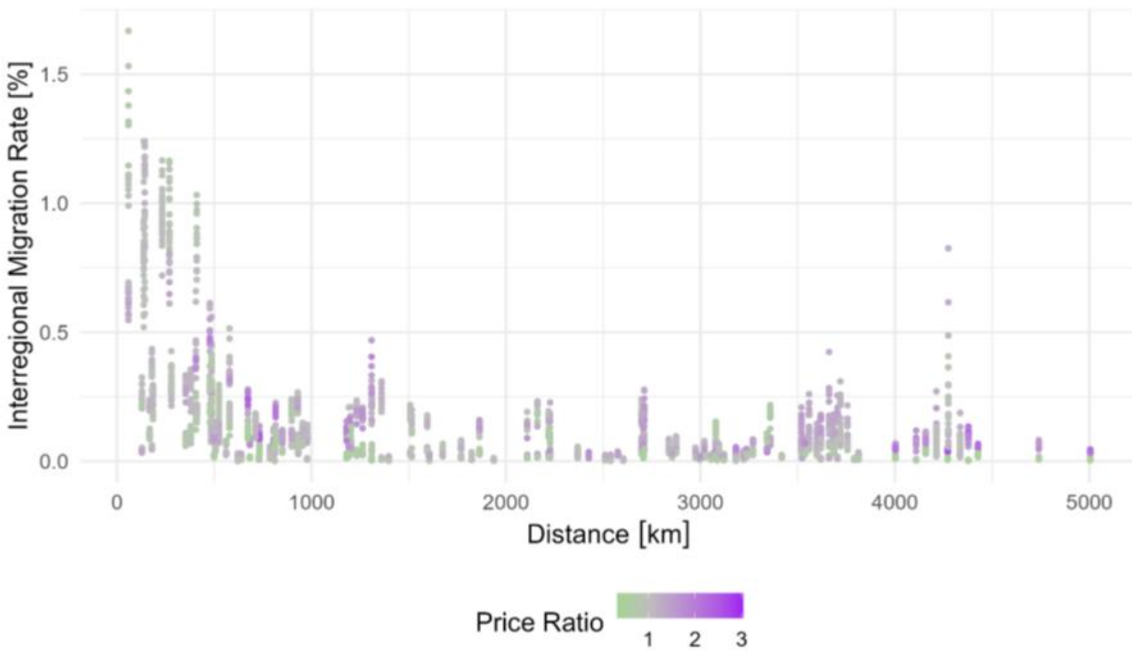
At the same time, outmigration from Toronto and Vancouver intensified. Net inter-regional migration to and from Toronto declined from –23,000 people in 2011 to –52,000 in 2021. The outlying regions of Ontario and British Columbia absorbed more migrants as the relative balance of prices between them and their metropoles changed.

Calgary and Edmonton show that price changes are not the whole story. Despite a falling relative price ratio, in migration to the Alberta cities declined during the late 2010s. Alberta's major industry, energy extraction, bust and unemployment greatly increased turning away migrants. The impact of housing prices is important, but not the only driver of migration.

A3.1.2 Internal migrants prefer locations that are nearby

The vast majority of moves within Canada happens within a region. Moving is an expensive endeavor, both in terms of financial cost and the social and psychic costs for uprooting one's life. Thus, families tend to prefer to remain in one geographic location when they change homes. Likewise, most migrants that choose to leave their region tend to move to regions nearby. Figure A3.1 maps out this dynamic.

Figure A3.1: Inter-regional migration rate vs distance vs price ratio



Source: Statistics Canada, CMHC calculations.

The left axis measures the migration rate from one region to another. The bottom axis measures the distance between the two regions. There is a clear downward relationship between distance and migration rate. Almost all the regional pairs that exhibit a high rate of migration are within 500 km of each other, and the highest frequency migration pairs are within 100 km of each other.

The highest pair, from Toronto to the rest of Ontario are adjacent and their population centers are within 50 km, or an hour's drive. Such a move would have minor effects on one's social circles and could be feasibly completed in a short period for lower cost than, say, a move from Toronto to Alberta (a distance of around 3000 km).

When we add relative price into the plot, by coloring the migration pair based on the ratio of price in destination to origin, we see a clear pattern emerges. The migration routes with the highest migration rate are those that both have a low distance and a low ratio of price between the destination and the origin. People choose to move to places that are nearby and aren't much more expensive than their current location.

Migration pairs where the destination price is high tend to occupy the bottom of the plot. Some of the farthest move pairs have the lowest relative price ratios and see low migration rates. At a certain distance, moving costs trumps lower housing costs.

Thus, we intend to model the following relationship: people who move from one region to another want to improve their life by either reducing their housing costs or improving their employment prospects, however moving long distances is unattractive.

A3.1.3 Age structure of migrants

To account for demographic changes through inter-regional migration, we first analyzed data provided by Statistics Canada which allowed us to see the number of movers per year (last 12 months as of July 1st of each year), from 2006-2007 to 2020-2021.

We obtained Net migration for the 16 regions of our analysis by subtracting Out-migrants from In-migrants. Migration includes movements within the province (intra-provincial) and elsewhere in Canada (interprovincial). For example, for Montréal, a migration with the rest of Quebec would be intra-provincial and a migration with Calgary would be interprovincial. A migration within the Montréal CMA was not considered.

$$In.Migrants = Interprovincial\ In.Migrants + \ Intraprovincial\ In.Migrants$$

$$Out.Migrants = Interprovincial\ Out.Migrants + \ Intraprovincial\ Out.Migrants$$

$$Net\ migration = In.Migrants - Out.Migrants$$

Figure A3.2 shows the net migration per year, for the 16 regions of the analysis. We can see that through the years, the rest of Ontario has been gaining more and more migrants (net) while Toronto has been losing more and more. Factoring migration was thus necessary in our population projections and the additional impacts on the housing markets.

Again, note that migration here does not include international migration, which is considered in the Population framework (see Appendix 4).

Figure A3.2: Net migration to all centers

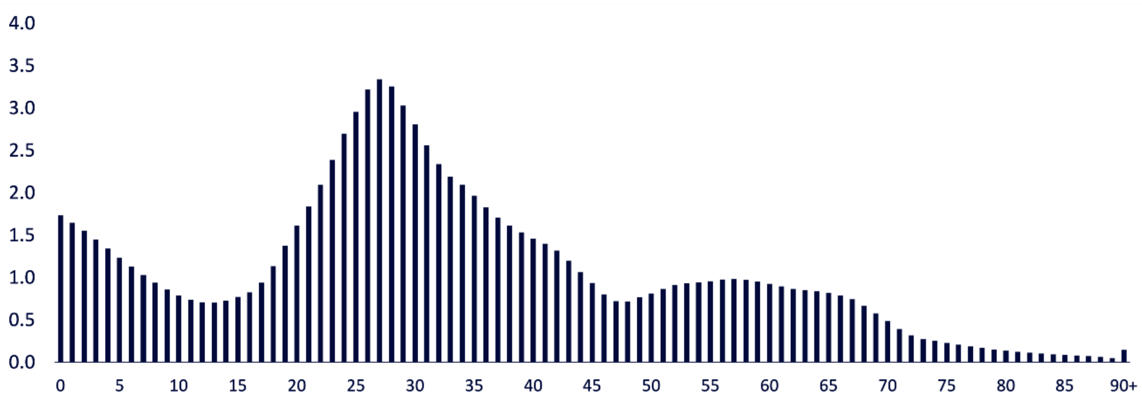
	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Toronto	(20,794)	(21,907)	(18,423)	(20,565)	(15,282)	(23,512)	(25,614)	(27,580)	(28,377)	(29,790)	(40,395)	(43,341)	(43,759)	(54,585)	(83,431)
Ottawa-Gatineau	4,129	6,196	6,545	5,241	3,686	3,746	530	805	2,723	5,569	11,781	8,154	7,673	9,444	3,759
Rest of Ontario	(1,977)	2,692	(1,945)	11,878	8,703	9,548	10,425	11,366	16,486	33,872	42,563	45,830	43,658	49,540	62,848
Montreal	(15,765)	(15,835)	(11,264)	(11,485)	(10,732)	(12,807)	(14,787)	(13,966)	(16,340)	(13,641)	(11,088)	(13,833)	(16,853)	(19,422)	(28,841)
Rest of Quebec	1,782	2,649	2,278	7,270	5,108	5,719	5,473	927	972	2,153	2,697	7,550	11,768	13,604	24,662
Vancouver	(2,041)	(1,801)	2,641	1,746	(932)	(5,528)	(6,008)	(2,917)	723	(814)	(7,386)	(10,669)	(8,487)	(6,040)	(3,954)
Rest of British Columbia	16,813	16,173	7,256	7,047	4,503	2,935	3,894	12,165	19,435	27,196	26,121	24,417	21,607	23,056	29,262
Calgary	6,008	4,606	4,687	(1,631)	4,382	12,849	16,396	14,452	9,598	(2,779)	(3,097)	523	2,664	3,862	(327)
Edmonton	11,450	5,544	8,033	1,835	5,871	12,151	16,755	18,922	15,257	3,064	2,066	3,050	3,538	3,360	(346)
Rest of Alberta	15,814	4,690	(30)	(3,734)	(1,973)	2,113	4,774	1,382	(3,658)	(15,578)	(14,571)	(7,041)	(8,410)	(9,675)	(8,705)
Manitoba	(5,499)	(3,674)	(3,136)	(2,427)	(3,497)	(4,234)	(4,993)	(6,844)	(6,632)	(4,867)	(5,121)	(7,109)	(7,270)	(8,231)	(2,807)
Saskatchewan	1,474	4,120	2,946	2,116	539	1,759	313	(1,950)	(4,511)	(4,307)	(5,797)	(8,441)	(9,415)	(11,352)	(7,199)
Nova Scotia	(3,995)	(1,773)	(722)	587	(6)	(2,797)	(3,443)	(2,508)	(2,341)	783	2,761	2,977	3,586	5,517	8,827
New Brunswick	(2,618)	(878)	(217)	555	(152)	(1,797)	(3,313)	(3,479)	(2,786)	(1,093)	447	461	1,638	1,790	4,542
Newfoundland and Labrador	(3,954)	(493)	1,873	1,503	(12)	497	475	175	127	228	(1,434)	(2,698)	(2,577)	(1,991)	499
Prince Edward Island	(827)	(309)	(522)	64	(206)	(642)	(877)	(950)	(676)	4	453	170	639	1,123	1,211

Source: Statistics Canada, CMHC calculations.

Statistics Canada also sent us data on the number and share of movers by age, by CMA/region, versus the Rest of Canada (it was not possible to have it versus other CMA/regions). Figure A3.3 is an illustration for Toronto which is very similar for all regions. As seen, movers from 25 to 34 years of age represent the higher share of movers.

The results of our model take this age distribution of movers into consideration by redistributing total movers into movers by age (see Section A3.3).

Figure A3.3: Toronto - Share of out-migrants from Toronto by age, average from 2019-2020 to 2021-2022, %



Source: Statistics Canada, CMHC calculations.

A3.2 Model

A3.2.1 Theoretical model

To justify the functional form of our model, we develop a theoretical model to explain why people choose to migrate from one region to another. The model must account for the stylized facts displayed above, namely that households move away from expensive attractive cities like Toronto and Vancouver if prices get too high but still prefer to minimize the distance that they move.

We choose to model households as our fundamental economic agent for conceptual ease.[49] At each period, each household chooses whether to remain where they currently live or move to one of the other regions. Each agent maximizes its own utility by combining housing, amenity, and the numeraire consumption good relative to their budget constraint:

$$u_r = u(S_r, C_r, A_r)\ s.t. P_r S_r + C_r = M_r \tag{3.1}$$

For ease of notation, we omit the time subscript. Households living in region *r* receive income *M* equal to the average income of the region they inhabit each period. They choose to consume housing S based on

[49] Theoretical models describing the household formation, tenure choice decision are covered in Appendix 5 for household formation and Appendix 6 for tenure choice.

local prices P to maximize the amount of housing, numeraire consumption C, and amenity A utility they can attain. Solving the utility maximization problem renders the following indirect utility function:

$$V_r = v(P_r, M_r, A_r) \quad (3.2)$$

The household compares its bundle of consumption, relative to prices and endowment income, to what it could attain in other locations -*r*. It selects the location that maximizes overall utility:

$$\max_r V(v_r, v_{-r}) \quad (3.3)$$

Following the Rosen-Roback conjecture (Roback, 1982), equilibrium occurs when housing prices and migrants are such that utility is equal across all regions. This guarantees that a unique price vector exists to satisfy the household problem. Making our utility maximization problem (3.1) more concrete and following Diamond (2016), we assume that the utility function consists of Cobb-Douglas preferences over the goods:

$$\max u_r = S_r^{\alpha} C_r^{1-\alpha} + A_R \ s.t \ P_r S_r + C_r = M_r \quad (3.4)$$

Cobb Douglas utility makes the utility function and resulting indirect utility function (3.2) a specification that is additive in logarithms:

$$v_r = \beta_m m_r + \beta_p p_r + a_r \quad (3.5)$$

Household utility within a particular city is decreasing in housing prices and increasing in income. Households that live in high prices metropolitan areas must dedicate more of their budget to each unit of housing, lowering overall consumption of both goods. Amenity itself is a function of several exogenous and idiosyncratic factors:

$$a_r = x + \delta_r - \tau d_{r,-r} + \varepsilon_r \quad (3.6)$$
$$\tau = \tau_0 + \tau_1 p_{-r} \quad (3.7)$$

$$\varepsilon_r \sim Type\ I\ Extreme\ Value \quad (3.8)$$

Where x contains demographic information about the migrant that affects its ability to move and appreciate local amenity, δ contains exogenous characteristics of the current region, d is the distance between regions, τ is the physical and psychic costs of distance from the current location, and ε is an idiosyncratic factor for each household. The psychic costs of moving should also directly impact the effect of prices on mobility. Due to the difficulty and cost of moving, households should be less willing to take advantage of a price difference between far locations. When we assemble equations 3.4 to 3.8, we see the classic conditional utility model (McFadden, 1973):

$$v_r = \beta_p p_r + \beta_m m_r + \Gamma x + \delta_r - \tau d_{r,-r} + \varepsilon_r \quad (3.9)$$

Placing (3.9) in (3.3), we generate the probability that a household chooses to live in region *r* instead of another region-*r*[50]:

$$\Pr(V_r > V_{-r}) = \frac{\exp(\beta_p p_r + \beta_m m_r + \Gamma x + \delta_r)}{\sum_{k \in r} \exp(\beta_p p_k + \beta_m m_k + \Gamma x + \delta_k - \tau d_{r,k})} \quad (3.10)$$

[50] Note the distance between the current location and the current location is zero.

Aggregating (3.10) gives us the population in each city. We observe that prices, income, and distance play a role in determining the population in each city. Further, from our definitions of the utility maximization problem and distaste for distance, we see that high prices in the home location increase the likelihood of relocating while high prices in the destination reduce that likelihood.

If prices are high in the destination location, a worker may not be able to move there even if their income increases because of the move. Equilibrium occurs as suggested above: people move until a price vector exists that balances the indirect utilities provided by income, amenity, and price.

The theoretical model also satisfies our other stylized fact that migration is decreasing in distance. Distance enters the probability model with a negative sign, weighing on migration decisions.

A3.2.2 Empirical model

Seeing the theoretical model provides an underpinning to the stylized facts presented previously, it is prudent to use the model to generate an empirical equation to estimate the impact of relative prices on migration decisions. Gravity models have a long history in the spatial equilibrium literature, dating back to the 19th century. The gravity model lends itself naturally to evaluating migration flows, as it naturally falls out of a migration choice Bellman equation (Redding & Rossi-Hansberg, 2017).

In fact, most empirical spatial equilibrium models are of the same broad class of model and can be transformed into the other with small changes in assumptions (Behrens & Murata, 2021).

Thus, a gravity model is reasonably micro-founded and therefore appropriate for counterfactual analysis that is robust to the Lucas Critique. The model form is appealing, as distance is known to reduce migration (Schultz, 1982) and population of the destination influences migration choice as larger populations generate more entrepreneurs who generate positive labour demand shocks (Beaudry, Green, & Sand, 2018).

Thus, a gravity model is a natural reduced form modelling choice. Briefly, the gravity model for migration relates the total number of inter-regional migrants (*IRM*) or migration rate to the population in region *i* and region *j* (Pop_i and Pop_j) and the distance between them (d_{ij}):

$$IRM_{ij} = g\left(Pop_i, Pop_j, d_{ij}, x_{ij}\right) \tag{3.11}$$

Our estimated model (3.12) flows from equation (3.9) and the gravity equation (3.11) above. Note that aggregating the inverse of (3.9) generates the people who choose to migrate. We intend to estimate the number of people that choose to migrate from one location to another in each period. We estimate the inter-regional migration rates (*IRR*), the aggregated probability that households will move from one region to another, instead of on individual households so we can no longer use a logit model.

We follow the general estimation strategy for gravity models, employing a log-log model on relative regressors using OLS (Anderson, 2011). Schultz (1982) referred to this as the pseudo logit model. We estimate the following regression:

$$IRR_{ijt} = \beta_p \frac{p_{jt}}{p_{it}} + \beta_u \frac{ur_{jt}}{ur_{it}} + \beta_M \frac{m_{jt}}{m_{it}} + \beta_{pop} \frac{pop_{jt}}{pop_{it}} + \beta_{dist} d_{ij} + \beta_{p,dist} \frac{p_{jt}}{p_{it}} * d_{ij} + \Gamma X_{ijt} + \epsilon_{ijt} \tag{3.12}$$

With β_i representing reduced-form coefficients and ur, the unemployment rate. X_{ijt} includes demographic regressors of potential migrants, housing starts relative to stock in the destination as a measure of availability, relative indigenous population, national terms of trade, temperature in January, and the difference in homicide rate.

The error term contains dummy variables for the region pairs, a dummy variable for whether the province is in the Prairies, and whether two regions are adjacent. The terms of trade variable and Prairie variable are interacted, as much of Canada's resource extraction industries are in the Prairie provinces which appreciate a high price of exports.

Given (3.9), we expect the relative price coefficient and distance coefficients to be negative. Our theoretical model and stylized facts also imply that the interaction between prices and distance should be positive to moderate the effect of prices on migration. Equation (3.9) also suggests the coefficient on relative incomes to be positive and that on relative unemployment to be negative.

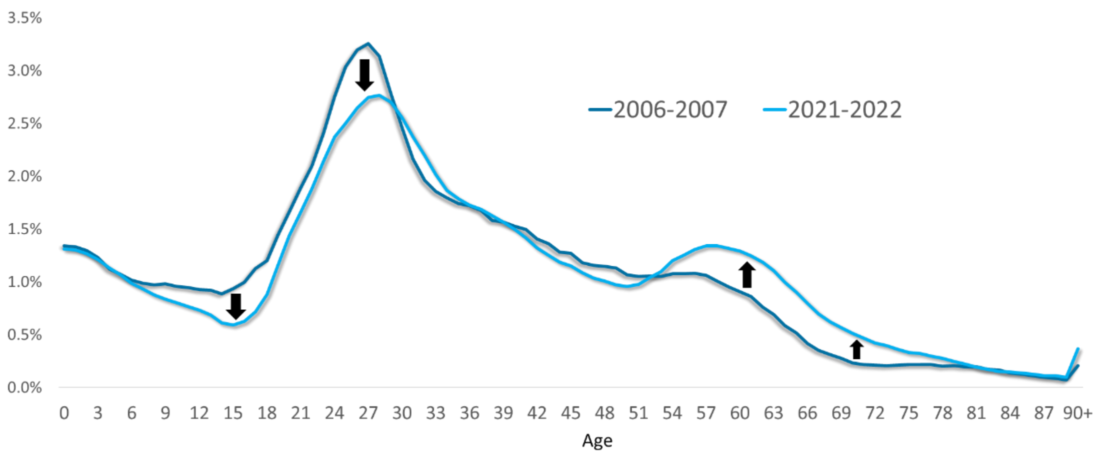
A3.3 Migration by age

The demographic projection model (see Appendix 4) operates on annual data split out by age. To render the inter-regional migration estimates compatible, inspired by Meen et al. (2005), we apply an age distribution to the flow of inter-regional migrants to and from each region. Thus, we apply our estimate of the age structure of migrants to the estimates of the gravity model to make them compatible with the demographic framework.

We saw previously the need to take into consideration the age distribution of movers when incorporating the inter-regional migration, as persons in their late 20s are the ones with the higher shares of movers. This information allows us to use the projected total migration numbers by region, estimated by our models, and redistribute them into the different ages.

Moreover, we want to take into consideration the changing demographics through the aging of the population. As seen in Figure A3.4, the share of movers from about 55 years old to 75 years old increased from 2006-2007 to 2021-2022. Thus, the share of movers should not only reflect the past, but what should be the share of movers in the future. To do so, we consider the weight of the different ages in the projected population and use it to influence the share of movers in the future.

Figure A3.4: Share of out-migrants from Montréal, by age, 2021-2022 vs 2006-2007



Source: Statistics Canada, CMHC calculations.

Once the projected migration flows from region *i* to region *j* are obtained from the gravity model, the model then distributes the results into the different ages as follows (example for out-movers aged 25 years old):

$$MIG^{i\,to\,j}_{25,t} = MIG^{i\,to\,j}_{TOT,t} \times \left[\left(\frac{MIG^{i\,to\,j}_{25,t0}}{MIG^{i\,to\,j}_{TOT,t0}}\right) + \left(\frac{POP^{i}_{25,t}}{POP^{i}_{TOT,t}}\right) - \left(\frac{POP^{i}_{25,t0}}{POP^{i}_{TOT,t0}}\right)\right]$$

- $MIG^{i\,to\,j}_{25,t}$: Migration flows from *i* to *j* for people aged 25 years old at time *t* in the future
- $MIG^{i\,to\,j}_{TOT,t}$: Migration flows from *i* to *j* for all ages at time *t*, as projected by our model
- First term in brackets: Migration flows from *i* to *j* for people aged 25 years old relative to migration flows from *i* to *j* for total population at time *t0* (3-year average based on most recent historical years)
- Second and third terms: To account for changes in demographics, population aged 25 years old relative to total population, at time *t* in the future, minus the same at *t0*

A3.4 Key elasticities in the inter-regional migration model and their implications

The coefficient on relative prices (indicated by β_p in equation 3.12), the most important elasticity in the inter-regional migration model, results in an elasticity on the rate of migration of 1.3. That is, a 1% increase of house prices in the destination region leads to a decline in the number of people moving there by about 1.3% (ceteris paribus).

This is in line with Cavalleri, Luu & Causa (2021). An increase in the price ratio between two regions decreases the migration rate of people moving from location *i* to location *j*, while at the same time increasing the amount of people leaving *j* to go to *i*. The empirical model confirms what we posit in the theoretical model and observe in the stylized facts: as relative prices diverge, more people move.

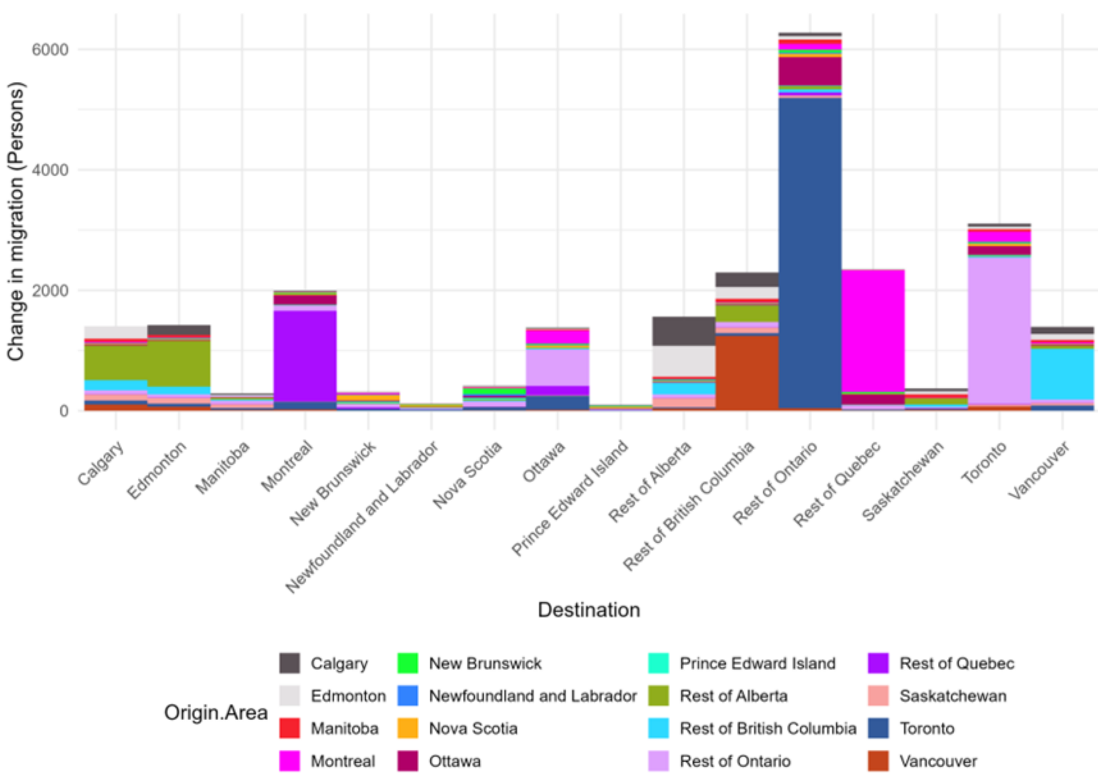
The availability metric, starts per unit of stock, suggests that it is easier to move to a particular destination if they're building homes for you to move into. Distance between two centers, as expected, has a negative impact. Finally, a 1% increase in the relative population ratio increases the migration rate by half a percent.

A3.5 Model experiment

To demonstrate that proximity and size play a large part in the source and number of migrants for all regions in the inter-regional model, we apply an 8% price shock to each region. As shown on Figure A3.5, small centers closer to larger centers get more migrants than small centers that are further away from large centers.

For instance, despite being smaller than Saskatchewan, Nova Scotia receives more net migrants due to its relative proximity to Quebec and Ontario. Thus, our model captures that regions near large regions will absorb a disproportionate share of migrants from their large expensive neighbors if they become relatively more affordable. This is consistent with "drive until you qualify" behavior observed in Canada's largest cities (CMHC, 2017).

Figure A3.5: Contribution to in migration change after a negative 8% price shock in each region



Source: Statistics Canada, CMHC calculations.

A3.6 Interconnections with other sub-models of the IHM when performing different projection scenarios

The inter-regional migration model enforces spatial equilibrium in the IHM when performing projection scenarios: when the ratio of prices, the starts to stock ratios, demographic ratios, and economic variables change, the model shifts population between regions. This directly impacts population and the number of households, by changing the population that feeds into the population model each period. The altered population then flows into other sub-models of the IHM.

The inter-regional migration model, the housing starts model and the household formation model take population as a direct input and the price model takes household counts as their direct input. Increased migration to a region increases prices, increases the total number of households, and increases starts through increased total population.

These interconnections set the base for dynamic relationships with feedback effects between projected inter-regional migration flows and other key variables in the IHM.

Appendix 4: Population framework

The population model of the IHM incorporates a standard demographic model for each of the 16 sub-national regions. Each region's demographic profile is modeled as a population pyramid that transitions in each timeframe by the addition of what are known as the "Components of Population Growth". Components of population growth are calculated by applying age- and sex-specific rates to individual birth-year cohorts, this is known as the "Cohort-Component" method of population modelling. The methodology has a long history, dating back to at least the 1940's (Thompson, 1943).

The components and assumptions used in the IHM are adapted from a projection produced by Statistics Canada's Centre for Demography. This projection is modified to account for the most recently available data as well as changes to national immigration policy. This projection also omits Statistics Canada's inter- and intra-provincial migration components, since the domestic migration component is obtained from the inter-regional migration model described in previous Appendix 3. Inter-regional migration flows are determined within the IHM with endogenous reactions to housing and economic factors.

This appendix describes the structure of the population model in the IHM.

A4.1 Base population

The demographic model is a standard cohort-component method, in which a population pyramid (or base population) is presented as:

$$p_{asrt}$$

where:

- *p* is the population count
- *a* is an age index
- *s* is a sex index
- *r* is a region index
- *t* is a time index (annual)

And total population in region *r* in year (or time) *t* is given by:

$$P_{rt} = \sum_{a=0}^{90} \sum_{s=1}^{2} p_{asrt}$$

A4.2 Transition

When we move from one period to the next, we account for the aging process by use of a lag operator in both the time and age indices, we then add the components of population growth unique to that age, sex, and region resulting in an updated population.

$$p_{\mathrm{asrt}} = p_{\mathrm{a-1srt-1}} + n_{\mathrm{asrt}} + i_{\mathrm{asrt}} + d_{\mathrm{asrt}}$$

where:

- n is natural increase
- i is international migration[51] and
- d is domestic migration

A4.2.1 Natural increase

Natural increase is simply births less deaths for each region, sex, and age. Thus:

$$n_{\mathrm{asrt}} = births_{\mathrm{asrt}} - deaths_{\mathrm{asrt}}$$

where:

- *births* is the sex, region and time specific count of babies born within Canada[52]
- *deaths* is the age, sex, region, and time specific count of deaths

Births

In order to generate births, we take the lagged population of women by age and region and apply the Age-Specific Fertility Rate or ASFR as well as the Sex Ratio.

$$births_{\mathrm{srt}} = \sum_{a=0}^{90} \mathrm{p}_{\mathrm{a-1,s=2,r,t-1}} \times ASFR_{art} \times SexRatio_{srt}$$

where:

- *ASFR* gives the frequency of births by age of mother expressed as a share of population
- *SexRatio*- the sex ratio gives the share of male and female newborns

Deaths

A mortality table (*MORT*) is applied to the lagged age and time population to obtain deaths in the current period.

$$deaths_{asrt} = p_{a-1,s,r,t-1} \times MORT_{asrt}$$

where:

- *MORT* is a table of age, region, and sex specific frequencies of deaths expressed as a share of population.

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[51] Note: Statistics Canada uses an inter-period time index for components of population (e.g. 2022/2023) rather than a *t* index, they also include a-1 age index to distinguish migrants born in the transition period outside of a given region *r*.

[52] In practice, the age index for births is redundant since all births with age a>0 are set to zero.

A4.2.2 International migration

There are five components of international migration, with all but the non-permanent resident component having an identical computation. All international components have a national-level parameter that controls the rate of migration and then localised weighting that distributes the national total by region, age, and sex.

$$i_{\mathrm{asrt}} = \sum_{c=1}^{5} i_{casrt}$$

where:

- c is an index for the component of international migration

    1. *Immigration*
    2. *Emigration*
    3. *Returning Emigrants*
    4. *Net Temporary Emigration*
    5. *Net Non-Permanent Residents*

Immigration[53], emigration[54], returning emigrants[55], net temporary emigration[56]

Regional, sex, and age specific migration takes the total national population, applies the national level migration rate, and then applies localised weights.

$$i_{\mathrm{casrt}} = \left(\sum_{r=1}^{16} P_{r,t-1}\right) \times MigRate_{ct} \times MigWt_{\,casrt}$$

where:

- i is the component, age, sex, region, and time specific migration count
- c is the migration component (immigration, emigration, returning emigrants, net temporary emigration)
- P is the total population for region r

[53] An immigrant refers to a person who is or has ever been a landed immigrant (permanent resident) and who has been granted the right to live in Canada permanently by immigration authorities. Immigrants are either Canadian citizens by naturalization (the citizenship process) or permanent residents under Canadian legislation. Some immigrants have resided in Canada for a number of years, while others have arrived recently. Most immigrants are born outside Canada, but a small number are born in Canada. Also, children born in other countries to parents who are Canadian citizens that reside temporarily in another country are not included in the category as they become Canadian citizens at birth.

[54] Canadian citizen or immigrant who has left Canada to establish a residence in another country, involving a change in usual place of residence. Emigration may be either temporary or permanent. Where the term is used alone in this document, it references to a person's permanent emigration which involves severing residential ties with Canada and acquiring permanent residency in another country.

[55] Canadian citizen or immigrant having previously emigrated from Canada and subsequently returned to the country to establish a permanent residence.

[56] Net temporary emigration represents the variation in the number of temporary emigrants between two dates. Temporary emigration includes Canadian citizens and immigrants living temporarily abroad who have not maintained a usual place of residence in Canada.

- *MigRate* is the national level frequency of migrants (expressed as a share of total population) for component *c* in year *t*
- *MigWt* is the regional, component, sex, and age specific share of national migration

Non-permanent residents[57]

Unlike the other international migration components, non-permanent residents (NPR) are modeled as a stock instead of a flow. First, the total count of NPRs is expressed as a share of the total Canadian population. Then the net change is derived by taking the difference in year *t* and *t*-1 to obtain the net flow.

$$NPR_{\mathrm{asrt}} = \left(\sum_{k=1}^{16} P_{r,t-1}\right) \times NprShare_t \times NprWt_{\,asrt}$$

where:

- *NPR* is the age, sex, regional, and time specific count of NPRs
- *NprShare* is the time specific annual share of NPRs
- *NprWt* is the age, sex, regional, and time specific share of national NPRs

$$i_{\mathrm{c=NPR,asrt}} = NPR_{asrt} - NPR_{asrt-1}$$

A4.2.3 Domestic migration

Domestic migration is generated from the inter-regional migration model described in Appendix 3. However, it is an input into the cohort-component model. An age, sex, region, and time specific net flow is fed to the cohort-component framework from the inter-regional migration model. Thus, the input from that model is simply taken as:

$$d_{\mathrm{asrt}}$$

A4.3 Interconnections with other sub-models of the IHM when performing different projection scenarios

Population mobility projected by the inter-regional migration model directly impacts total population by feeding into the population model at each period.

[57] A non-permanent resident is a person who is lawfully in Canada on a temporary basis under the authority of a valid document (work permit, study permit, Minister's permit or refugee) issued for that person along with members of his family living with them. This group also includes individuals who seek refugee status upon or after their arrival in Canada and remain in the country pending the outcome of processes relative to their claim. Note that Immigration, Refugees and Citizenship Canada uses the term temporary resident rather than non-permanent resident.

On the other hand, projected population feeds into many other sub-models in the IHM. The inter-regional migration model, the housing starts model and the household formation model take population as a direct input. Changes in population also impact house prices in the IHM through:

- the number of households and
- the ratio of total population aged 25-34, a key demographic group supporting new housing demand

These interconnections set the base for dynamic relationships with feedback effects between projected population and other key variables in the IHM.

Finally, it is important to highlight a key element of heterogeneity in the population model built into the IHM, which is the differential exposure to international migration. For instance, when performing shocks on national immigration rates, the population changes more in centers that are more exposed to immigration, like Toronto, Vancouver, and Montréal and in younger age groups as immigrants are typically in the first-time homebuyer's bracket.

Appendix 5: Household formation model

This appendix describes the household formation model, which is one of the key endogenous sub-models of the IHM. The objective of this sub-model is to project the number of households as a function of housing, economic and demographic variables. This requires the projections of headship rates. The microstructure underlying the household formation model allows to project them at a very detailed level for a broad range of groups of individuals. Our results are in line with theoretical expectations and allow to perform a broad range of scenarios.

A5.1 Model motivation and literature

The total number of households is a key element of the housing demand, and the literature shows that household formation is affected by changes in demographic and economic variables. The most common strategy in the literature is to analyze young adults' decision to leave their parents and form new households.

Demographic characteristics such as age, marriage status and the presence of children are mostly considered as the predominant factors influencing household formation. Meen et al. (2005) used a bivariate probit model to estimate the household formation as a function of demographic and economic variables. They found that demographic variables are more crucial than economic factors to model household formation.

But the economic context does play a role in household formation for young adults. Lee & Painter (2013) found that the probability for young people to form a new household decreases with economic hardship. A recession decreases the probability of household formation between 1 to 9 percentage points depending on age.

An increase of the unemployment rate by about 1 percentage point also lowers the probability of household formation by about 1 to 2 percentage points for renters and up to 1.3 percentage points for owners.

Using data for 25 European countries between 1994 and 2018, Martínez Mazza (2020) found that a 1 percentage point increase in the unemployment rate at the time of graduation decreases the probability of household formation by 1.5 percentage points.

Regardless of the macroeconomic situation, those with larger incomes are more likely to form new households. For example, Lee & Painter (2013) shows that a decrease of the real wage by about 1% lowers household formation rates by about 0.16 to 0.33 percentage point.

House prices also directly impact the decision to form a new household. Ermisch (1999) found that a tighter housing market, causing higher prices, significantly delays household formation for young people. He found that the elasticity of the child departure rate with respect to house prices was –2.5. Acolin, Lin & Wachter (2024) found that decreasing affordability (rent-to-income or price-to-income ratio) is a factor in the rise of co-residence with parents.

In the United States, for the 2000-2021 period, the decline in housing affordability explained about a quarter of the increased co-residence. Moreover, there are non-linear effects with the association between affordability and co-residence being strongest in the most unaffordable markets. Meen et al. (2005) estimates showed that price elasticities of household formation vary in the range –0.1 to –0.15.

A5.2 Modelling approach

A5.2.1 Estimation methodology: Probit regression with longitudinal data

Following Meen et al. (2005) and Andrew & Meen (2003), we focus our analysis on household formation for young adults leaving their parents. This approach allows to estimate the probabilities of forming a household at a very detailed level for a broad range of groups of individuals. Their estimations therefore rely on probit model and micro panel data.

We use the Statistics Canada's Longitudinal Administrative Databank (LAD). The longitudinal perspective of the LAD allows us to follow a panel of individuals through time and estimate the transition of these individuals from being a member of a preexisting household to forming a new household. We therefore create a sample of individuals living with their parents in 2011 and we follow their behavior over the following 10 years.

This strategy allows us to create our binary dependent variable: household formation (*HHF*). In 2011, no individual had formed a household (*HHF*=0). Over time, as some of those individuals leave the parent's home, new households are formed (*HHF*=1). This creates our panel of individuals that supports our probit regression model, which can be illustrated as follows in the most general terms:

$$\Pr(HHF = 1 | X,\ Y\ ) = \Phi(X\beta + Y\alpha) \qquad (5.1)$$

where Φ represents the cumulative standard normal distribution function and β and α are coefficient vectors associated with fundamental determinants of household formation. *X* represents the vector of binary demographic variables including gender, marital status, age group, presence of children and previous year's status (living with parents or not in the previous year). Y represents the vector of continuous variables and include housing costs (function of house prices and the mortgage rates), after-tax income, and unemployment rate.

Note that income is measured at the individual level while housing costs and unemployment rate are measured at the regional level. Moreover, income and house prices are both expressed in real terms by deflating them with the CPI.

Table A5.1 gives the list of the demographic, housing and economic variables used in the household formation model.

Table A5.1: List of demographic, housing and economic variables in the household formation model

Variables	Description
Demographic	
Gender	Takes value 1 if the individual is male. Otherwise 0.
Marital status	Takes value 1 if the individual is *de facto* married, includes common-law.
Presence of children	Takes value 1 if the individual has kids.
Age dummy	For 25-29 and 30-34, with 18-24 as the base.
Living with parents in the previous year	Takes value 1 if the individual was living with parents in the previous year.
Housing and economic	
Housing costs	Real average house prices*mortgage rates (regional level).
Income	Logarithm of total after tax income of the individual (deflated by regional CPI).
Unemployment rate	Unemployment rate at the regional level.

A5.2.2 Projecting headship rates and the number of households

The probabilities of forming a household depend on demographic and socio-economic characteristics. These probabilities are broken down by gender, marital status, age groups, presence of children or not, living with parents in previous period or not, and income quintiles. As a result, the household formation model derives headship rates for 400 individual types over the projected period (Table A5.2).

Table A5.2: Projecting headship rates for 400 individual types

Variables	Description	Number of individual types
Gender	Male=1, Female=0	2
Marital status	Married & Common Law=1; Single=0	2
Age groups	18-24; 25-29; 30-34; 35-59; 60+	5
Presence of children	Yes=1; No=0	2
Living with parents one year ago	Yes=1; No=0	2
Income quintiles	Q1; Q2; Q3; Q4 and Q5	5
		Total = 2 · 2 · 5 · 2 · 2 · 5 = 400

Using estimated coefficients $\hat{\beta}$ and $\hat{\alpha}$ obtained from 5.1 and projected demographic, housing and economic variables X and Y, the *z-value* are projected for these 400 individual types as follows:

$$z\text{-}value = X\hat{\beta} + Y\hat{\alpha}$$

These projected *z-value* are then translated into household formation probabilities using the probit model (5.1) and the cumulative standard normal distribution.

It is important to highlight that these household formation probabilities change with variations in housing and economic variables over the projected period when running simulations with the IHM, such as housing costs (function of house prices and the mortgage rate), income and unemployment rate. As a result, any shock in the model that affects household formation probabilities generates different household projections relative to the counterfactual scenario. Making household formation probabilities endogenous to housing costs and economic factors is a key feature of the IHM.

Once estimated, household formation probabilities are translated into headship rates. Typically, everyone who forms a new household is a head except those living with a partner (married or common law). To avoid double counting, the headship rates for individuals living with a partner is half of the household formation probability. Table A5.3 summarizes the link between household formation probabilities and headship rates.

Table A5.3: From household formation probability to headship rates

Marital status	
Single: (single, divorced, widow)	Headship rate = household formation probability
Couple: (married, common law)	Headship rate = 0.5*household formation probability

Projected headship rates are finally multiplied by the projected number of individuals in each group in order to get the total number of households in each group for each region. Household projections for the 400 groups are then aggregated to form the total number of households (a key determinant of housing demand) to feed into the house price model.

As discussed previously, our modelling framework focuses on household formation of young adults leaving their parents. Our sample database only includes people under 35 years old. As a simplification and following Meen et al. (2005), the probabilities of forming a household for the 30-34 age group is therefore used as a reference to estimate household formation probabilities for the older age groups (35-59 and 60+) in the IHM.

For instance, for a male, aged 35-59, married, with children, not living with his parents in the previous period and in the income quintile 5, its probability to form a household will be the same as an individual aged 30-34 with the exact same characteristics in a given year and a given region. After 35 years old, most individuals have already formed separate households.

As the estimated probabilities of forming households for older individual types are higher, they are less sensitive to changes in the economic variables (as housing costs) compared to younger groups (Meen et al., 2005).

A5.3 Key elasticities in the household formation model and their implications

It should be mentioned that the elasticities of the household formation model cannot be read directly from our probit estimations since the coefficient vectors β and α affect the probability to form a household via the *z*-value. Therefore, we must perform a specific shock in the IHM to estimate the elasticity of a given variable for each region, obtained by aggregating 400 individual types.

Moreover, to isolate a given variable's elasticity of household formation for each region, we had to mute some key channels in the IHM. The shock is therefore performed in "partial equilibrium" so that the retroactions from other endogenous variables in the IHM are shut off.

The price elasticity of household formation, the key elasticity of the household formation model, is discussed in Section 2.3.1.2 of Chapter 2. It shows that the price elasticity of household formation is larger in unaffordable regions like Vancouver and Toronto, which stems from the nonlinearity of the probit regression function in the household formation model.

Section 3.3.2.4 of Chapter 3 explores the impact of the “additional-supply” scenario on the number of households and shows an important element of granularity built into the IHM: younger age groups are more positively affected by an improvement in affordability, which is also explained by the nonlinearity feature of the probit regression function.

These results show that the household formation model properly captures the fact that younger individuals and those living in unaffordable regions have overall lower probabilities to form households (i.e., there are more suppressed households among these individuals), but benefit the most from improvements in affordability.

Other economic variables have a fundamental influence on the projected number of households when performing different economic scenarios. These variables include the income, the mortgage rate and the unemployment rate:

- the income elasticity of household formation is around 0.04, which means that a 10% increase in income leads to a 0.4% increase in the number of households[58]
- a 1 percentage point decrease in the unemployment rate increases the number of households by about 0.5%
- a 1 percentage point decrease in the mortgage rate (which reduces housing costs) increases the number of households by around 2.4%

As for the house price elasticity above, the nonlinearity feature of the probit regression function properly captures that younger individuals and those living in unaffordable regions are more sensitive to changes in these economic variables when performing different economic scenarios with the IHM.

A5.4 Interconnections with other sub-models of the IHM when performing different projection scenarios

The household formation model is fully integrated into the IHM when performing demographic, economic and policy scenarios over the projected period. First, the household formation model uses projections produced by other sub-models of the IHM as inputs, such as house prices from the house price model (described in Appendix 1) and the mortgage rate, income and unemployment rate from the exogeneous economic block.

These key housing and economic variables have a fundamental influence on headship rates over the projected period. As described earlier, to obtain the total number of households for each group for each

[58] This low income elasticity is not surprising as life changing decisions, such as first marriage and first child, are commonly seen in the literature as the key drivers of household formation. Meen et al. (2005) also found a weak income elasticity of housing formation. Acolin, Lin & Wachter (2024) found that other economic factors (house prices and unemployment rate) have more impact than income for household formation.

region, headship rates are multiplied by the projected number of people for each individual type. The aggregation of the 400 types within a region gives the total number of households for each region.

As a result, the total number of households projected depends on the composition of the population projected by the population model described in Appendix 4. Hence, the number of people projected for each individual type is a very important input in the household formation model.[59]

Moreover, the total number of households projections, a key determinant of housing demand, impact house prices in the IHM. Furthermore, the projected number of households in each group feed into the tenure choice model, which allows to distribute the number of households by tenure (own vs. rent) and to estimate the total ownership rate in each region. Thus, the total ownership rate depends on the composition of households projected by the household formation model.

These interconnections set the base for dynamic relationships with feedback effects between the number of households projected and other key variables in the IHM.

[59] As population projections from the population framework are only ventilated by age and gender in each region, they need to be further disaggregated (by marital status, presence of children, living or not with parent in the previous year and by income quintile) in order to project the number of individuals in each group. Inspired by Meen et al. (2005), we break down the population in each of the 10 groups already disaggregated by age and gender (from the population framework) by marital status, presence of children, living with parents in the previous year and income quintile, using micro data from the LAD in 2020 and assuming the same shares over the projected period.

Appendix 6: Tenure choice model

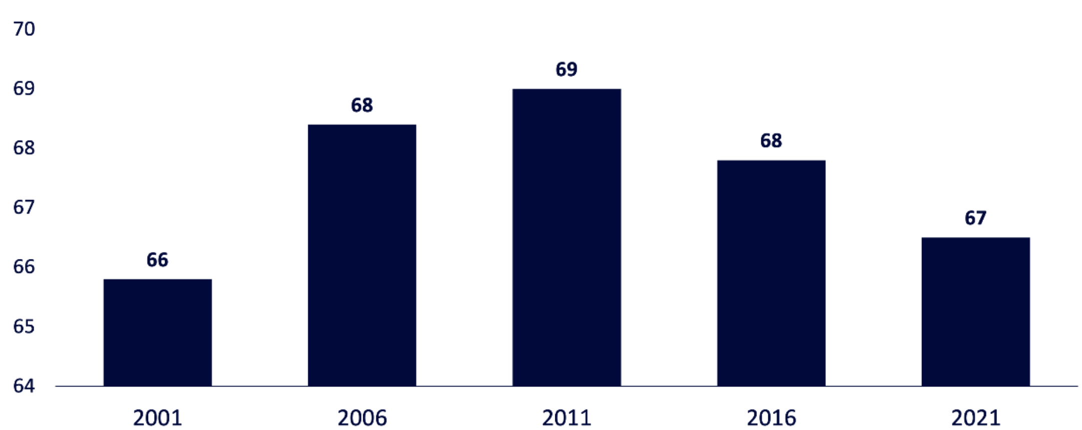
While the housing demand is not tenure-specific in the IHM, separately estimating a demand for ownership and rental segments emerges as a necessity. This appendix describes the tenure choice model.

A6.1 Stylized facts

Homeownership ratio is not constant. It is not constant among geographies, and it is not constant through time. Figure A6.1 and Figure A6.2 show those two dimensions of variation. At the national level, the homeownership ratio increased between the 2001 Census and 2011 Census, and then decreased in the following two Censuses in 2016 and 2021. Among the major CMAs, Montréal consistently had lower ownership ratios than Toronto or Vancouver.

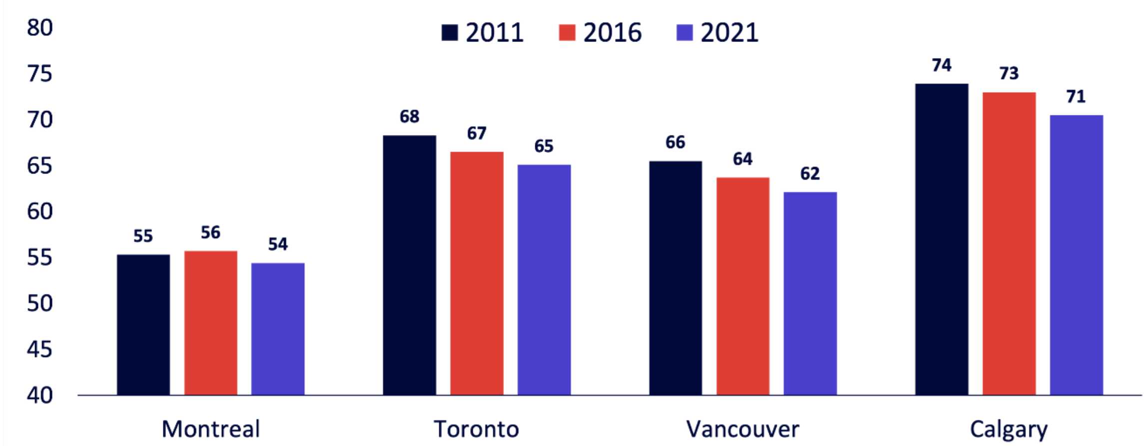
Homeownership also changes with demographics. This is most visible in the age distribution. Young households tend to be more likely renters while middle aged households have higher than average ownership ratios (Figure A6.3).

Figure A6.1: Ownership ratio in Canada, %



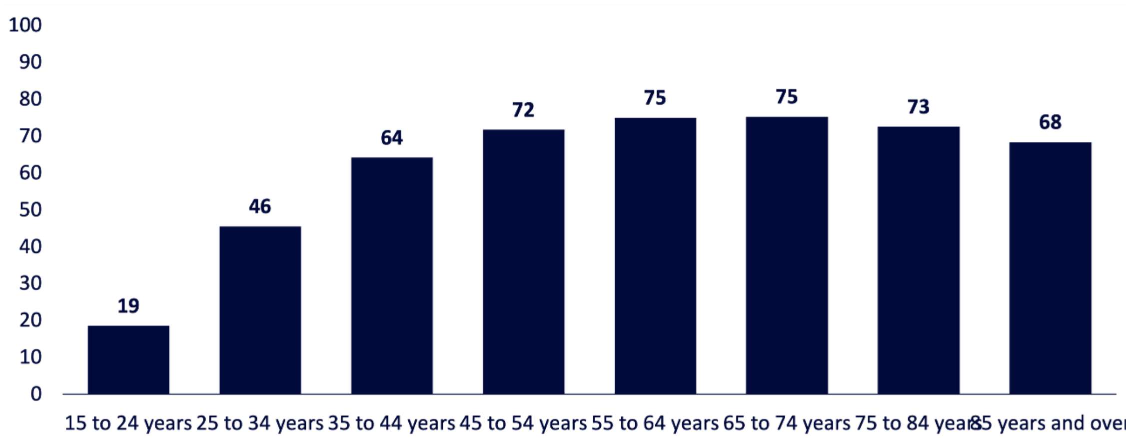
Source: Statistics Canada Census of Population.

Figure A6.2: Ownership ratio in major CMAs, %



Source: Statistics Canada Census of Population.

Figure A6.3: Ownership by age group of household head (Census 2021), %



Source: Statistics Canada Census 2021.

The findings from the past dynamics of homeownership in Canada can be summarized in 4 stylized facts:

- Ownership rates change over time, but not with a constant trend.
- Ownership rates show significant differences among CMAs.
- Age groups show different ownership rates.
- Economic variables matter for homeownership.

A6.2 Model and data

A6.2.1 Modeling approach

Housing tenure is, by its nature, a binary variable. A household is either a renter or an owner. Being in either of these two states can be therefore associated with a certain probability and modeled as a binary outcome model. Without loss of generality, the tenure variable is assumed to take value 1 if a household is owner. Therefore, the marginal effects of the coefficients correspond to the change in ownership probability.

As argued above, ownership depends on demographics, and also depends on economic variables. This establishes the main frame of the econometric model. The conditional probability of being a homeowner, conditional on economic and demographic factors can be written as:

$$Pr(Homeowner = 1|X, Y) = f(X\beta + Y\Gamma) \quad (6.1)$$

where β and Γ are coefficient vectors associated with fundamental determinants of ownership, X is a vector of demographic variables including indicator variables and Y is a vector of housing and economic variables. In short, we estimate the probability of ownership based on the demographic, housing and economic characteristics of a household. In doing so, we also include the geography as a third factor. Geography is approached the same way as the rest of the IHM.

A6.2.2 Demographic variables

Household types are defined in the same way as the household formation model in the previous Appendix 5. This simply follows from the fact that to simulate the number of homeowners in any type, one needs to have an estimated number of households in the same type. Therefore, household types differ by the gender and age of household head, marital status, and presence of children. Among those, gender and presence of children appear in the vector of demographic variables as binary controls.

This excludes the number of children from the analysis and therefore a family with kids would be treated the same regardless the number of kids. Age is not included as an explanatory variable but rather used for splitting the sample.

Specifically, we estimate the model separately for young, middle-aged, and older age groups. In that, we follow the approach adopted by Meen et al. (2008). Age groups are defined as 18-34, 35-59 and 60+. 18-34 age group is further divided into three sub-groups as 18-24, 25-29 and 30-34. In the estimation for this young sample, additional dummy variables are included in the model for these sub-groups.

A6.2.3 Housing and economic variables

Tenure choice can be affected by household characteristics as well as general macroeconomic variables. Besides, Andrew & Meen (2003) find that economic factors matter more than the demographic ones. Income of a household, rent in the area they reside, interest rates and more specifically mortgage rate, borrowing conditions and many other economic factors can play a role in this decision.

In a theoretical approach, the choice of ownership over rental would require either a strict preference for owning, or without any frictions the costs of owning and renting should be equal in equilibrium.

On the other hand, there are several frictions that would cause the observed prices to deviate from such an equilibrium condition. The most obvious friction would be a borrowing constraint. In absence of the capacity to borrow and purchase, a household cannot optimally choose and therefore the necessity of equality between user cost and rent does not have to hold.

We separately include a user cost and a rent variable in our model. The user cost of owning includes the financing cost, property taxes and an expected capital appreciation term with a coefficient.

For the simulation, since our rent projections also depend on the user cost for the turnover rents (as described later in Appendix 7), the equilibrium condition of equality of user cost to rent asymptotically holds. Following the rest of the IHM and also Meen et al. (2008), the transaction costs are not taken into account while estimating the user cost.

The family income of a household appears both as its logarithm in the model, and it is augmented with a binary variable corresponding to the income quintile that household belongs to in their geography and age group. This captures the distributional differences in homeownership and serves the purpose of better predicting the ratio of homeownership, at the cost of underestimating the actual elasticity of income.

Our data set does not include an intertemporal dimension. Therefore, the macroeconomic conditions with cyclical variations cannot be addressed, or at least their impact cannot be estimated. On the other hand, cross-sectional variation in macroeconomic conditions is addressed with including the unemployment rate at the regional level.

Borrowing constraints probably play an important role in the ability of purchasing a home. This is why Meen et al. (2008) include those in their model. We also follow that example as well as Andrew (2012) and include a binary variable of being constrained for each type of household.

Andrew (2012) models the borrowing constraint with two channels: wealth and income. Wealth constraint would matter in being able to afford a down payment while income appears in the ability to pay back a mortgage loan. With no information available about the wealth of a household, we did not pursue this dimension. For income, the regulation on the mortgage stress test rules in Canada provides a clearly defined borrowing constraint. We treated a household as constrained if their income level does not permit obtaining a loan to purchase an average home in their Census Tract with 20% down payment.

A6.2.4 Data

To estimate a model as described above, we would need to have the observations for tenure with a rich information set covering economic and demographic characteristics of households. This is only available with the microdata of Census. We estimate the tenure choice model relying on the household level data in the merged dataset of 2016 and 2021 waves of Census of Population by Statistics Canada.

Although the dataset covers both 2016 and 2021 Censuses, there is no intertemporal dimension at the sample such that we do not have multiple observations for a household.[60]

In merging the datasets from two censuses, all monetary economic variables are deflated using corresponding regional CPI value. Therefore, rents, house prices and income differences only reflect real variations.

Census files include all the individuals within a household. The sample excludes those individuals who are not reported as the household head. The final sample is at the household level. Accordingly, the income variable used is not the individual income of the household head but the total after tax income of the household.

For each household, the average price, average rent and unemployment rate variables are calculated within the sample based on the average values of rents and prices in the census tract, and the unemployment rate in their census tract.

In the calculation of the user cost variable, the price appreciation expectation is assumed to follow a 30-year moving average of price changes in each region of the 16 regions that the IHM is based on. The choice of 30-years is a deviation from the approach in the way the user cost is adopted in the price model as described in Appendix 1.

There are two main reasons for this deviation. First one is theoretical, the tenure choice is a more long-term life decision and therefore we assumed that long-term average of appreciation would be more appropriate to use than the short-term fluctuations for the user cost. Second reason is more practical, the longer-term moving average provides a smoother outlook for the variable, eliminating further fluctuation in user cost. The average price change is calculated using CMHC's repeat sales price index.

Table A6.1 gives the list of the variables used in the tenure choice model.

[60] Homeownership is a state variable of a household which changes only a few times during lifetime. Therefore, the best model of analyzing tenure would follow a panel of households through time and estimate the transition. In that, one can also differentiate the behavior of current owner-occupiers with renters. However, these are not feasible with the data we had. We had to limit our analysis to a cross-section.

Table A6.1: List of demographic, housing and economic variables in the tenure choice model

Variables	Description
Demographic	
Gender	Takes value 1 if the household head is male. Otherwise 0.
Marital status	Takes value 1 if the household is *de facto* married, includes common-law.
Presence of children	Takes value 1 if there are kids in the household.
Age dummy	For 25-29 and 30-34, with 15-24 as the base. Only in young sample.
Housing and economic	
Income	Logarithm of total after tax income of the household (deflated by CPI).
User cost	User cost of ownership, based on prices in census tract (deflated by CPI), expected appreciation in region, tax in province and interest rate in Canada.
Average rents	Average rents in census tract (deflated by CPI).
Unemployment rate	Unemployment rate in census tract.
Constrained	Takes value 1 if household income is not sufficient to get a mortgage loan for 80% of the average price in the census tract with that year's interest rate and mortgage stress test rules.
Income quintile dummy	Four binary variables for second to fifth quintiles, with first quintile being the base.
Region dummy	Fifteen binary variables for region, except the base region Toronto.

A6.2.5 Model specification and estimation methodology: Probit regression

The model is a binary outcome model of housing tenure that estimates the probability of homeownership as a function of economic and demographic variables. As described above, in the most general terms it can be written as:

$$Pr(Homeowner = 1|X, Y) = f(X\beta + Y\Gamma) \quad (6.2)$$

First, the function $f()$ is assumed to be the cumulative distribution function (CDF) of a normal distribution. Hence, our model is a probit model. This is a convenient assumption without loss of generality.

Above, we defined X as a vector of demographic variables including indicator variables, and Y as a vector of economic variables. More specifically, X is the vector of binary variables which mainly correspond to demographic information, including marital status, existence of kids, gender of the household head, and also a dummy variable for the region. Y is the vector of housing and economic variables, including continuous variables such as the logarithm of after-tax real family income of the household, average rent, user cost of ownership based on average home price, and unemployment rate in the census tract. Y also includes a binary variable corresponding to belonging second to fifth income quintiles within the age group of the household in the broader region (CMA, Province or Rest of Province) and a binary variable of whether the borrowing constraint binds.

With these, the model to estimate takes the following form:

$$Pr(Homeowner = 1|X, Y) = \Phi(X\beta + Y\Gamma) \quad (6.3)$$

A convenience of the probit assumption is the fact that the marginal effect of each variable is a multiple of the probability density function.

$$\frac{dPr()}{dY_j} = \gamma_j \phi(X\beta + Y\Gamma) \tag{6.4}$$

Where $\phi()$ denotes the probability density function of the normal distribution and γ_j is the j^{th} component of the coefficient vector of economic variables, Γ (see Table A6.2.1). Therefore, in the simulation phase, the *z-value* also predicts how responsive a group of households is to a change in any variable.[61] Closer to score prediction to 0, where the probability density function peaks, higher would be the absolute impact of a change in any variable.

As discussed above, the model is estimated separately for young, middle-aged, and older age groups.

A6.2.6 Projecting ownership rates

The household types in the tenure choice model are the same as in the household formation model except for the past status of living with parents for each type which isn't relevant for tenure choices. As a result, ownership rates are broken down by gender, marital status, age groups, presence of children or not, and income quintiles.

The tenure choice model therefore derives ownership rates for 200 household types over the projected period, instead of 400 types as for the household formation model (Table A6.2).[62]

Table A6.2: Projecting ownership rates for 200 household types

Variables	**Description**	**Number of household types**
Gender	Male=1, Female=0	2
Marital status	Married & Common Law=1; Single=0	2
Age groups	18-24; 25-29; 30-34; 35-59; 60+	5
Presence of children	Yes=1; No=0	2
Income quintiles	Q1; Q2; Q3; Q4 and Q5	5
		Total = 2 · 2 · 5 · 2 · 5 = 200

Using estimated coefficients $\hat{\beta}$ and $\hat{\Gamma}$ obtained from (6.3) and projected demographic, housing and economic variables X and Y, the *z-value* are projected for these 200 household types as follows:

$$\textit{z-value} = X\hat{\beta} + Y\hat{\Gamma} \tag{6.5}$$

[61] This relates to the point highlighted previously in Chapter 1: the microstructure underlying the household formation and tenure choice models, where different individual and household types respond differently to changes in housing and economic factors, allows to generate disaggregated household projections and their distribution across tenures (own vs. rent) at a very detailed level. This important element of granularity built into the IHM can be used to assess the effects of different economic, demographic and policy shock scenarios on the future demand for housing for many different individual and household types.

[62] The sum of the household numbers for a type living with and without parents corresponds to the number of households in that type for the tenure choice model.

These projected *z-value* are then translated into ownership probabilities for each type of household in each region using the probit model (6.3) and the cumulative standard normal distribution.

The ownership probabilities are then multiplied by the household number projected by the household formation model to calculate the projected number of owners in each group.[63] The summation of estimated owners in each group gives the total number of owners in a region and this way, using the prediction for total number of households in that region, the total ownership rate prediction for that region is calculated.

A6.3 Key elasticities in the tenure choice model and their implications

Similar to the household formation model, the estimated probit regression coefficients do not correspond to elasticities. To predict price or income elasticities, we need to conduct an isolated experiment, preventing the other channels in the IHM to affect the results. The elasticities can only be estimated in a partial equilibrium exercise.

For instance, a permanent 10% decrease in house prices (ceteris paribus) relative to the counterfactual scenario increases ownership rates in 2035 by about 0.3 percentage. The impact is greater in major centers.

For example, the increase is 0.4 percentage point in Toronto while in Vancouver and Montréal, ownership rates increase by 0.6 percentage point relative to the counterfactual scenario.

The way we constructed the tenure choice model prevents us from obtaining a reliable estimate of the income elasticity of homeownership. This follows from the modeling choice of including income quintile dummies. As explained above, this better captures the differences in ownership rates among the income distribution, but with the cost of underestimating the actual level impact of income.

In another exercise, this time without isolating the impact of a single variable, we explore the change in ownership rates in the scenario with additional supply relative to the business-as-usual scenario (see Section 3.3.2.5 of Chapter 3).

One key observation is that there is a significant distributional component in the change in homeownership behavior relative to the business-as-usual scenario, which illustrates an important element of granularity built into the IHM. The biggest differences occur in higher income and younger households, and middle-income and middle-aged households as seen in Figure 3.49, Figure 3.50 and Figure 3.51.

For older households, or higher income middle age groups, as they already have high ownership ratios, the change between scenarios is low.

[63] The household formation model calculates the number of household heads for each type of household (age, gender, kids, marital status and income quintile) based on the quintiles of income distribution. Therefore, the predictions from that model for each type of household for each quintile is recalculated by dividing the sum of the five quintiles for a given type of household from the household formation model by five. The tenure choice model is based on the distribution of household income, and not that of the individual income. This way, each income quintile for each type of household has equal number of households.

A6.4 Interconnections with other sub-models of the IHM when performing different projection scenarios

To project ownership rates, the tenure choice model uses as inputs the results of other sub-models in the IHM, such as projected average house prices from the price model (Appendix 1), average rents from the rent model (Appendix 7) and income, the mortgage rate and the unemployment rate from the exogeneous economic block.

More specifically, the final tenure choice projections rely on the projections obtained by the household formation model for each type of household. The tenure choice model projects a homeownership probability for each type of household, and the aggregation of all the types within a region gives the total homeownership ratio for each region. The projected total ownership rate therefore depends on the composition of households projected by the household formation model.

The tenure choice model does not directly impact other sub-models of the IHM. But its outputs allow to project the future demand for ownership and rental housing, which can be used to break down by tenure (own vs. rent) the supply gap estimates (see Section 3.3.2.8 of Chapter 3). It is then assumed that the additional housing units required (beyond business-as-usual) to meet predefined price targets should be distributed according to this future projected demand.

Appendix 7: Rent model

The rental sector is also modeled in the IHM. The future path of average rents is projected separately from house prices. This appendix describes the rent model.

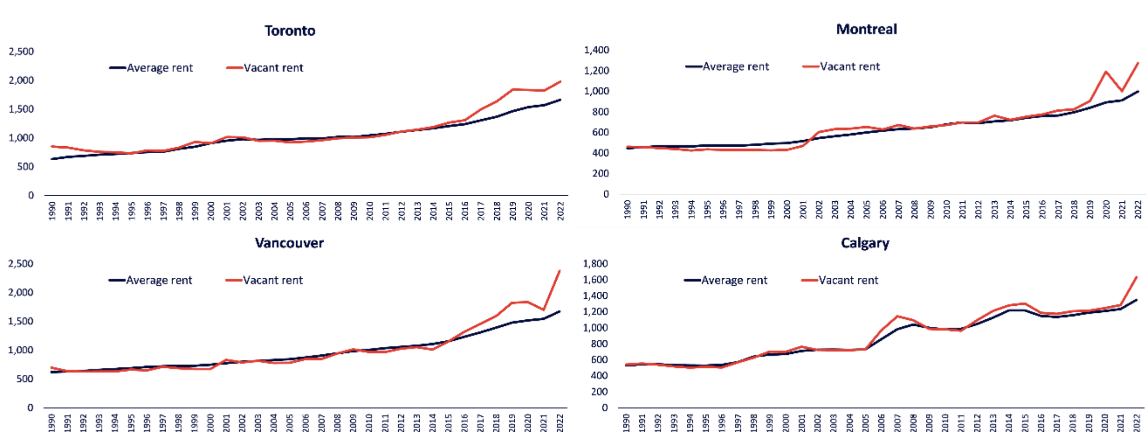
A7.1 Stylized facts and literature

Price stickiness is a well-known concept in the economic literature. It is particularly relevant in the case of rents, since there are rent control regulations in most Canadian regions (CMHC, 2020). Different approaches have been developed in the literature to model sticky prices. Among the commonly used approaches are the Taylor model (Taylor, 1980) and the Calvo staggered contracts models (Calvo, 1983). In the Taylor model, the time during which prices are fixed is known. In the Calvo model, there is a constant probability that the prices charged by a firm change.

The approach we use to model rents is inspired by the Calvo model. Because of rent control regulations, we know that prices are more likely to change when there is a turnover, i.e., when the renter of a certain unit is replaced by another one. For each region in the model, we thus assume a constant probability that the rent of each rental unit changes on a yearly basis. This constant probability is tied to the turnover rate in the region.

Figure A7.1 shows the historical relationship between vacant rents and average rents for different CMAs. In our analysis, vacant rents are used as a proxy for turnover rents. This indicator is the closest data we have about the price of rental units whose renter changed in a given year.

Figure A7.1: Average rents and vacant rents for different CMAs, 1990-2022



Source: CMHC calculations. Average rent of purpose-built private rental units (apartments and rows, all bedroom types). Vacant rent: average rent of vacant units, also referred to as “asking” rent, i.e., the rent the owner is asking for a unit available for immediate rental (physically unoccupied and a new lease has not been signed yet).

In the past, average rents and vacant rents have followed each other closely. More recently, they have started diverging, with vacant rents growing at a faster pace than average rents. This is in part because turnovers are opportunities for landlords to increase rents at the market price. Rental demand surged across the country amid strong population growth and declining homebuying affordability, which led to tight rental market conditions. Stronger competition among potential renters favoured a rapid increase in market rents in several regions.

A7.2 Methodology

At the foundation of our methodology to model average rents is thus the need to incorporate price stickiness. We do so by modelling separately turnover rents and non-turnover rents and then combining their projections using an estimated turnover rate. This combination takes the following form:

$$R_{i,t} = \omega_i R_{i,t}^{turnover} + (1 - \omega_i) \cdot R_{i,t}^{non-turnover} \tag{7.1}$$

Where $R_{i,t}$ is the average rent for region i at time t, ω_i is the estimated turnover rate for region i, $R^{turnover}$ is the turnover rent and, $R^{non-turnover}$ is the rent for non-turnover units. For each region, ω_i is the average turnover rate observed in the past 5 years of data, i.e., 2018-2022 (CMHC, 2023).

The models used to project turnover rents and non-turnover rents are presented in the following Section A7.2.1 and Section A7.2.2. We calibrate our models using historical data for average rents ($R_{i,t}$) and for vacant rents, our proxy for turnover rents ($R_{i,t}^{turnover}$). Both variables come from the CMHC Rental Market Survey and are calculated using all units from the full sample of privately initiated structures with at least three rental units. For vacant rents, we focus on the sub-sample of units that are vacant.

A7.2.1 Turnover rents

The methodology used to model turnover rents is derived from the user cost of capital approach described by Meen et al. (2008). The theory behind the user cost of capital approach is that over the long term, once market rigidities are absorbed, rents and owner-occupier housing costs need to be tied together. If it was not the case, all households would eventually either own or rent a house and one of the two markets would cease to exist. The arbitrage relationship between rents and the cost of owning a house takes the following form:

$$R_{i,t}^{turnover} = (r_t - \gamma \dot{P}_i^e + \delta + PT_{i,t} + TC_{i,t} + MC_{i,t}) \cdot P_{i,t} \tag{7.2}$$

where P is the nominal house prices, r is the nominal mortgage rate, δ is the annual rate of depreciation, e is a superscript representing an expected value, $(\dot{})$ represents the rate of change of a variable and PT, TC, and MC are respectively the property taxes, the transaction costs, and the maintenance costs, all in percentage of the property value. As in Meen et al. (2008), transaction costs are kept at zero. This is because transaction costs are encountered at the purchase of the house and would need to be discounted over the period of residence in the house, which is unknown. Maintenance costs are also assumed to be zero.

$\dot{P}^e$ is the rate of the expected house price appreciation, which is multiplied by γ, the value that homeowners give to this price appreciation. The value of this parameter γ, which lies between zero and one,[64] is unknown and needs to be estimated. We use data over the period 1990-2022 for the estimation. γ is chosen to minimize the root mean square error between our projections of the turnover rents and the data on vacant rents.

In the body of literature using the user cost to estimate rent, γ has commonly been fixed at 1, though Meen shows that it can be as low as 0 in the United Kingdom. Estimates are more likely to be lower in the short-term than over the long-term because of front-end loading of mortgages. Our estimates for γ vary between 0.3 and 0.8, which makes sense given the horizon of the model. These estimates are higher than Meen et al. (2008).

It is important to mention that the user cost approach assumes that the quality and the size are on average the same for owned houses and rentals. If owned houses tend to be bigger and of better quality than rentals, then this assumption is probably leading to an overestimation of rents. This effect might, however, be partly captured in some of our estimated parameters (e.g., γ). Controlling for the size and quality of dwellings could be done with a hedonic model (Bracke, 2013) but would add a high level of complexity to the model as it would require many additional variables and assumptions about their future trajectory.

A7.2.2 Non-turnover rents

Non-turnover rents are projected using the following formula:

$$R_{t,i}^{non-turnover} = \min\left(\alpha_i^{non-turnover}, \alpha_i^{average\ rent}\right) \cdot R_{\bar{t},i}^{non-turnover} \quad (7.3)$$

The difficulty with modelling non-turnover rent is that we don't have historical data for it. However, we can determine its level at some specific points in time. More specifically, during years when turnover rent equals average rent, we can deduce that they also equal non-turnover rent. For each region, we thus identified the year that minimizes the difference between turnover rent and average rent and used it as a starting point ($R_{\bar{t},i}^{non-turnover}$).

From that starting point, projections of non-turnover rates are produced by making them grow at a certain inflation rate ($\alpha_i^{non-turnover}$). This inflation rate varies by region because of the different rent control regulations but is fixed over time. The inflation rate is estimated by minimizing the root mean squared errors between actual average rents and our projected average rents over the historical period.

Over the projected period, an upper bound ($\alpha_i^{average\ rent}$) is added to this inflation rate. It consists of the average growth rate of average rents in each region over the historical period. This upper bound is added to have a better fit with the most recent data where we observe strong market rigidities, i.e., a stronger discrepancy between turnover rents and average rents.

Different methods were considered instead of this upper bound (e.g., using the 1-year lagged or 5-year lagged average rent as the rent for non-turnover units, implicitly assuming that for non-turnover units, everyone started renting their dwelling 1 or 5 years ago) but this upper bound method was shown to have the best fit with the data.

[64] A value of zero for γ implies that only nominal interest rates affect demand as the capital gains element drops out of the equation. A value of one implies that only real interest rates matter. An intermediate value means that both real and nominal interest rates matter (Meen et al., 2008).

A7.3 Interconnections with other sub-models of the IHM when performing different projection scenarios

As previously mentioned, projected house prices by the house price model (described in Appendix 1) are used as inputs in the rent model. However, their paths can diverge because rents and house prices react differently to, for example, the mortgage rate in the IHM.

Outputs from the rent model – projected average rents – are used as inputs in the tenure choice model (described in Appendix 6). It allows households to compare rents and owner-occupier housing costs to make an informed decision. Projected rents can also be compared to rent benchmarks to assess changes in rental affordability conditions (see Section A9.1.3).

Appendix 8: Exogenous economic variables

A8.1 Approach, key properties and implications

The macroeconomic variables used in the IHM can be divided into two groups: national variables and regional variables. For national variables, there is no additional process over the usual macroeconomic forecasting of CMHC. Interest rates fall into this category as neither the mortgage rate nor the short-term interest rate differ among regions. Other key macroeconomic variables, on the other hand, vary by region. GDP, disposable income, unemployment rate, and inflation need to be projected for each region.

The macroeconomic projections for internal purposes at the CMHC are produced using the Oxford Economics Global Economic Model for national, and the Oxford Economics Canada Provincial Territorial Model for provincial economic variables. These national and provincial projections form the basis of the economic projections used in the IHM.

The first key assumption for the regional projections of monetary variables, such as GDP and disposable income, is that the ratios of per capita values between CMA and province values are constant at recent averages. The second key assumption is for CPI and unemployment rate such that those variables follow the same dynamics within province. Both these assumptions follow from two reasons.

First, CMHC's usual projection exercise is at the provincial level, therefore the model-based projections are only available for provinces. Second, we did not develop CMA level models to separately project those variables at that geographic level.

A8.2 Interconnections with the other variables

The economic variables are assumed as exogenous. Therefore, neither endogenous changes in house prices nor inter-regional migration affects the macroeconomic outlook. On the other hand, the opposite is not true. Almost all sub-models use macroeconomic projections. The housing starts model, for example, has the short-term interest rate, output gap and construction sector wages as inputs.

From house prices to inter-regional migration flows, household formation to tenure choice, all housing and demographic outcomes explicitly modeled in the IHM are based on several macroeconomic variables.

While treating these economic variables as exogenous is not ideal, it is likely not having a large impact on the model results. The assumption that feedback effects from housing to economic factors are small and their influence on simulation results are negligeable is realistic for most of the economic, demographic and policy shock scenarios performed in the IHM.

However, the assumption that economic factors are unresponsive to changes in housing variables becomes more difficult to justify under scenarios that imply a sharp decline in house prices triggered by a major adverse event. For example, a global economic downturn leading to widespread unemployment and mortgage defaults, where the ability of households to continue to service their debt is dramatically affected. The assumption that economic factors are unresponsive to housing becomes a clear limitation of the IHM if performing such shock scenarios.

Appendix 9: Affordability targets, measures and distribution

A9.1 Defining the appropriate level of affordability

To estimate a housing supply shortage ("supply gap"), there needs to be an explicit definition of what a world with sufficient housing supply looks like. Only then can we assess the gap between the existing housing stock, and this desired supply that would support greater affordability.

Defining the appropriate level for housing supply is easier said than done. Housing affordability is multidimensional, and the housing system is complex. The many diverse realities of the Canadian population can't be boiled down into simple metrics that fully reflect everyone's housing conditions. When defining how to measure affordability, researchers always have to make choices based on data availability and the specific context and objectives of the work.

A9.1.1 Homebuying affordability ratio

In the context of the IHM, the most practical and readily available data relating to housing affordability are house prices. The assumption is that there is a supply shortage if house prices in a given region are higher than they should be. And when that's the case, we can estimate how much more housing supply would be required to drive prices towards this more affordable level.

In this work, the affordable level for house prices in a given region is informed by looking at the historical relationship between average house prices and average household incomes. Mortgage rates and homeowner expenses (property taxes, utilities, etc.) are also factored in since they directly impact the real cost of purchasing a home:

$$\alpha_{it} = \frac{P_{it}}{Y_{it}} * \left[\frac{r_t(1+r_t)^{12n}}{(1+r_t)^{12n-1}} + c_{it}\right] \quad (9.1)$$

Where:

α = homebuying affordability ratio
i = subscript for geography
P = average house price (based on a CMHC repeat sales price index)
Y = monthly average gross household income
r = effective monthly mortgage rate
c = estimated monthly homeowner expenses
n = amortization (years)

This results in the "homebuying affordability ratio", i.e. a simple house price-to-income ratio, adjusted for changes in mortgage rates and homeowner expenses (as seen in Figure 3.14 to Figure 3.30 in Section 3.3.1.3 of Chapter 3). It is a measure of relative homebuying affordability over time. The higher the ratio, the less affordable the market.

The estimated monthly homeowner expenses (c) include property taxes, utilities (fuel, electricity, water, etc.), home insurance and maintenance and repairs costs. They are estimated using a range of data sources and assumptions.

A9.1.2 Setting a homebuying affordability target for the future

This price-to-income measure allows to identify periods when homebuying, i.e. the purchase of a residence, was generally the least expensive. It informs on potential affordability targets for the future. For instance, while it may be too late to ever go back to the relatively low homebuying costs from the early 2000s, we can aim to restore homebuying affordability as it was around 2019, just before the pandemic widespread deterioration.

For example, in Toronto, the adjusted price-to-income ratio gradually increased starting in the early 2000s up to 59% in 2019, and 71% in 2024 (see Table 3.1 in Section 3.3.1.3 of Chapter 3). The supply gap in Toronto is defined as the number of additional annual housing starts, beyond business-as-usual, that would be required for the ratio to go back to its 2019 level (59%) by the end of 2035. Given the economic and demographic projections explored in the scenario analysis in Chapter 3, this 59% ratio would be reached if house prices in Toronto increase by only 19.8% between Q3 2024 and Q4 2035, instead of the 62.6% projected in a business-as-usual scenario.

Where these ratios are projected to be in the future in a business-as-usual scenario, compared to their targeted level, is central to understanding the size of the supply shortage in each region. Other choices for the targeted affordability level and time horizon would be possible, leading to different estimates of the "supply gap".

A9.1.3 Rental market affordability ratio

While affordability targets for the IHM model are primarily based on house prices, the framework also captures rental market conditions. We look at the historical and projected relationship between rents and average household incomes (rent-to-income):

$$\omega_{it} = \frac{R_{it}}{Y_{it}} \tag{9.2}$$

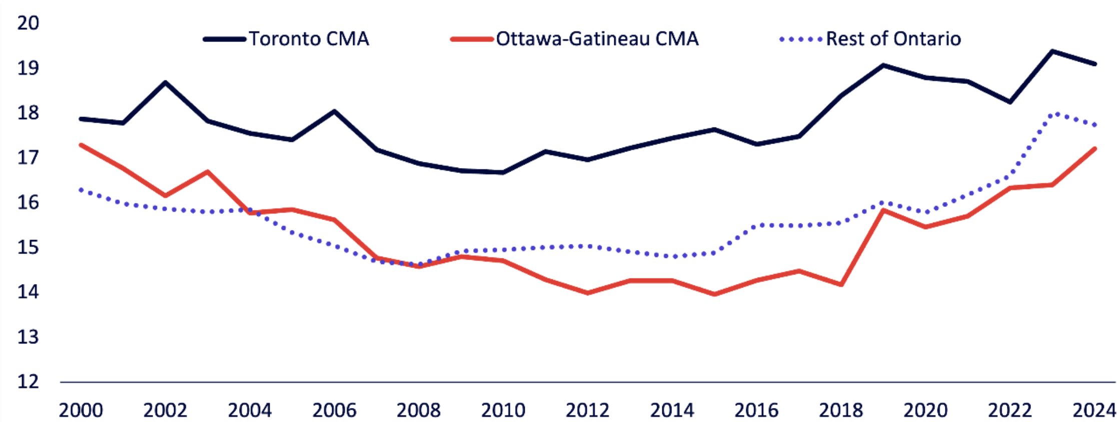
Where:

ω = rent-to-income ratio
R = average rent of purpose-built units (from the CMHC Rental Market Survey)

This allows to monitor the improvement or erosion of rents affordability over time, under different supply scenarios. The higher the ratio, the less affordable the market.

Rental market affordability somewhat improved in the first decade of the 2000s with income growth overall outpacing rent growth, but the trend reversed afterwards (illustration for Ontario in Figure A9.1).

Figure A9.1: Rental market affordability ratio (rent-to-income), selected regions, %



Source: CMHC calculations.

A similar approach to homebuying affordability can be applied to rental affordability. The rent-to-income ratio observed in a previous period of relative affordability in the rental market can be set as a target, or benchmark, for the future. The average rent level that would restore this rent-to-income ratio can be compared to projected rents to assess the evolution of the gap between "affordable" and actual rents.

$$R_{it}^{gap} = R_{it} - RAB_{it} \tag{9.3}$$

Where R_{it} is the observed or projected average rent, RAB_{it} is the rental affordability benchmark (rent level associated to a predetermined price-to-income ratio), and R_{it}^{gap} is the rent gap for region i at time t. The gap indicates by how much the average rent would need to decrease for the rent-to-income ratio (based on the average household income) to go back to a selected predefined "affordability" level. A positive rent gap thus implies that the rental market affordability is worse than during this benchmark period.

A9.2 Monitoring affordability at different income levels

The homebuying and rental market affordability ratios presented previously are based on average housing costs and average household incomes. They are relevant from a modeling perspective, but don't tell much on the distribution of affordability challenges across households with different income levels.

To address this question, we evaluate how total additional housing supply may impact households at different points in the income distribution, primarily by describing how their "options" have changed. In particular, we monitor the share of the ownership and rental housing markets that would be "qualifiable" (in the case of ownership) or "affordable" (in the case of rental) for them.

As additional supply is added to the market, there are changes throughout the house price (and rent) distributions. For instance, a larger proportion of units becomes qualifiable or affordable with a lower income level. These changes depend on the shape of the price and rent distributions.

An illustration of this approach is provided for Ottawa-Gatineau in Figure 3.52 for the ownership market, and Figure 3.53 for the rental market (Section 3.3.2.7 of Chapter 3). The following sections describe how we make use of several simplifying assumptions in order to describe how changing supply might result in changing outcomes for households of various income levels.

A9.2.1 Approach

While the core models of the IHM make use of single measures of house prices, rents, and household incomes (averages, or a dollarized index associated with an historical average), there is a need to describe affordability across the income distribution. We do so in two similar, but different ways for ownership and rental housing:

- For ownership, we describe the share of the price distribution that a given income level would be able to qualify for
- For rental, we describe the share of the rent distribution that would be "affordable" to a given income level

Conceptually, we have the following:

$$QS(Y_{qit}, X_{qit}, F_{it}) = F_{it}\left(MQPL(Y_{qit}, X_{qit})\right) \quad (9.4)$$

and

$$AS(Y_{qit}, G_{it}) = G_{it}(0.3Y_{qit}) \quad (9.5)$$

Where the qualifiable share (QS) is dependent on the household monthly gross income level Y_q, the house price cumulative density function (CDF) F (price distribution), and a vector X of other variables relevant for the maximum qualifiable house price level ($MQPL$)[65] including down payment, amortization period, OSFI rules (e.g. GDS limits, stress test, etc.), mortgage rates, mortgage loan insurance premium (if applicable), property taxes, utilities, home insurance and maintenance and repairs costs. Similarly, for rents, the "affordable" share (AS) is dependent on the household income level Y_q, and the rent CDF G (rent distribution).

We interpret an increase in qualifiable share or affordable share for a given income as an improvement in affordability. Improvements in affordability at a given income level (an increase in either QS or AS) can come about through two mechanisms: a greater "qualifiable price" or "affordable rent" (via improvements in income or other variables in X), or a change in the distribution bringing more of the distribution below the relevant "qualifiable price" or "affordable rent" thresholds.

[65] The maximum qualifiable house price level is the same kind of calculations that would be done by a financial institution to determine the maximum loan they could underwrite for a mortgage application. This determines the maximum house price a household could qualify for a purchase. There are currently 5 income levels considered in the IHM: the 10th, 25th, 50th, 75th and 90th income percentiles. The down payment assumption for mortgage qualification is the minimum requirement for insured mortgages in the case of the 3 lowest income levels, and 20% for the 2 highest income levels.

A9.2.2 Assumptions and implementation

For each distribution (of household income, house prices, and rents) it is assumed that the distributions remain constant around the mean of the distribution over time. A reference period is then used to project the distribution around the mean.

These assumptions are made for the purpose of simplicity and tractability. However, the reasonableness of these assumptions is supported by the stability of distributions around the mean over time in most cases. Distributions (of household income, house prices, and rents) are reasonably stable over time, especially if one can exclude the extreme tails of the distributions.[66]

Furthermore, we do not have a continuous distribution for either prices or rents, and so we discretize the process using particular quantiles. For prices, we use price percentiles (from 0.01 to 0.99). This is enough resolution to allow estimations of the qualifiable share of house prices. For example, it is estimated that in the scenario with additional supply considered in Chapter 3, the median household income in 2035 would allow to qualify for 62% of homes in Ottawa-Gatineau in 2035, compared to only 27% in the business-as-usual scenario (Section 3.3.2.7).

For rents, as we currently do not have sufficiently high-resolution quantiles (we only have the 10th, 25th, 50th, 75th, and 90th percentiles), affordable rents for a given income level are simply compared (visually) against the rents at the available quantiles. While the rent distribution is based on the Census, the nominal average rent level around which the distribution is centered is based on a series of average rents from the CMHC's Rental Market Survey. Choices for Y_q are based on projected income quantiles.

[66] This conclusion is based on analyses of Census data where the distribution of these variables in past censuses could be reasonably "estimated" in most cases using the 2021 distribution as a reference period.

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