UNPACKING MOVING:

A Quantitative Spatial Equilibrium Model with Wealth*

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Abstract

We argue that incomplete markets and income risk explain a large fraction of moving rates, especially for low-wealth individuals. We reach this conclusion by developing a quantitative dynamic spatial equilibrium model with endogenous wealth accumulated through liquid and illiquid assets (homeownership) under income risk and incomplete markets. Given the rich individual and spatial heterogeneity, our model is well-suited to compare people- to place-based policies aimed at reducing inequality. *Do moving vouchers (people-based) or reduction in housing regulations (place-based) enhance welfare relatively more for the poor?* Moving vouchers only marginally increase the welfare of eligible households, and those who receive the vouchers tend to move to locations with lower house prices and wages. In contrast, lower housing regulations in Vancouver can substantially decrease the welfare gap between the rich and poor nationwide. As this policy increases housing affordability in more productive cities, it reduces the incentive for low-wealth families to move precautionarily to low housing costs locations. Lower housing costs increases the insurance value of high-income cities and allows for higher wealth accumulation through homeownership for poorer households.

JEL codes: G51, R12, R13, R2, R31, R52

Keywords: dynamic spatial models, wealth, incomplete markets, housing policies, moving vouchers

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1 Introduction

One of the main challenges of the modern world is that individual and spatial socio-economic disparities are large and growing. Geographic mobility is often considered a way to mitigate these differences as individuals could move to places with better jobs and social conditions. Moving to places with better opportunities can also mitigate the impact of idiosyncratic shocks, downturns, or structural transformations that lead to a decline in returns to some occupations. Alternatively, shocks can also be buffered through accumulated wealth or access to credit markets as standard in macroeconomics. Despite the interaction between these two insurance mechanisms being potentially quantitatively significant, the study of simultaneous forward-looking consumption-saving and moving decisions is not present in most quantitative studies aiming to understand migration and policies that induce spatial reallocation.

To unpack and quantify the role of consumption-saving decisions under incomplete markets on migration, we develop a tractable dynamic spatial equilibrium model with uninsurable income risk, endogenous wealth accumulation through liquid and illiquid (homeownership) assets and costly migration. Besides the endogenous wealth distribution, the model also features rich individual and spatial heterogeneity. Due to the high dimensionality of the problem, solving and bringing the model to the data is a challenging task, which we address by combining state-of-the-art macro and spatial economic quantitative methods.

The *key* insight of this paper is that jointly accounting for endogenous wealth and migration decisions under income risk and incomplete markets is first-order in explaining migration behavior, especially for financially constrained individuals. When facing an unexpected life event, individuals with low liquid wealth and lack of credit access, despite housing transaction costs, may move to mitigate the impact of shocks since they cannot tap into their savings. Through this channel, even if all individuals face the same migration costs, the benefits of moving depend on their wealth, generating endogenous migration elasticities that vary with wealth. Moreover, incorporating markets incompleteness and homeownership in dynamic spatial equilibrium models is crucial to compare the aggregate and distributive impact of policies inducing moving relative to place-based policies aimed at reducing socio-economic disparities.

The paper is divided into three main parts. We start with suggestive evidence of how individual location decisions vary with wealth determinants in Canada. We exploit a rich monthly panel of individuals from *TransUnion Canada*, a credit bureau data set from 2011 to 2019. It covers nearly every person in Canada with a credit report and includes individual demographic and financial characteristics. Crucially for our analysis, the data set also keeps track of individual locations across time.The key empirical finding is that individuals' migration propensities decline monotonically with the ability to borrow after controlling for other observable characteristics such as age, homeownership status and balance sheet composition.[1,2] Overall, this heterogeneity in migration propensities for different levels of access to credit calls for a deeper understanding of the joint consideration of location choices and wealth accumulation and the complementary between these two sources of insurance.

To that end, the paper's main contribution is to develop and solve a quantitative life-cycle spatial equilibrium model with uninsurable income risk and wealth accumulation that delivers heterogeneous migration propensities across demographic groups consistent with empirical evidence. Locations are heterogeneous regarding productivity, amenities, labor market risk and housing market characteristics. The economy is populated by overlapping generations of risk-averse households who face idiosyncratic income shocks and mortality risks during working years. Heterogeneous households endogenously accumulate wealth through liquid and illiquid assets. They can become homeowners by acquiring illiquid housing units and saving or borrowing through a one-period non-contingent liquid asset subject to a borrowing constraint. Since markets are incomplete, risk-averse households cannot perfectly hedge against income and longevity risks, generating the standard precautionary saving motive. Every period, households make forward-looking decisions on location, tenure status (own or rent), non-housing and housing consumption and savings. There are moving frictions as moving is subject to monetary and utility moving costs. On the supply side, each location produces a tradable good using local labor subject to decreasing returns to scale. Productivity is endogenous as agglomeration forces drive productivity up with location size. The construction sector builds new additions to the local residential stock and a competitive sector manages rental units. Wages, house prices and rental prices in each location are endogenously determined in

[1]We find that conditional on location and time, individuals with a credit score above 800 points (super prime borrowers) are 1.21p.p. less likely to move to a different city in a given year than those with a credit score below 640 points (very poor borrowers). A higher credit score is associated with easier access to credit and more favorable loan terms, so this evidence suggests that migration propensity is negatively correlated with the ability to borrow. Consistent with previous evidence, we also find that renters and younger individuals are also more likely to move.

[2]In a complementary paper, Giannone, Paixao and Pang (2021) exploiting an unanticipated drop in international oil prices and the differential exposure to the oil industry across locations, find that, on average, individuals with lower credit scores, younger and renters are more likely to move in response to the shock. It also find that besides moving more, they are more likely to move to locations with lower housing costs. We interpret this result as suggestive that the more credit-constrained have a more challenging time buffering the shock locally and that housing affordability is an important consideration in their location choice rather than "moving to opportunity" alone.

equilibrium.

Given this set of ingredients, the model combines two streams of the literature. First, we follow the spatial equilibrium literature summarized by Redding and Rossi-Hansberg (2017) and characterized by rich location heterogeneity and costly migration. Recent advances incorporate endogenous wealth in a stylized framework (i.e., Bilal and Rossi-Hansberg, 2021). Second, in the spirit of Kaplan, Mitman and Violante (2020), we add fully-fledged consumption-saving decisions with liquid and illiquid assets. Combining these two strands of the literature is crucial to quantifying the role of income risk and market incompleteness on location decisions and comparing the aggregate and distributional effects of different policies. However, this comes at the cost of high dimensionality, which raises computational challenges in solving the model and bringing it to the data.

We overcome this by combining solution methods from the quantitative spatial literature and the macro literature on heterogeneous agents. The joint consideration of location and consumption-savings decisions under incomplete markets and non-myopic agents generate highly non-linear policy functions that are key to generating the core results of the paper. Therefore, we cannot implement dynamic hat-algebra for counterfactual analysis that requires policy functions to be log-linear in state variables as in Caliendo, Dvorkin and Parro (2019), Kleinman, Liu and Redding (2021) and Dvorkin (2023). Crucially, we implement a global solution method that keeps track of the wealth distribution within and across locations, as in the dynamic heterogeneous agents' literature.

We take the model to the data by matching key features of Canada's largest 27 largest Census Metropolitan Areas (CMAs) in 2016. We characterize cities' heterogeneity in productivity by inverting the wage equation. Amenities are backed up to match the population distribution. Following the methodology developed in Guren et al. (2021), we estimate housing supply elasticities for all cities of Canada. The most salient parameters driving migration and wealth decisions are determined using internal calibration. The first set by matching different aggregate migration moments. The second set, which includes parameters such as discount factor, bequest function, and housing grids, is obtained by matching several moments of the wealth and home equity distributions. Overall, the model matches the data satisfactorily. We highlight that despite homogeneous migration costs, our framework closely matches the heterogeneous migration rates by age, homeownership status, and wealth to the data.

The joint location and consumption-saving decision are at the core of the model's mechanism. Households can smooth their utility in the presence of uninsurable income risk by accessing financial markets or adjusting their location. Since households are forward-looking, the model also gives rise to both *precautionary savings* and *precautionary moving* motives. In other words, migration and wealth work as imperfect substitute insurance channels against uninsurable income risk. To quantify the different channels that determine the migration propensity, we compare our benchmark results against those generated by shutting down, one at a time, homeownership, income risk and borrowing constraint. Overall, we find that income risk and borrowing limit matter significantly more than homeownership in determining migration behavior. We find that in the absence of income risk and borrowing limit, the aggregate migration rate is, respectively, approximately 60% and 35% lower than in the baseline economy. Reducing income risk or financial constraints significantly attenuates the precautionary moving motive, implying that self-insurance is quantitatively a key driver of location choice. Most of the decline is driven by financially constrained households since high-wealth households can easily accommodate income shocks by adjusting their savings rather than moving, avoiding the large utility moving cost. Low-wealth households, instead, cannot smooth consumption through financial markets due to the borrowing constraint, which increases the value of moving relative to staying. Despite homeownership not being quantitatively very important in determining moving rates, a lower bound on housing consumption plays an important role. Thus, low-wealth households are more likely to move to locations with lower housing costs. Our baseline specification implies a migration cost between Canadian cities for an average person of approximately 196,303 CAD (in 2016 units). However, not accounting for the ability to smooth shocks simultaneously by either moving or through the financial markets will deliver higher model-implied moving costs.

Our framework presents three main features that make it the ideal ground to compare the aggregate and distributional implications of people- relative to place-based policies. First, by considering uninsurable income risk and wealth accumulation through liquid and housing and life-cycle motives, we can micro-found endogenous moving rates that vary with individual heterogeneity. This heterogeneity allows us to identify and compare the mechanisms through which different policies work. Second, given that most of the household wealth is concentrated in housing, embedding a fully-fledged homeownership model allows us to analyze policies that direct impact the housing market and bring a new perspective to the distributional impacts of different policies. Third, the general equilibrium nature of our model and its tractability allows us to incorporate in our quantification the policies' impact through the change in relative prices across space, a critical factor in pinning down location choices.

We start by studying the implications of *moving vouchers* (*people-based policy*). We analyze the implementation at the national scale of moving vouchers across cities for low-income families. We analyze an *unconditional* moving voucher against a voucher *conditional* on moving to a city with a higher median income than the current one. Both policies are associated with low take-up rates, although they almost double under unconditional vouchers. Overall, these policies increase welfare but only marginally. The low take-up rates and marginal welfare gains are driven by low-income and low-wealth individuals moving to cheaper locations to insure against income risk. For low-wealth families, the amount of insurance provided by temporary conditional vouchers does not compensate for the loss in insurance of not moving to cheaper locations. We conclude that moving vouchers have a minor impact partly because they do not address housing affordability, one of the main important drivers of low-wealth households' location choices.

We compare it with a *place-based policy*, in particular, we ask what are the implications of less stringent *housing regulations* in Vancouver, one of the most productive but expensive locations in North-America. A 30% increase in landing permits for construction increases welfare in Vancouver and Canada as a whole and reduces welfare inequality by wealth in the long run. The increase in housing supply in Vancouver leads to a decrease in house prices and an increase in population in Vancouver. The spatial reallocation drives the spillovers of this policy across space, resulting in lower house prices and higher wages across the entire country. Making housing more affordable increases the insurance value of living in high-income cities, reducing the incentive for low-wealth households to move precautionarily to low-housing-cost locations. In the long-run, the higher concentration of households in more productive but expensive cities increases welfare at the aggregate level by 1.06%.

The main conceptual difference between moving vouchers and lower housing regulations is that the first leads to higher house prices while the latter decreases them everywhere. Despite the latter being a place-based policy that only applies to Vancouver, it leads to higher welfare to low-wealth households across the country than people-based moving vouchers, as it allows for higher insurance in relatively more expensive but productive cities. These welfare results highlight the importance of incorporating homeownership decisions in this class of models even if it is not quantitatively very relevant to explain migration rates.

Related Literature This paper relates to several quantitative spatial and macro literatures branches. A large literature analyzing individual location choices highlights the role of spatial heterogeneity and migration costs in static or partial equilibrium frameworks as summarized by Redding and Rossi-Hansberg (2017). Desmet and Rossi-Hansberg (2014), Desmet, Nagy and Rossi-Hansberg (2018), Giannone (2017), Lyon and Waugh (2018), Oswald (2019), Eckert and Kleineberg (2019), Caliendo, Dvorkin and Parro (2019) among others, allow for forward-looking migration decisions but do not consider consumption-saving decisions under incomplete markets. Recent papers such as Kleinman, Liu and Redding (2021) and Cai et al. (2022) provide dynamic general equilibrium models with forward-looking decisions and local capital accumulation. Still, two different types of agents make each of these decisions independently. Forward-looking workers can move across space but are hand-to-mouth, while landowners accumulate capital but are immobile. Dvorkin (2023) develops a tractable spatial equilibrium model with location and wealth choices. Given the specification of log-additive value functions, migration choices are independent of individual wealth. Therefore, in these papers, migration is only driven by differences in income, amenities and rents across space but lack migration as an insurance mechanism under market incompleteness.

Bilal and Rossi-Hansberg (2021) is the first paper to conceptualize a theory where consumption-saving decisions determine location choices, putting forward the location asset hypothesis. We depart from this paper in two key dimensions. First, conceptually, while our theory embeds the location asset hypothesis, it also allows for an asset in a location through homeownership. According to their theory, moving allows smoothing utility for financially constrained individuals who reallocate to cheaper locations. In our framework, by introducing homeownership, the value of a location is redefined. Differences in wages and house prices across locations imply different investment opportunities through housing and liquid savings. Therefore, homeownership induces a new source of sorting across locations. Second, quantitatively, given the theoretical objective of their exercise, they abstract from costly migration, factor price determination, rich spatial heterogeneity, life-cycle considerations. Embedding our model with these rich features allows us to quantify the role of consumption-saving in determining net mobility patterns, and analyzing policy counterfactuals where both the location asset hypothesis and the asset in a location are important. In contemporaneous work, Greaney (2020) develops a related model in continuous time. In contrast to our work, he focuses on understanding how uneven regional growth affects wealth inequality.

We also contribute to a large literature in macroeconomics of household heterogeneity induced by idiosyncratic productivity shocks and incomplete markets (e.g., Aiyagari, 1994; Huggett, 1993; Imrohoroğlu, 1989) with wealth accumulation through two assets (e.g., Heathcote, Storesletten and Violante, 2009; Kaplan and Violante, 2014; Kaplan, Mitman and

Violante, 2020). In this strand of the literature, agents can only insure themselves through savings. Instead, we develop a quantitative framework where agents can insure themselves by accessing financial markets or moving. So, our framework simultaneously gives rise to *precautionary savings* and *precautionary moving*. We quantify the strength of the *precautionary moving* motive and how it depends on the level of access to financial markets. Adding the extra insurance channel leads to different policy implications.

Naturally, our work also relates to the literature that aims at explaining migration rates and moving costs across locations (e.g., Molloy, Smith and Wozniak, 2014; Kennan and Walker, 2011; Diamond, McQuade and Qian, 2019). We highlight the conceptual departure from these papers by incorporating consumption-saving decisions. First, our moving costs are common across demographic groups. The heterogeneity in the migration rates is driven by the different dynamic benefits across agents and not by differences in preference or moving costs. Second, our estimates show that not accounting for insurance through wealth accumulation may overestimate moving costs since all the income risk is buffered through migration.

The paper also relates to several studies that analyze the impact of moving-inducing policies to reduce economic and social inequality. Chetty, Hendren and Katz (2016) examine the impact of the MTO experiment empirically. In contrast, through the lens of our model, we analyze the aggregate and distributional welfare effects of different types of moving vouchers across cities and provide a potential rationale for the low take-up rates of such programs despite the differences in institutional setting and goals. Favilukis, Mabille and Van Nieuwerburgh (2023) are the first to study housing affordability policies in a dynamic structural model for NYC. Several empirical papers study how rent regulations and zoning policies in specific cities impact the local economy (e.g., Palmer, 2015; Davis, Gregory and Hartley, 2018; Diamond, McQuade and Qian, 2019). By developing a framework with rich individual and spatial heterogeneity and wealth accumulation, we offer a laboratory to study and quantify the effects of housing affordability and other place-based policies across locations and at the aggregate level.

The rest of the paper is divided into the following sections. Section 2 describes the Canadian *Transunion* data and presents empirical regularities on migration patterns. Section 3 develops the theoretical framework. Section 4 shows how we solve the model, reports the estimation and the calibration strategy and comparison with the data. It also discusses and quantifies the main mechanisms of the model. Section 5 reports policy counterfactuals: moving vouchers and decreasing housing regulations. Finally, section 6 concludes.

2 Empirical Evidence

This section presents evidence that moving propensity decreases with an individual's ability to access financial markets after controlling for other individual characteristics, particularly age and homeownership, two important determinants of an individual's wealth and that previous literature has shown to be relevant for individual moving decisions (i.e., Molloy, Smith and Wozniak, 2014). In and by itself, this evidence does not constitute a new contribution as patterns of migration by these groups are known to the literature in different countries or similar dimensions. Yet, it reinforces existing evidence on migration patterns by wealth determinants, validates our data and it is an important input for the quantitative exercise in the subsequent sections.

2.1 Data Description

Our data source is *Transunion Canada*, one of the two credit reporting agencies in Canada. It collects the individual credit history of about 35 million individuals, covering nearly every person in Canada with a credit report. It's a monthly longitudinal panel of individuals available since 2009[3] that includes information on borrowers' characteristics such as age, credit score and liabilities. Specifically, we observe credit limits, balances, payments, and delinquency status for different credit accounts such as mortgages, auto loans, credit cards, and lines of credit. Although homeownership status is not directly observed, we infer that an individual is a homeowner if she has a mortgage account with a positive outstanding balance or if a fully amortized mortgage is associated with the current individual's residence. Crucial to our analysis, the data tracks an individual's residence over time, particularly the Forward Sortation Area (FSA) that corresponds to the first three digits of the individual's postal code.

We restrict our sample to individuals between 25 and 85 years old. Individuals below 25 years old are underrepresented in our data due to the lack of credit history.[4]

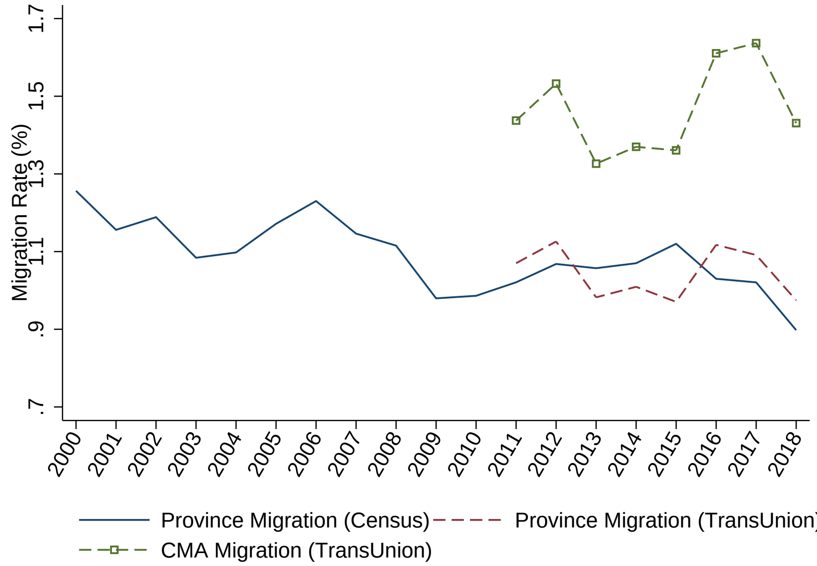
Figure 1 plots migration rates across different geographic units within Canada. The blue line shows the official yearly inter-provincial migration rates from Statistics Canada. The red dash-line shows inter-provincial migration rates using the *Transunion* data.[5] Both series

[3]Our analysis starts in 2011 given the limited data coverage before that year.

[4]Anecdotal evidence suggests that young individuals keep the addresses of their relatives as their official residence during school years. Avoiding miscalculating migration rates among post-secondary educated individuals is another reason not to include this demographic group in our sample. We exclude individuals above 85 years old due to the possibility of unreported deaths and to prevent capturing people's movements for nursing homes or similar facilities. The results are not sensitive to this restriction.

[5]Migration rate across provinces is defined by the number of people reported changing the address to a

Figure 1: Migration Patterns in Canada: Census vs TransUnion



Note: Figure 1 plots the yearly inter-provincial migration rate using Census data (solid blue line) between 2000 and 2018 and using TransUnion data (red dashed line) between 2011 and 2018. The green dashed-squared line plots the yearly migration rates among Canadian CMAs using TransUnion data between 2011 and 2018. *Source:* Statistics Canada and TransUnion.

are very similar in magnitudes and fluctuations over time, suggesting that *Transunion* is well-suited to analyze moving in Canada. Moreover, it allows us to compute migration rates across Canadian cities at a higher frequency and for different demographic groups, which is impossible using official migration statistics. The green dashed line presents the migration rate between census metropolitan areas (CMA)[6,7]. Between 2011 and 2019, on average, 1.54 percent of the Canadian population aged between 25 and 85 moved between CMAs per year.

2.2 Migration Patterns by Demographic Groups

We now document how migration rates vary for different demographic groups. We are particularly interested in analyzing how moving decisions are impacted by financial constraints,

different province divided by the total number of individuals in the dataset in the previous year.

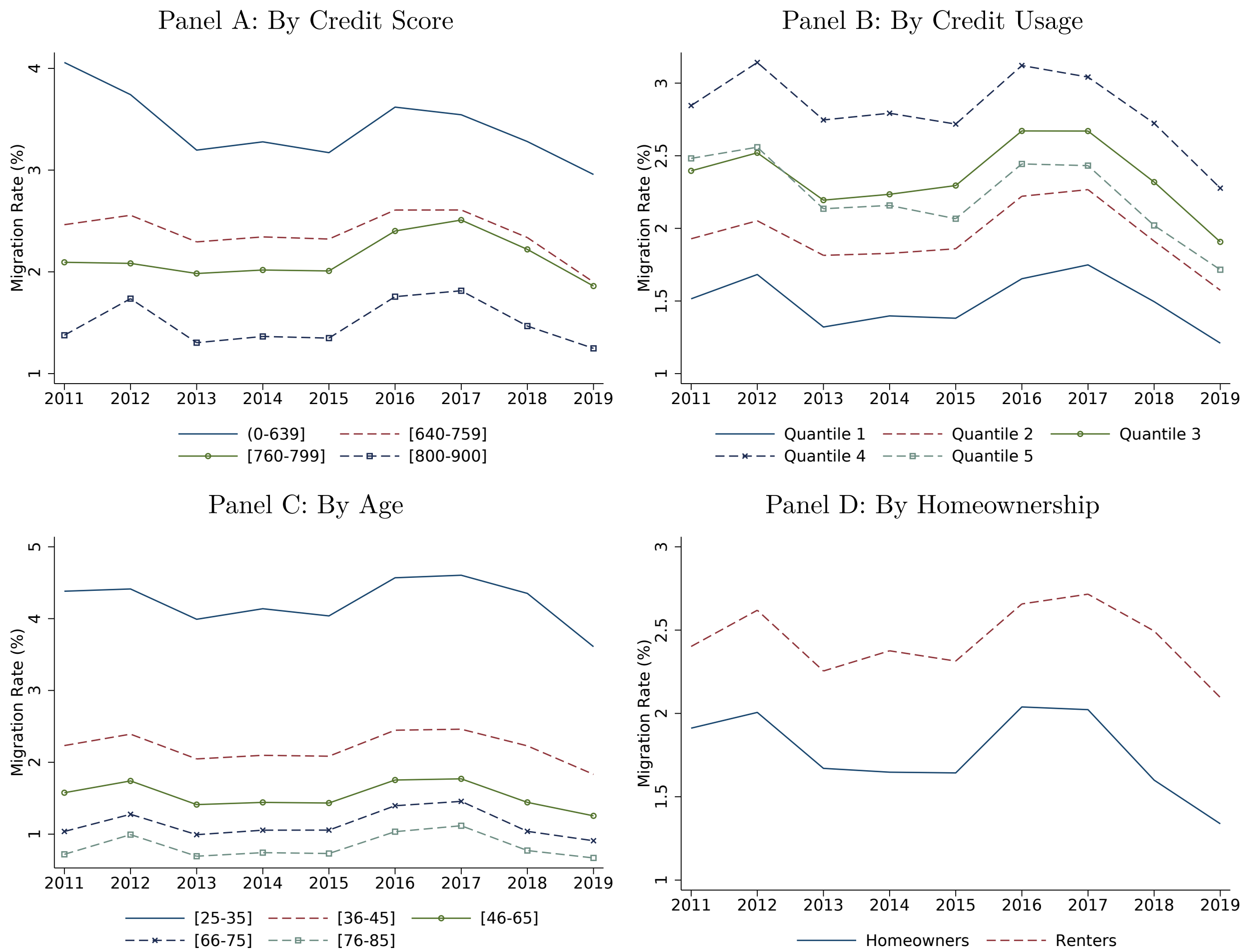
[6]A city is defined as a census metropolitan area (CMA) or a census agglomeration (CA) that is formed by one or more adjacent municipalities centered on a population core. A CMA must have a population of at least 100,000, of which 50,000 or more must live in the core. A CA must have a core population of at least 10,000. To be included in the CMA or CA, other adjacent municipalities must integrate with the core, measured by commuting flows derived from previous census place of work data.

[7]Migration rate across CMAs is defined by the number of people reported to change the address to a different CMA divided by the total number of individuals living in a CMA in the previous year.

notably, the individual's ability to access financial markets. We use two measures of financial constraints, credit score and credit usage. Financial institutions widely use credit scores to determine an individual's creditworthiness and for loan underwriting and pricing. On average, borrowers with higher credit scores tend to have easier access to credit and more favorable loan terms (Beer and Li, 2018). Credit usage is the total outstanding non-mortgage debt balance divided by the credit limit. We consider any open credit account of credit cards, installments, auto-loans and lines of credit. We abstract from mortgage debt to capture sources of credit that individuals can easily adjust, potentially in response to unexpected life events. We view high credit usage as a proxy for higher financial constraints as it is harder for individuals to increase their debt in the short run if their outstanding debt is already close to the limit.

Figure 2 plots annual migration rates across Census Agglomerations (CAs) for different individual characteristics. In Panel A, we partition the sample into 4 groups of credit score, 0-639, 640-759, 760-799, and 800-900, commonly designated, respectively, as very poor, near prime and prime, prime plus and super prime. In Panel B, we split the sample into quintiles of credit usage. Panel C and D, migration rates are computed by age groups (25-35, 36-45, 46-55, 66-75, 76-85) and homeownership status (renter vs homeowner), respectively.

Figure 2: Migration Rates across Canada Cities by Demographic Groups



Note: Figure 2 plots the migration rates between Canadian Cities (CAs) between 2001 and 2019 by credit score (Panel A), credit usage (Panel B), age (Panel C) and homeownership status (Panel D). The migration rate is defined by the number of people moving across cities divided by the total population in the same set of cities in the year before. *Source:* TransUnion.

Panel A and panel B present evidence of differential migration rates across measures of credit access. According to both measures, more constrained individuals tend to move more frequently than less constrained individuals. Specifically, Panel A shows that migration rate decreases monotonically with credit score and Panel B shows that individuals with higher credit usage rates (more constraint) also move more on average.

Panel C shows a monotonically decreasing relationship between age and migration flows for individuals between 25 and 85 years of age. Specifically, individuals between 25 and 35 move, on average, roughly twice as much as people between 36 and 45 and more than four times than individuals above 65 years old. Panel D shows the difference in migration rates between homeowners and renters. Renters, on average, are 25% more likely to move than homeowners. These two last results are consistent with findings for migration flows across US states as in Molloy, Smith and Wozniak (2014), which reinforces the validity of our data in the study of migration both at aggregate level and by demographic groups.

Regression Framework To account for the correlations between demographic characteristics, we formally assess how moving decisions depend on individual characteristics. Specifically, we estimate the following linear probability specification:

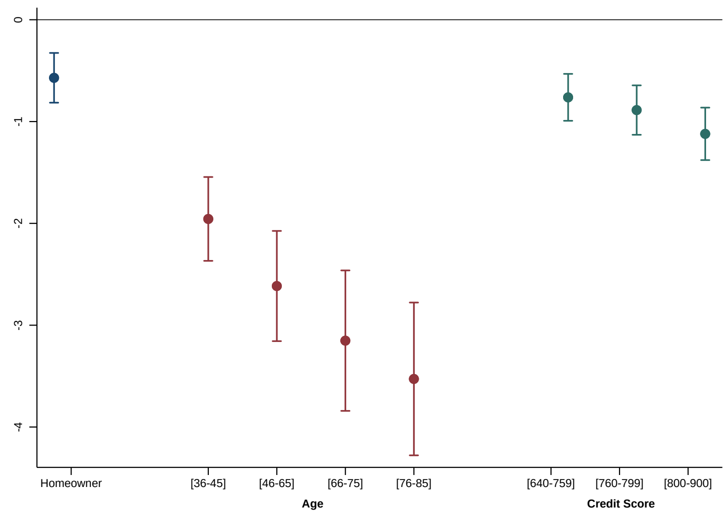
$$\mathbb{1}[Move_{i,z,t}] = \beta_0 + \beta_1 X_{i,t-1} + \delta_{z,t} + \epsilon_{i,z,t} \quad (1)$$

where $1[Move_{i,z,t}]$ is an indicator variable taking the value 100 if individual i in city z at time t moves to a different city, and 0 otherwise, meaning that the coefficients are in units of percentage points. $X_{i,t-1}$ are individual characteristics such as age, homeownership and credit score. We also control for other time-varying characteristics $W_{i,t-1}$ as credit usage, home equity and delinquencies. Our preferred empirical specification includes city-by-quarter fixed effects to control for local shocks or changes in local economic conditions. It also controls for trends in migration patterns and for city characteristics such as amenities, long-run productivity levels, and quality of life, among others. In other words, this specification allows comparing individuals within a city in a given period. We cluster standard errors at the city level.

Panel A of Table A.1 in Appendix A reports the results of estimating the specification of equation (1) for individuals that live in CAs for different combinations of controls and fixed effects. Results hold across specifications. Figure 3 reports the estimates of our preferred specification (column 8 of Panel A of Table A.1) with the vertical bands representing 99% confidence intervals for the point estimates in each quarter. The first coefficient in blue reports the estimate for homeowners. After controlling for other individual characteristics, we find that within a given city and a quarter, homeowners are, on average, 0.57p.p. less likely to move than renters. The coefficients in red under the "Age" group report the estimates of the relative moving propensity of the different age groups relative to the youth group (individuals with ages between 25 and 35 years old). The likelihood of moving decreases monotonically with age. Individuals between 36 and 45 years old are 1.96p.p. less likely to move than those between 25 and 35. This difference increases monotonically up to 3.53p.p. in the group 76-85 years old.

The last set of coefficients relates to the "Credit Score" group. The probability of moving

Figure 3: Determinants of Migration Decisions



Note: Figure 3 reports the point estimates of the linear probability model 1. The vertical bands represent 99% confidence intervals for the point estimates in each quarter. The first coefficient (in blue) reports the point estimate for the homeowner indicator variable. The second set of estimates under the umbrella "Age" (in red) reports the estimates for age group indicator variables using the 25-35 years old group as the baseline. The third set of estimates under the umbrella "Credit Score" (in green) reports the estimates by credit score group indicator variables relative to the credit score group [0-640]. *Source:* TransUnion.

for individuals with credit scores between 640 and 759 is 0.76p.p. smaller than the moving probability of those with a lower credit score and this difference monotonically increases as credit score goes up. Individuals at the top of the credit score distribution are 1.21p.p. less likely to move than those at the bottom of the distribution. Overall, we conclude that after controlling for the correlation between age, homeownership and access to credit, among other individual characteristics, financial constraints are a relevant factor for moving decisions. More financially constrained individuals (lower credit scores) are more likely to move than those less financially constrained in the same city in a given quarter. These results also highlight that age and homeownership alone are not good proxies for the role of wealth in migration decisions. These results contribute to the literature studying population flows in developed countries that mostly use standard surveys or census data that lack information on individuals' finances and credit scores. They complement the results in Bilal and Rossi-Hansberg (2021) that analyzes migration flows in France.[8]

[8] They find that households at the bottom quintile of the financial income distribution tend to move more than their counterparts at the top of the distribution. However, our data allows us to directly identify measures of an individual's access to credit, a crucial element that determines an individual's ability to smooth shocks, particularly for low-wealth individuals. Moreover, we have access to credit scores that is a slow-adjusting object, relaxing some of the identification concerns related to the fact that moving and savings are simultaneously chosen.

We produce a battery of robustness checks in Appendix A. Panel B of Table A.1 replicates the analysis in Panel A of the same table but restricts the sample to CMAs, the 35 largest Canadian cities. Panels A and B of table A.2 use credit usage as a proxy for financial constraints rather than credit score, with the latter table restricting the sample to CMAs. It shows that individuals with higher credit usage (more financially constrained) are more likely to move than those with lower credit usage. Due to data limitations, we calibrate the model developed in the next section to the Canadian CMAs, so this exercise makes the data and the model comparison closer.

3 A Quantitative Heterogeneous Agents' Spatial Equilibrium Model with Wealth

Motivated by the empirical evidence above, we develop a quantitative life-cycle spatial equilibrium model with uninsurable income risk and wealth, which can be accumulated through illiquid housing and a liquid asset. After observing an idiosyncratic location preference shock, households jointly choose their consumption-saving profile and where to live subject to both monetary and utility moving costs. This framework gives realistic and strong insights into the role of income risk, wealth and financial frictions on moving decisions. It highlights *precautionary moving* as an alternative insurance channel against income shocks, particularly relevant for those at the bottom of the wealth distribution.

3.1 Space

The economy is defined by L locations indexed by $l = \{1, 2, ..., L\}$. Locations differ in four dimensions: exogenous productivity (z^l), amenities (A^l), housing supply elasticities (κ^l) and labor market risk. Location subscripts are omitted unless necessary.

3.2 Household Environment

Demographics The economy is populated by a measure-one of continuum finitely-lived households. Age is indexed by $q = \{1, 2, ..., Q\}$. Households live at most Q periods, but face mortality risk with the survival probabilities, $\{\lambda_q\}$, varying over the life cycle. Population in the entire economy is constant and normalized to one. Newborns are distributed across locations according to $G(l)$. Households work in the initial $\bar{Q}$ periods and retire after that.

Preferences Households value non-durable consumption c, housing services s and location-specific amenities A. The instantaneous utility function u_q is given by:

$$u_q(c, s, A) = \frac{e_q[(1-\alpha)c^{1-\gamma} + \alpha s^{1-\gamma}]^{\frac{1-\sigma}{1-\gamma}} - 1}{1-\sigma} + A, \tag{2}$$

where α measures the relative taste for housing services, $\frac{1}{\gamma}$ measures the elasticity of substitution between housing services and non-durable consumption, and $\frac{1}{\sigma}$ measures the intertemporal elasticity of substitution. Non-durable consumption is the numeraire good in the economy. The instantaneous utility function is age-specific as the exogenous equivalence scale, $\{e_q\}$, captures deterministic changes in household size and composition over the life cycle. Households leave bequests to future generations when they die. These are captured by a warm-glow bequest motive a la De Nardi (2004):

$$\varphi(a) = \bar{\varphi}\frac{(a + \underline{a})^{1-\sigma} - 1}{1-\sigma} \tag{3}$$

where $\bar{\varphi}$ captures the intensity of the bequest motive and $\underline{a}$ determines the curvature of the bequest function and hence the extent to which bequests are a luxury good.

Endowments Households receive a labor income endowment $y^l_{i,q}$ given by

$$\log\, y^l_{i,q} = \begin{cases} \log\, w^l + \chi_q + \epsilon_i & \text{if } q \leq \bar{Q} \\ \log\, w_{ret} + \chi_q & \text{if } q > \bar{Q} \end{cases} \tag{4}$$

Income process for working-age households ($q \leq \bar{Q}$) has three components. First, the location-specific wage, w^l, that is endogenously determined and depends on the local productivity. The last two components reflect individual labor productivity. A deterministic age component χ_q common across locations which captures the hump-shaped pattern in average labor income over the life-cycle, and an idiosyncratic component ϵ_i that follows a first-order Markov chain on the space $\{\epsilon_1, ..., \epsilon_S\}$. We assume $\epsilon_0 = 0$ and interpret this realization of the shock as unemployment. The Markov chain for $\epsilon > 0$ is common across locations but the transition to $\epsilon = 0$ differs across locations. Therefore, the employment status Markov transition matrix Π^l is location-specific. The initial employment status is drawn from the stationary distribution π^l. If unemployed, households receive an unemployment subsidy, w_u, common across locations.

When moving, a household's income is a combination of their income in the previous location and income of the new location linked to the households' income shock drawn from the new location stationary distribution. Explicitly, a household that moves from location l with productivity state ϵ to location j' will receive in the period of the move $\tilde{y}^{l'}_{i,q+1} = (1-\upsilon)y^l_q(\epsilon) + \upsilon y^{l'}_{q+1}(\epsilon')$. This assumption can be interpreted as households moving within the period which is assumed to be two years. It also implicitly makes moving costs dependent on individual income and location productivity. If $w^l < w^{l'}$, lower υ implies higher forgone income from moving, which can be interpreted as higher moving costs. Moving to less productive locations is then associated with lower moving costs. Similar implicit moving costs are also present in Bilal and Rossi-Hansberg (2021) and Favilukis, Mabille and Van Nieuwerburgh (2023).

Upon retirement, households receive a retirement benefit w_{ret}, common across locations, and the deterministic age profile component. Households are born with an endowment of wealth that is drawn from a location-specific exogenous distribution and that correlates with initial income.

Housing Housing services can be acquired through either renting ($d = 0$) or owning ($d = 1$). Households have a higher preference for homeownership: owning a house of size h provides $s = \omega h$ units of effective housing services with $\omega \geq 1$, while a rental property of the same size only provides $s = h$ units of housing services. Owner-occupied and rental housing sizes belong to two finite sets, $\mathcal{H}^H$ and $\mathcal{H}^R$, respectively. Rental units are weakly smaller than owner-occupied houses.

A household in location l pays $R^l h$ per period to rent a house of size h and $p^l h$ to purchase a house of the same size. Ownership carries a maintenance cost of $\delta p^l h$ which fully offsets physical depreciation and a property tax of $\tau_h p^l h$ per period. When buying a house, households face a proportional transaction cost of $F p^l h$. Renters can adjust their housing consumption costlessly.

Liquid Asset and Wealth Agents can borrow or save through an one-period financial asset b in the international financial market. Positive savings have a fixed exogenous return r common across locations. Borrowing is allowed at a fixed exogenous cost $r + \iota$, with $\iota \geq 0$, common across households. For simplicity, we define $r^b = r\mathbb{1}[b \geq 0] + (r + \iota)\mathbb{1}[b < 0]$. Renters face a limit to unsecured borrowing of $\underline{b}$. Homeowners can use their housing as collateral but borrowing cannot exceed $\underline{b} + \xi p^l h$. The borrowing constraint is summarized by:

$$b' \geq \underline{b} + \mathbb{1}[d = 1]\xi p^l h \tag{5}$$

Wealth a is the sum of household's financial wealth b and housing value $p^l h$ if homeowner:

$$a = b(1+r) + \mathbb{1}[d=1]p^l h$$

Location Choice Households receive idiosyncratic location preference shocks and decide where to reside. We assume that every period agents draw a vector of L independent Type 1 Extreme Value location shocks with a scale parameter ν. If households decide to move, they incur in a monetary moving cost F_m and an utility moving cost which depends on the distance between the origin and destination locations. Specifically, utility cost of moving from location l to l', $\tau^{l,l'}$, is given by:

$$\tau^{l,l'} = \tau_0 + \tau_1 D_{l,l'} \tag{6}$$

where $D_{l,l'}$ is distance between locations. We depart from most of the literature by assuming homogeneous moving costs, *i.e.*, migration costs do not on households' characteristics as age or homeownership status. However, as we will show later, in the presence of income risk and wealth, the benefits of moving depend on individual states generating distinct migration patterns for different demographic groups consistent with the data despite the homogeneous moving costs.

Government The government revenues, captured by the function $\mathcal{T}(.)$, come from a progressive labor income tax schedule and a proportional property tax τ_h levied on house values. Government revenues also include the sale of new land permits for construction which are described in section 3.4. On the costs side, the government pays the pensions of retired households. Net tax revenues, which are always positive, finance a public good that is not valued by households.

Timing At the beginning of a period, a vector of idiosyncratic location preference shocks realizes and location choices are made. Moving costs are paid if moving occurs. Households observe their idiosyncratic income state and choose between renting and owning. Households simultaneously choose non-durable consumption, housing services and liquid assets subject to the borrowing constraint. Homeowners pay a transaction cost in case housing consumption differs from the previous period or moving has occurred. Homeowners also pay maintenance costs and property taxes. At the end of the period, the death shock is realized. Households that die leave accidental bequests.

3.3 Households' Decisions

Households take as given the aggregate state of the economy that includes wages w_t^l, housing prices p_t^l, rental prices R_t^l and previous housing stock H_{t-1}^l across all locations. Households form beliefs about the evolution of the aggregate variables.[9] The household's individual state variables are the individual wealth at the beginning of the period a_t, the idiosyncratic income shock ϵ_t, age q and the variable $\bar{h}_t$ that incorporates the housing tenure status (d_{t-1}), housing consumption and location in the previous period. $\bar{h}_t$ equals housing consumption in the previous period h_{t-1} if the household was a homeowner ($d_{t-1} = 1$) that did not move ($l_t = l_{t-1}$) and zero otherwise. In a compact way, $\bar{h}_t$ is given by $\bar{h}_t = h_{t-1}\mathbb{1}[d_{t-1} = 1 \cap l_{t-1} = l_t]$.

At the beginning of a period but after location choice is made, households in a given location l chooses between being a renter $\left(d_t^l(a_t, \epsilon_t, q_t, \bar{h}_t) = 0\right)$ and a homeowner $\left(d_t^l(a_t, \epsilon_t, q_t, \bar{h}_t) = 1\right)$ by solving:

$$V_t^l(a_t, \epsilon_t, q_t, \bar{h}_t) = \max\left\{V_t^{R,l}(a_t, \epsilon_t, q_t, \bar{h}_t), V_t^{H,l}(a_t, \epsilon_t, q, \bar{h}_t)\right\}, \tag{7}$$

where V_t denotes the value function at the beginning of the period in location l, $V_t^{R,l}$ the value of renting and $V_t^{H,l}$ the value of owning.[10] The decision of renting versus owning is based on the comparison of the respective value functions.

Renters' Problem At time t, households of age q in location l with wealth a and income shock ϵ and that decides to rent choose how much to consume of non-durable good c, rental units h and liquid savings b that solves:

$$\begin{aligned} V_t^{R,l}(a_t, \epsilon_t, q_t, \bar{h}_t) = &\max_{c_t, h_t, b_t} u_q(c_t, s_t, A^l) + (1-\lambda_q)\varphi(a_{t+1}^l) \\ &+ \lambda_q \beta \mathbb{E}_t\left\{\max_{\{k\}_{k=1}^L} V_{t+1}^k(a_{t+1}^k, \epsilon_{t+1}, q_t + 1, \bar{h}_{t+1}^k) - \tau^{l,k} + \nu\tilde{\epsilon}_{t+1}^{i,k}\right\} \end{aligned} \tag{8}$$

$$\begin{aligned} \text{s.t.} \quad & c_t + R_t^l h_t + b_t = y_t^{\epsilon,l} + a_t - \mathcal{T}(y^{\epsilon,l}) \\ & b_t \geq \underline{b} \\ & a_{t+1}^k = (1 + r^b)b_t - F_m \mathbb{1}[l \neq k] \\ & s_t = h_t \in \mathcal{H}^R, \quad \bar{h}_{t+1} = 0 \end{aligned}$$

The renter must pay R_t^l per rental unit and savings can be negative but subject to the

[9]Alternatively, we could define the state variable as the distribution of households across age groups, housing tenure and wealth across locations. We assume rational expectations.

[10]Value functions are indexed by subscript t to reflect potential changes in the aggregate state.

borrowing constraint. The continuation value has two components. With probability $1 - \lambda_q$ the household dies and leaves bequests. With probability λ_q the household survives and after the vector of idiosyncratic location preference shocks $\bar{\epsilon}_{i,t}$ is observed, the household decides the new location. If the household decides to remain in the same location, no moving costs occur and the next period wealth consists of $(1 + r)b_t$. If the household decides to move, utility and monetary moving costs occur. In this case, the next period's wealth consists of $(1 + r)b_t - F_m$. Therefore, next period wealth a^k_{t+1} depends on moving or not. $\mathbb{E}_t$ corresponds to expectation over idiosyncratic location preference shocks, idiosyncratic productivity shocks and aggregate state across all locations.

Homeowners' Problem At time t, a household of age q in location l with wealth a and productivity shock ϵ and that decides to own their housing services chooses how much to consume of non-durable good c, owned housing units h and liquid savings b that solves:

$$\begin{aligned} V_t^{H,l}(a_t, \epsilon_t, q_t, \bar{h}_t) = \max_{c_t, h_t, b_t} & \; u_q(c_t, s_t, A^l) + (1 - \lambda_q)\varphi(a^l_{t+1}) \\ & + \lambda_q \beta \mathbb{E}_t \left\{ \max_{\{k\}_{k=1}^L} V^k_{t+1}(a^k_{t+1}, \epsilon_{t+1}, q_t + 1, \bar{h}^k_{t+1}) - \tau^{l,k} + \nu \tilde{\epsilon}^{i,k}_{t+1} \right\} \end{aligned} \tag{9}$$

$$\begin{aligned} \text{s.t.} \quad & c_t + b_t + p^l_t h_t \left(1 + F \mathbb{1}[h_t \neq \bar{h}_t]\right) = y^{\epsilon,l}_t + a_t - \mathcal{T}(y^{\epsilon,l}) \\ & b_t \geq \underline{b} - \xi p^l_t h_t \\ & a^k_{t+1} = (1 + r^b)b_t + p^l_{t+1} h_t \left(1 - \delta_h - \tau^l_h\right) - F_m \mathbb{1}[l \neq k] \\ & s_t = \omega h_t, \quad h_t \in \mathcal{H}^H, \quad \bar{h}_{t+1} = h_t \mathbb{1}[k = l] \end{aligned}$$

Homeowners' problem differs from renters' problem in two main dimensions. First, homeowners can partially finance their house purchases subject to the collateral constraint $\xi p^l_t h_t$. Second, homeowners are subject to τ_h and maintenance costs δ^l_h per unit of housing value.[11] Second, houses are illiquid assets as households face transaction costs F when buying a new house $(h_t \neq \bar{h}_t)$. As in the renter's problem, next period wealth also depends on the location but besides savings and potential moving costs, next period wealth also includes the property value at $t + 1$.[12]

[11] As shown in equation (14) below, the physical depreciation is offset by residential investment undertaken by the construction sector. We allow property taxes to vary across locations to match the heterogeneous rental-price ratios across Canadian cities.

[12] For tractability, we assume homeowners trade houses every period even if they remain in the same house. However, the transaction cost F is not paid by homeowners that remain in the same location with the same housing units $(\bar{h}_t = h_t)$. Note that we could re-write the budget constraint as having $p^l_t(h_t - h_{t-1} + F\mathbb{1}[\bar{h}_t \neq h_{t-1}])$. If a household does not move and does not adjust its own-housing consumption,

Migration Given that the idiosyncratic location preference shocks are *i.i.d.* over time and distributed Type-I Extreme value with zero mean, the continuation value in case of survival in equations (8) and (9) can be rewritten as

$$\lambda_q \nu \log \left(\sum_{k=1}^{L} \exp \left(\beta \mathbb{E}_t V_{t+1}^k (a_{t+1}^k, \epsilon_{t+1}, q_t + 1, \bar{h}_{t+1}^k) - \beta \tau^{l,k} \right)^{\frac{1}{\nu}} \right). \tag{10}$$

As shown by McFadden (1973), this assumption also implies a closed-form analytical expression to the share of movers across locations. $\mu_t^{l,k}$ denotes the share of households with the same individual state and homeownership status (d_t) that choose to move from location l to location k and it is given by:

$$\mu_t^{l,t}(a_{t+1}^k, \epsilon_t, q_t, \bar{h}_{t+1}^k, d_t) = \frac{\exp \left(\beta \mathbb{E}_t V_{t+1}^k (a_{t+1}^k, \epsilon_{t+1}, q_t + 1, \bar{h}_{t+1}^k) - \beta \tau^{l,k} \right)^{\frac{1}{\nu}}}{\sum_{k=1}^{L} \exp \left(\beta \mathbb{E}_t V_{t+1}^k (a_{t+1}^k, \epsilon_{t+1}, q_t + 1, \bar{h}_{t+1}^k) - \beta \tau^{l,k} \right)^{\frac{1}{\nu}}} \tag{11}$$

where a_{t+1}^k, d_t and $\bar{h}_{t+1}$ are optimal savings, housing tenure and housing consumption choices derived from agents' optimization problems.

3.4 Production

There are two production sectors in each location: a tradable good sector which produces non-durable consumption and a construction sector which produces new houses. Productivities are location-specific and labor, supplied inelastically, is perfectly mobile across sectors within the location.

Final Good Sector Each location produces a uniform final good that can be traded across locations. Productivity is location specific and has two components: (i) an exogenous location-specific TFP denoted by z^l and (ii) an endogenous agglomeration force that depends on the city size, $\bar{N}^l$. The competitive final good sector in location l operates the following technology:

$$Y^l = z^l \left(N_c^l \right)^{\eta} \left(\bar{N}^l \right)^{\zeta}$$

where N_c^l is the total effective employment in the final good sector in location l.[13] The

this term equals zero. The simplifying assumption that homeowners buy and sell their owned houses every period is innocuous in this context since we don't aim to analyze the impact of high-frequency changes in the housing market.

[13] For simplicity, profits are fully taxed by the government.

equilibrium city-level wage in location l is then given by

$$w^l = \eta z^l \left(N_c^l\right)^{\eta-1} \left(\bar{N}^l\right)^{\zeta} \tag{12}$$

Construction Sector As in Kaplan, Mitman and Violante (2020), there is a foreign-owned competitive construction sector that operates in each location the following production technology:

$$I^l = \left(z^l N_h^l\right)^{k^l} \left(\bar{L}^l\right)^{1-k^l}$$

where N_h^l is the effective labor employed in the construction sector and $\bar{L}^l$ is the amount of new available buildable land.[14] The housing investment that solves a profit maximization problem of a developer is given by:

$$I^l = \left(\frac{\kappa^l p^l z^l}{w^l}\right)^{\frac{\kappa^l}{1-\kappa^l}} \bar{L}^l \tag{13}$$

where w^l is given by equation (12) due to free labor mobility across sectors within locations. The housing supply elasticity is given by $\frac{\kappa^l}{1-\kappa^l}$.

The overall housing stock in location l evolves according to

$$H_t^l = (1-\delta)H_{t-1}^l + I_t^l. \tag{14}$$

Rental Sector Following Kaplan, Mitman and Violante (2020), we assume that risk-neutral foreign investors can arbitrage between the owned-housing market and the rental market, which connects housing prices and rents in the following way:[15]

$$R_t^l = p_t^l - \left(1 - \delta_h - \tau_h^l\right) \frac{\mathbb{E}_t p_{t+1}^l}{1+r} \tag{15}$$

[14] Government issues and sells new permits equivalent to $\bar{L}^l$ units of land to developers in a competitive market as assumed in Kaplan, Mitman and Violante (2020) and Favilukis, Mabille and Van Nieuwerburgh (2023). This implies that all rents from land ownership accrue to the government and the construction sector makes no profits in equilibrium.

[15] As presented in Kaplan, Mitman and Violante (2020), this formula can be derived from the optimization problem of a competitive rental market that can frictionlessly buy and sell housing units and rents them to households.

3.5 Equilibrium

Given the set of parameters and the exogenous interest rate r, a competitive equilibrium is a location-specific price vector $\{w_t^l, p_t^l, R_t^l\}_{l=1}^{l}$ and allocations, namely, housing stock and population (labor supply) consistent with the households and firms optimization and that clear the markets in each location. A stationary equilibrium is one in which all equilibrium objects are time-invariant. A formal equilibrium definition is provided in Appendix B.

4 Solving and Taking the Model to the Data

In this section we report how we solve the model and how we take it to the data. We then show how the model successfully matches key moments of the migration and wealth data. We highlight that our model generates heterogeneous moving rates quantitatively consistent with the data even with homogeneous moving costs. We finally explore the main mechanisms of the model, focusing on the main forces that drive migration decisions. Through a decomposition exercise, we show that income risk and financial constraints increase significantly migration rates, especially for the low -wealth ones.

4.1 Solving the Model

The rich individual and spatial heterogeneity combined with a dynamic consumption-saving decision in the presence of income risk and incomplete markets generates a large state space. Incomplete markets and frictions in the housing market make the household problem non-convex. Moreover, analyzing the welfare impacts of policies counterfactual requires solving for transition dynamics. For these reasons, solving this model and bringing it to the data is challenging. Given the complexity of this class of models, one of the main contributions of this work is to provide a method to solve dynamic quantitative spatial equilibrium models with heterogeneous agents, uninsurable income risk and wealth accumulated through durable and non-durable assets.

Discussion About Solution Methods The spatial literature has recently developed innovative approaches to solve models with rich spatial heterogeneity. In their pioneer work, Caliendo, Dvorkin and Parro (2019) develop dynamic hat-algebra to solve for counterfactuals in changes rather than levels. Kleinman, Liu and Redding (2021) extend the dynamic hat-algebra to account for local capital accumulation and solve for the transition path towards the equilibrium using spectral analysis. Dvorkin (2023) uses dynamic hat-algebra to solve a model with simultaneous location and wealth decisions with log-linear value functions which makes migration elasticities independent of wealth.

However, we cannot use similar methods to perform counterfactual analysis in our framework. In contrast with these papers, we assume the existence of borrowing constraints and non log-linear value functions, generating highly non-linear policy functions and preventing aggregation in closed form. This layer of complexity, which is key to generate the core results of this paper as migration elasticities varying with wealth, prevents us from applying dynamic hat-algebra and solving for the transition paths using spectral analysis.

Instead, we borrow insights from global solution methods used in macroeconomics literature that solve high-dimensionality problems and that keep track of the wealth distribution within and across locations and combine them with the key assumption of the quantitative spatial economics literature. In particular, we assume a Type-1 Extreme value preference shock that generates closed forms expressions for the shares of the population in each subgroup. The household finite time horizon avoids time-intensive computational procedures as value function iteration. Given the closed-form solution of the household value function in the last period of life, we can easily solve their lifetime problem using backward induction. We find that the iterative method goes far in solving life-cycle spatial equilibrium models with incomplete markets and endogenous wealth accumulation even with multiple assets.

Algorithm for the Stationary Equilibrium and Transition Dynamics Appendix section C provides detailed information about the solution method. Here we provide a summary of the main steps.

Stationary Equilibrium To solve the stationary equilibrium, we guess a city-level wage vector and population distribution. We obtain the implied house price vector that matches the house price index to the median income ratio obtained directly from the data. Given price vectors and the value function for the last age group (Q) in closed form, we solve for value functions and policy functions using backward induction. Given the distribution of age one group from the data, we solve forward to obtain the updated population distributions. We then update the wage vector and implied house prices vector using local labor market clearing conditions. We repeat this procedure until wages in all the locations converge. Given the equilibrium house price vector, we solve for housing demand in each location. By inverting equation (14), we back up the local housing permits consistent with the stationary equilibrium.

Transitional Path To compute transitional paths for shocks that are not anticipated in the stationary equilibrium but once they occur, the full path is known by all forward-looking agents, we start by computing the pre- and post-shock stationary equilibria using the procedure above. In the new stationary equilibrium, we don't impose that the house prices to median income match the data. Instead, we guess a house price vector and update such guess using the local housing market clear conditions taking as given the housing permits backed up from the pre-shock stationary equilibrium. We then guess wage and house prices paths. At period 0 and period T, wages and house prices are equal to those in the pre- and post-shock stationary equilibria, respectively. We solve backward the value functions and policy functions along the path starting in period $T-1$ since in period T, value functions and policy functions are known, given by those in the new stationary equilibrium. Given the population distribution in the pre-shock stationary equilibrium, we can compute the population distribution by iterating forward. Wages and house prices are updated using the respective market clear conditions and the procedure is repeated until convergence is achieved. We check whether wages and prices in period T reach the corresponding levels in the after-shock stationary equilibrium. If not, we increase T.

4.2 Taking the Model to the Data

We take the quantitative model to the largest 27 largest CMAs in Canada, our city definition throughout the rest of the paper.[16] We solve the stationary equilibrium consistent with key features of the Canadian economy in 2016, since it coincides with the last wave of the Canadian Census and the Survey of Financial Security (SFC), which are the two data sources for many of our targets. SFS is a survey that provides a comprehensive snapshot of the net worth of Canadian households by collecting detailed information on households' assets, debts, income and employment.

We implement a mix of methods to bring the model to the data. A subset of model parameters, mostly those related with city heterogeneity, are assigned externally without the need to solve for the model. The remaining parameters are chosen to minimize the distance between a number of equilibrium moments. The resulting parameter values are summarized in Table D.1 in Appendix D and the targeted moments are in Table 1. A period in our analysis is two years.

Productivity City-level exogenous productivity measures, z^l, are obtained by inverting the

[16]There are about 35 CMAs in Canada with more than 100,000 inhabitants, but due to data limitations we have to restrict our analysis to 27 CMAs.

equilibrium wage equation defined in equation (12). To do so, we take average employment income, total employment and total population with ages between 25 and 85 years old from the 2016 Canadian Census. Following the literature, we set the elasticity of labor demand η to 0.75 which sits right within the range of values used for this parameter. We calibrate internally the coefficient of agglomeration forces, ζ, to 0.13 to match the correlation between city productivity and in-migration. This value also falls in between the estimates of agglomeration forces previously encountered. The city-specific exogenous component of productivity is reported in Panel A of Figure D.1 of Appendix D. We normalize exogenous productivities so that median annual household earnings (67,700 CAD in 2016) equals one in the model.

Amenities City-specific amenities are internally estimated in order to match the population distribution. We define city population as the total number of individuals with age between 25 and 85 years old. We obtain population data from 2016 Canadian Census. We normalize the city population so that the total population in the economy equals one in the model. Our distribution of amenities is reported in Figure D.2 in Appendix D.

Demographics and Income Households enter the model at age 25, retire at age 65 ($\bar{Q} = 25$) and die with certainty at age 85 ($Q = 30$). There is a death probability over a household's lifetime, $1 - \lambda_q$, obtained from Statistics Canada. The income process defined in equation (4) has two exogenous components. The age-specific component replicates the average income ratio differences across age groups in the data from the 2016 Census Canada. The stochastic component of earnings $\epsilon > 0$ is modeled as an AR(1) process in logs with annual persistence of 0.91 and the standard deviation of innovations of 0.20 as in Berger et al. (2018). The transition to the unemployment state ($\epsilon = 0$) is city-specific. The city-specific employment shock transition matrices M^l are built to meet two requirements. First, the steady-state unemployment rate in each city equals the average unemployment rate between 2014 and 2017 in the data; second, the average monthly employment-to-unemployment rate equals 1.5%. Both data moments are from Statistics Canada.Labor income is taxed following the functional form in Heathcote, Storesletten and Violante (2009), *i.e.*, $\mathcal{T}(y) = \tau_y^0 y^{1-\tau_y^1}$. τ_y^0 and τ_y^1 are chosen to match the federal and provincial effective tax rates across the income distribution. We obtain $\tau_y^0 = 0.92$ and $\tau_y^1 = 0.13$, which implies a mean effective tax rate of 3.7% and 15% at the 25th and 50th percentile of the income distribution in the model against 3.1% and

13.5% in the data.[17]

Migration We estimate the utility moving costs $\tau^{l,l'}$ using data on migration rates across Canadian cities from *TransUnion* and geographic distance $D_{l,l'}$ between any two pairs of cities. Distance is given by the straight line linking the geographic center of two cities. We normalize the distance between Guelph and Cambridge-Kitchener-Waterloo (C-K-W), the two closest CMAs in our sample, to one. The functional form of utility moving costs, $\tau^{l,l'}$, is given by equation (6). We inform our elasticities τ_0 by matching the average annual out-migration rate between Canadians of 1.54% and τ_1 by matching the correlation between distance and out-migration rate. As reported in Table 1, the data and model values are identical up to the second decimal. τ_0 and τ_1 equal 6.2 and 0.008, respectively. We pin down monetary moving costs, F_m, by matching the average migration rates of the youth (households with ages between 25 and 35 years old) and obtain a value of $F_m = 0.26$, which corresponds to 17,600 CAD (in 2016 unit). The dispersion of idiosyncratic location preference shocks, ν, is pinned down by matching the correlation between city average labor income and in-migration. The value of ν is 0.9, similar to Diamond (2016) that uses a ν equal to 1.

Wealth Distribution We collect data on wealth distribution in Canada from the 2016 SFS. Several moments of the wealth distribution are crucial to pin down the discount factor β, parameters of borrowing constraint defined in equation (5) and parameters of the bequest function defined in equation (3). Regarding the borrowing constraint, we set $\xi = 0.8$ and to match to the share of households with negative assets of 5.7% in the data, we set $\underline{b}$ to -1.2. The discount factor β is chosen to replicate the median wealth to an annual income of 3.83. An annualized β of 0.988 generates a median wealth-to-income ratio of 3.66 in the model. The two parameters of the bequest function, $\bar{\varphi}$ and $\underline{a}$ are chosen to match two other moments of the wealth distribution, the ratio of wealth at age 75 to wealth at age 65 and the 30th percentile of the wealth to income distribution. These two moments are in the data 0.54 and 1.41, respectively, and imply $\bar{\varphi} = 900$ and $\underline{a} = 19$. To match these moments we need three other parameters taken directly from the literature. We set the annual risk-free interest rate to $r = 1.5\%$, the borrowing wedge ι to 1% and $\sigma = 2$ to give elasticity of intertemporal substitution equal to 0.5. Initial bequests mimic the empirical distribution of wealth at the age of 25 years old across cities.

Preferences We set $1/\gamma$, the elasticity of substitution between non-durable consumption

[17] https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110005801

and housing in equation (2) to 1.25 based on the estimates in Piazzesi, Schneider and Tuzel (2007). The consumption expenditures equivalence scale e_q are from Auclert, Dobbie and Goldsmith-Pinkham (2019). α is set to 0.85 in line with the estimates of Berger et al. (2018). The additional utility from owner-occupied housing relative to rental housing, ω, is chosen to match the average homeownership rate of 61% (Statistics Canada).

Housing To discipline housing-related parameters, we collect data on the distribution of homeowners' property value over total wealth in Canada from 2016 SFS. From TERANET, we obtain for each city house price index, average house sale price and average rental price. We back-up house prices per housing unit in the model by matching the city-specific ratio of house prices index to the average labor income. We back-up the equilibrium housing stock in each city and consequently, construction permits, $\bar{L}^l$, by inverting equation (14). The annual depreciation rate is set to 1.5% as in Kaplan, Mitman and Violante (2020). We match the house price to rent ratio in the model to the one observed in the data, which allows us to back a city-specific property tax by inverting equation (15). Housing transaction costs, F, are set to 7% as in Kaplan, Mitman and Violante (2020). To disciple housing grids, we take advantage of the distribution of homeowners' property value over total wealth and match the average house sale price over average income by city, which gives rise to city-specific housing grids. The owner-occupied house size set, $\mathcal{H}^H$, has three elements and the rental housing size set, $\mathcal{H}^R$, has two elements with the following structure: $\mathcal{H}^{H,l} = [o_1\bar{h}^l, \bar{h}^l, o_2\bar{h}^l]$ $\mathcal{H}^{R,l} = [o_3\bar{h}^l, o_1\bar{h}^l]$. $\bar{h}^l$ is chosen to match the average house sale price over average income by city. o_1 and o_2 are set to match the 30th and 50th percentiles of the distribution homeowners' property value over total wealth. As in Kaplan, Mitman and Violante (2020) we assume that the largest rental unit coincides with the smallest unit of owner-occupied house grid. o_3 is chosen to match the average size ratio of owned houses to rental houses.

Housing Supply Elasticities We estimate city-level housing price elasticities following Guren et al. (2021). Their approach exploits systematic differences in cities' responses to regional house price cycles. The main advantage of this methodology is that does not require data unavailable for Canadian cities like land availability, geographic characteristics and housing regulation as in Saiz (2010*b*). Instead, it relies mainly on long series of house prices at a high frequency that we obtain from TERANET. Appendix section D.1 reports the full description of this methodology applied to Canadian cities. Figure D.4 plots housing elasticities by city.

Table 1: Internally Matched Moments

Moment	Data Value	Model Value
av.out-migration (%)	1.54	1.54
corr.(distance,out-migration)	-0.23	-0.23
corr.(prod,in-migration)	0.894	0.86
corr.(wage,in-migration)	0.42	0.49
migration rate youth (25-35)	3.2	2.85
share pop. negative assets (%)	5.7	5.5
30th perc. networth/income	1.41	1.43
50th perc. networth/income	3.83	3.66
wealth age 85/wealth age 65	0.54	0.68
homeownership share	0.61	0.61
50th perc. home equity/networth	0.56	0.35
50th perc. home equity/networth	0.71	0.52
homeownership rate	0.61	0.61
Avg size owned house /rented house	1.5	1.46

Note: Table 1 reports the thirteen targeted moments used to obtain parameters values. Data sources are described in the main text.

4.3 Model Matching Data

This section presents a set of predictions from the parameterized model in the stationary equilibrium that we did not explicitly targeted. We focus on the distributions of wealth, income and population, key moments to match heterogeneous migration patterns and to perform policy counterfactuals.

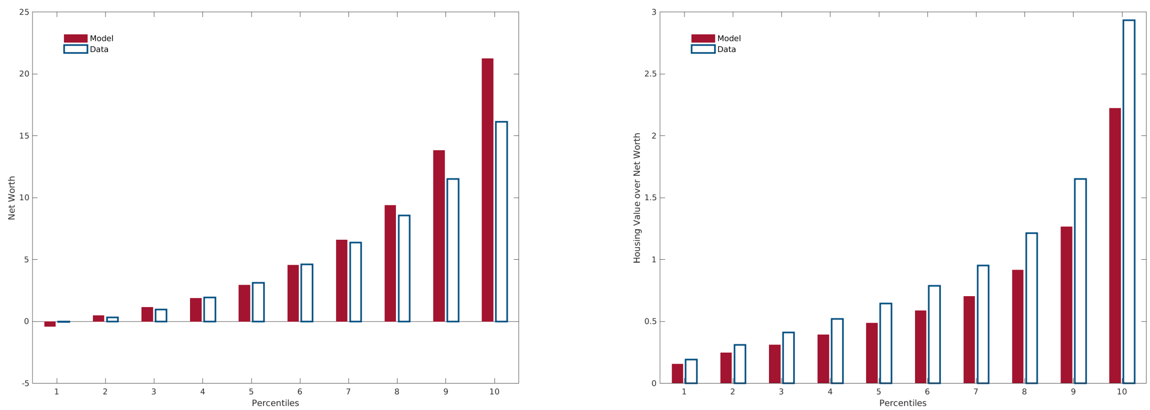
Wealth and House Value Distributions Panel A of Figure 4 plots the wealth distribution in the data and model. We explicitly target the second and fifth deciles, but the model is able to reproduce closely the entire wealth distribution in the data below the top decile. Migration decisions for households on the top of the wealth distribution are quite insensitive for individual conditions, so this shortcoming is not too problematic in our analysis. Panel B of Figure 4 reports the ratio between housing value and wealth for homeowners. Overall, the model matches closely the date but underestimates slightly the house value in terms of wealth at the top of the distribution. In Figure E.1 of Appendix E we report the wealth distribution separately by homeownership status.

Spatial Distribution Panel A of Figure 5 shows the population by the city where cities are ordered by size. We target this distribution in the calibration process in order to obtain city-level amenities, so not surprisingly model and data match very closely. The distribution of population in Canada is exponential as predicted by Zipf's law as showed by Gabaix (1999). Panel B shows the average income by city which is not targeted (income across cities depends on local productivity, city size and population distribution by age). Overall, the correlation between data and the model is very high.

Figure 4: Model vs Data: Distributions of Wealth and House Equity

Panel A: Wealth Distribution

Panel B: House Value to Wealth Distribution



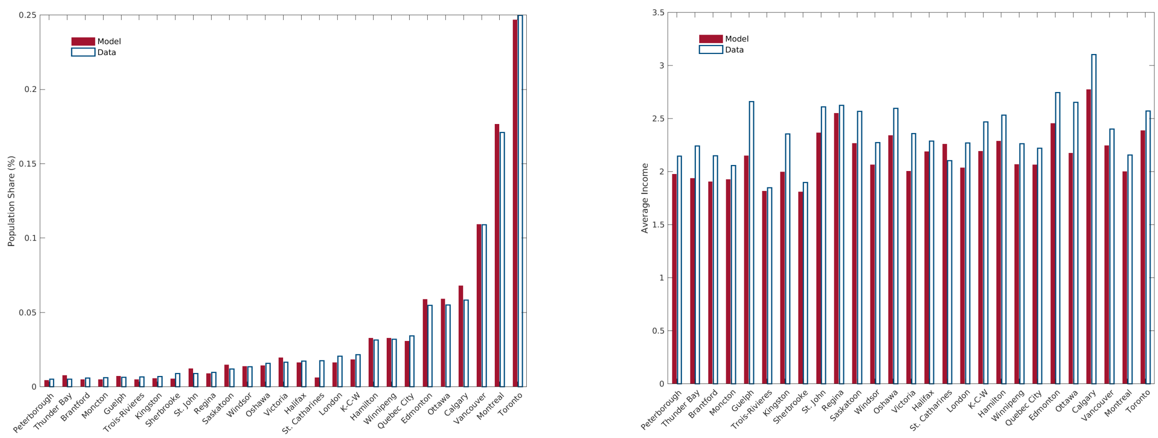
Note: Figure 4 plots the wealth and the house value to wealth ratio distribution. In Panel A, wealth is normalized by income. Panel B plots the distribution of household house value to wealth ratio. *Data Source:* SFS 2016.

Migration Figure 6 plots the migration rates across demographic groups in the model and data. Migration rates are not targeted in the calibration exercise, except average migration rate and migration rate for households with ages below 35 years old. Despite the homogeneous migration costs, we find that the model delivers heterogeneous migration patterns across demographic characteristics consistent with the data. Panel A plots the migration rates in the model and data by homeownership status. As in the data, the model generates higher migration rates for renters than homeowners. The model delivers a yearly migration rate for renters of 2.37% and approximately 1% for homeowners. In the data, the yearly migration rate is 1.8% and 1.23%, for renters and homeowners, respectively. In panel B, we observe that the migration rates by age group for in the model replicate very closely the ones in the data.

Figure 5: Model vs Data: Population and Income across cities

Panel A: Population

Panel B: Income



Note: Figure 5 plots the population (Panel A) and average income (Panel B) by CMA both in the data and in the model. In both panels cities are ordered increasingly by population size. *Data Source:* Statistics Canada.

Panel C reports the migration rates by wealth quartiles adjusted for age.[18] In the data we have no household-level wealth information so we are not able to replicate the same migration patterns on the data. Instead, we plot the migration rates by credit score bins.

Households at the bottom of the wealth distribution are financial constrained as they are closer to their borrowing limit and have less capacity to adjust their borrowing. Households with lower credit scores are less likely to obtain credit, therefore, more financial constrained. The underlying assumption is that wealth and credit score are highly correlated. We find both in the data and in the model that migration rates decrease with wealth. Households at the bottom of the wealth distribution are 3 times more likely to move than those at the top of the distribution. Specifically, on average, the annual moving rate is 2.62% and 0.56% for households at the first and fourth quartiles of the wealth distribution, respectively. In the data, we observe that households with a credit score below 640 move on average 2.2% per year while those with a credit score above 800 move at 1.1% annually.

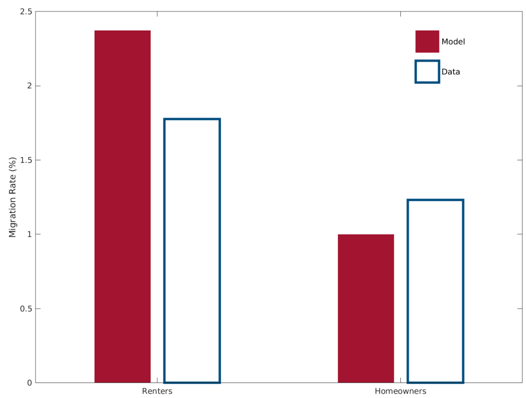
Figure E.3 of the Appendix section E plots migration rates by quintiles of the wealth distribution. This allows a deeper look at the migration rate at the bottom of the wealth distribution. It shows a non-monotonic relationship between wealth and migration decisions among the most constrained households. Although migration rates are still higher for the

[18]The model delivers a stronger correlation between age and wealth than the data. To build migration rates by wealth data, we measure migration rates across wealth quartiles for each age group and then computed the weighted average across wealth quartiles.

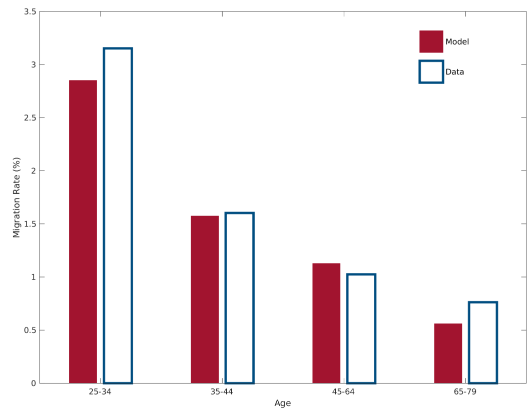
first two quintiles than the ones on top, the average migration rate for quintile one is 0.5 p.p. lower than for quintile two. This means that for very constrained households, monetary moving costs are important and prevent a relatively small mass of households from using migration to smooth shocks.

Figure 6: Model vs Data: Migration Rates across demographic groups

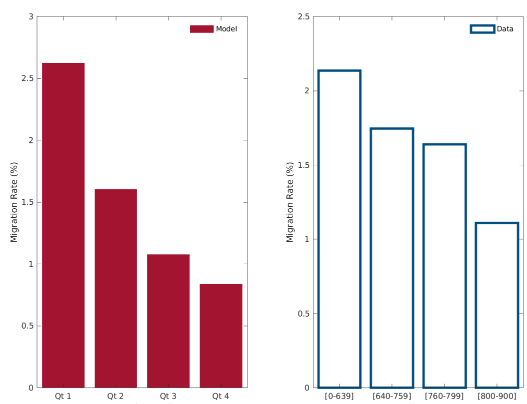
Panel A: By Homeownernship Status



Panel B: By Age



Panel C: By Wealth

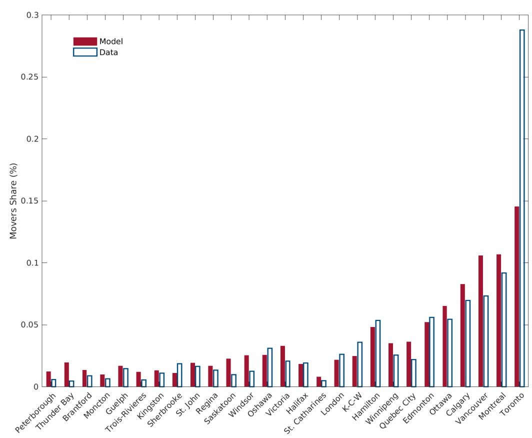


Note: Figure 6 plots the annual migration rates from the model (red bars) and from the data (hollow blue bars) by demographic groups. Panel A plots it by homeownership status, panel B by age and panel C by wealth on the left (model outcomes) and by credit score on the right (data outcomes). *Data source:* TransUnion.

Overall, the model performs satisfactorily in matching the heterogeneity in the migration rates observed in the data. This results suggests that heterogeneity in migration costs is less important to match the different migration rates across demographic groups than commonly thought. As it will become clear in section 4.4, income risk, endogenous wealth and financial constraints widen the moving benefits for different demographic groups, such that despite common moving costs the model generates heterogeneous migration rates consistent with the data.

We now analyze where households move to. Figure 7 plots the share of movers by destination city. Both in the data and in the model, more than 50% of the movers choose to move to the five biggest Canadian cities. In the data, there is a disproportional high fraction of movers to Toronto (30%), while Montreal, the second city receiving the highest number of movers, only absorbs 9% of the migrants. The model is not able to able to match this discontinuity observed in the data, partially explained by the lack of heterogeneity in location preference shock. Nevertheless, the model is able to capture the main trends in terms of location choices. That can be seen in Table 2 which reports the correlation between the share of in-flows migrants and the characteristics of the destination cities.

Figure 7: Model Vs Data: In-Migration by city



Note: Figure 7 plots the in-migration rates in the model and in the data by destination. Cities are ordered in ascending order by population. *Data source:* TransUnion.

There is a very strong correlation between in-migration and the size of the destination city (0.93 and 0.96 in the data and model, respectively). In-migration is also strongly correlated with TFP (0.74 and 0.86 in the data and model, respectively), house prices (0.64 and 0.53 in the data and model, respectively) and amenities (0.57 and 0.66 in the data and model, respectively). Although the differences are small, the model generates more moving related to labor market factors while under predicts the correlation in terms of the house price index. In the next section, we unpack some of these correlations by analyzing the different economic forces that drive households moving choices.

Table 2: Model vs Data: Share of Migrants and Cities' Characteristics

	Correlation	
Characteristics	Data	Model
Average Labor Income	0.42	0.5
Average Income	0.31	0.39
TFP	0.74	0.86
House Prices Index	0.64	0.53
Population	0.93	0.96
Amenities	0.57	0.66

Note: Table 2 reports the correlation between the share of movers and the characteristics of the destination cities. *Data source:* TransUnion, Statistics Canada and TERANET.

In Appendix E, we present more evidence of the model's ability in matching the spatial heterogeneity observed in the data. In Figure E.2, we plot the distribution of median income and house prices across cities. Table E.1 shows the correlation between city characteristics such as house prices, wages, average income, population, TFP and amenities, both in the data and in the model. Overall, we find strong positive correlations between income, TFP and house prices in the data and in the model. However, the model underestimates the positive correlation between house prices and population but matches very well the relationship between population and TFP. In terms of amenities, there is a positive correlation between amenities and house prices, population and TFP both in the data and model. The model, however, overestimates the negative correlation between amenities and income measures.

4.4 Model Mechanisms

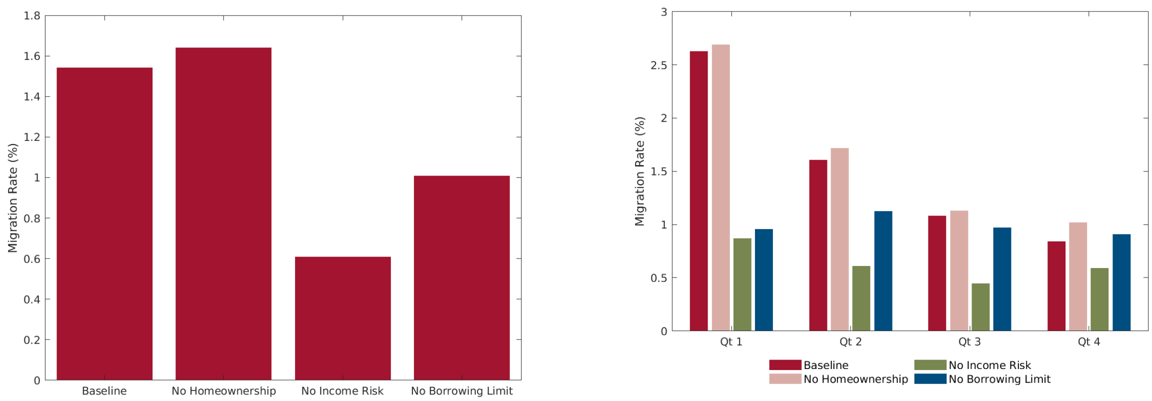
To understand and quantify the main channels that determine migration propensity, we compare our benchmark results against the ones generated by shutting down, one at a time, income risk, borrowing limit and homeownership. We focus on migration rates both at the aggregate and across the wealth distribution. In Appendix E, for completeness, we also present the results by homeownership and age.

What drives migration? Migration costs and idiosyncratic preference shocks drive migration in the majority of spatial equilibrium models. Crucially, in our model, there are three additional forces explored in this section: homeownership, income risk and financial frictions. Panel A of Figure 8 reports the aggregate migration rates for the economy i) in the baseline model, ii) with no homeowners, iii) with no income risk and iv) without borrowing constraint.[19]

Figure 8: Decomposition: Migration Rates

Panel A: Aggregate Migration Rate

Panel B: Migration Rate by Wealth



Note: Figure 8 reports the aggregate migration rates (Panel A) and migration rates by wealth quartiles (Panel B) for four alternative model specifications: baseline, No Homeownership, No Income Risk and No Borrowing Constraint.

Frameworks where risk-averse agents face uninsurable income risk generate precautionary behaviour. In the traditional macro literature without the spatial dimension, this precautionary behavior takes the form of precautionary savings to minimize the risk of hitting the borrowing constrained and being forced to cut consumption. In our framework, households simultaneously decide their consumption-savings profile and location which are two imperfect substitutes to smooth utility when faced by temporary but persistent income shocks. When hit by a negative shock, for instance, households will compare the value of staying in the current location relative to the value of moving. The value of staying depends crucially on the ability of households to smooth out utility variations by tapping into their savings or accessing the financial markets. Moving allows households to look for better opportunities but it is very costly. The optimal choice depends on the individual characteristics, particularly households' wealth, as described below. But as households are forward-looking, they will not only accumulate more savings but also choose to live in locations that deliver higher insurance value. In other words, our framework simultaneously delivers the standard *precautionary savings* as well as *precautionary*

[19]To be more precise, in each of these cases, we solve for the stationary equilibrium assuming the baseline parameterization. For the *No Homeownership* case we set additional utility from owned-housing services $\omega = 0$. For the *No Income Risk* case we set the dispersion of income shocks $\sigma_y = 0$ and no unemployment state. For the *No Borrowing Limit* case we drop the borrowing constraint by setting the natural borrowing $\underline{b} \rightarrow -\infty$.

moving.[20] As we can see in Panel A of Figure 8, the importance of these channels depends on the level of income risk and market incompleteness.

When income risk is shut down, both precautionary motives disappear. The average migration rate is 60% less than in the baseline economy, suggesting that precautionary moving is quantitatively very significant in driving migration decisions.

In the presence of borrowing constraints, households are limited in their ability to smooth income shocks by borrowing through the financial markets. The fear of hitting the constraint increases the motive for both precautionary savings and precautionary moving. Thus, reducing financial frictions makes consumption smoothing possible through borrowing, shrinking the value of precautionary moving. The aggregate migration rate is 35% lower when borrowing constraints are removed than in the baseline, suggesting a large role for market incompleteness to explain migration in the economy.[21]

When moving, homeowners face housing transaction costs besides the moving costs, which reduces the benefits of moving. However, this channel is not quantitatively significant. When we shut down the homeownership channel, the model generates an aggregate migration rate 0.2 p.p. higher than in the baseline economy.

Why do low-wealth households move more? In this framework, all households face the same migration costs, but the benefit of moving relative to staying varies across the state space, which generates different propensities to move across households facing the same shocks. Households want to smooth out utility across time and states of the world. When facing a negative income shock, households can smooth utility by borrowing more (or saving less) and cutting both housing and non-housing consumption. Households can also move to other locations, potentially re-optimizing to locations with either higher productivity or lower housing costs, but subject to monetary and utility costs.

The ability to smooth utility through borrowing is limited for households at the bottom of the wealth distribution. When faced with a negative income shock, low-wealth households that stay in the current location are more likely to cut consumption than high-wealth households,

[20] In standard Bewley-Huggett-Aiyagari class of models of income risk, incomplete markets, concave utility function but no migration, households build precautionary savings to smooth consumption across different contingencies. When hit by transitory but persistent income fluctuations, households with access to financial markets borrow and lend to mitigate the disutility of consumption fluctuations. Our model incorporates this mechanism, but, on top of that, households have also access to an additional source of smoothing: migration. Savings/Borrowing and migration are imperfect substitutes to smooth consumption in the face of uncertain individual incomes.

[21] Markets are still incomplete if the borrowing constraint is removed since households do not have access to a set of state-contingent securities that span over the all possible future states.

generating higher utility losses the more financially constrained households are. Although the net benefit of moving is similar across households, the value of staying is not. Therefore, low-wealth households may find it more costly (in utility terms) to stay than paying the large utility moving costs that allow them to re-optimizing to locations with either higher productivity or lower housing costs. Instead, high-wealth households are able to smooth income shocks by adjusting their savings. Since utility moving costs are large, they are more likely to stay and smooth consumption by adjusting their wealth. Thus, the value of moving relative to staying decreases along the wealth distribution, which rationalizes why low-wealth households tend to move more.

The strength of this channel is reported in Panel B of Figure 8, that plots the migration rates across wealth quartiles for different model specifications. The model specification without income risk (green bars) generates lower migration rates relative to the baseline economy (red bars) across the entire wealth distribution. The difference is striking for the first two quartiles of the wealth distribution, which shows how important is the moving motive for financial constrained households. Under the *No Borrowing Limit* case (blue bars), migration rates only decrease for the two bottom quartiles of the wealth distribution, which shows that the ability to smooth shocks through financial markets reduces substantially the value of moving relative to staying.

Moreover, migration rates become similar across the wealth distribution under these two cases. With no income risk or without borrowing constraints, the capacity to absorb income shocks becomes less dependent on households household characteristics, making the moving propensity less dependent on households' wealth. This result shows that income risk and incomplete markets alone generate the negative relationship between moving and wealth. This result also rationalizes why frameworks without simultaneously accounting for precautionary moving and precautionary savings motives require different moving costs across demographic groups to match the heterogeneity observed in the data.[22] As robustness check, Figure E.5 in the Appendix E reports the same decomposition exercise but re-paramaterizes the homogeneous migration costs for each case to match the average migration rate and the correlation between out-migration and city distance observed in the data. The main mechanisms described here are still present.

Where do households go? Precautionary moving affects how much individuals move and

[22]For completeness, we also report the results for the *No homeownership* case (pink bars) in Panel B of Figure 8. As expected from the small quantitative results in Panel A, the lack of homewownership does not significantly impact migration rates by wealth quartile.

their destination choices significantly. Low-wealth households tend to move more, but are more likely to move to locations with lower house costs potentially at the expense of higher wages. As mentioned before, low-wealth households in reaction to negative income shocks need to cut housing and non-housing consumption. Given that there is a minimum house size, households face a lower-bound on housing consumption and housing expenditure in each city.[23] A low-wealth and financially constrained household that already consumes the minimum housing services can only adjust non-housing consumption in facing a negative income shock leading to both inter- and intra-temporal utility losses. Therefore, locations where housing costs are lower allows to consume similar housing services than in other locations using a lower share of their income, freeing resources for non-durable consumption and savings which mitigates utility losses when hit by temporary negative shocks, particularly when housing is illiquid. Then low house house-price cities provide a higher insurance value, particularly for low-wealth households, than high house price locations in the presence of uninsurable income risk, which rationalizes why low-wealth households are more likely to move to such locations.

Figure 9 shows the quantitative strength of this channel, by plotting the fraction of households moving to cities with higher house prices (Panel A) and higher wages (Panel B) across the wealth distribution.[24] Without income risk or borrowing constraints, low-wealth households have less incentive to move to cities with lower house prices than in the baseline economy, taking advantage of a stream of future higher wages. This is quantitatively sizable, especially for the first quartile. The share of movers to higher house price destinations increases by approx. 8 and 10p.p. with no income risk and no borrowing limit, respectively. Similarly, the share of movers to higher wages destinations increases by approx. 15 and 7p.p. with no income risk and no borrowing limit, respectively. The higher ability to smooth income shocks through financial markets reduces the need for low-wealth households to achieve utility smoothing through low housing costs. These results show that the hypothesis of "location as an asset" proposed by Bilal and Rossi-Hansberg (2021) is quantitatively significant.[25]

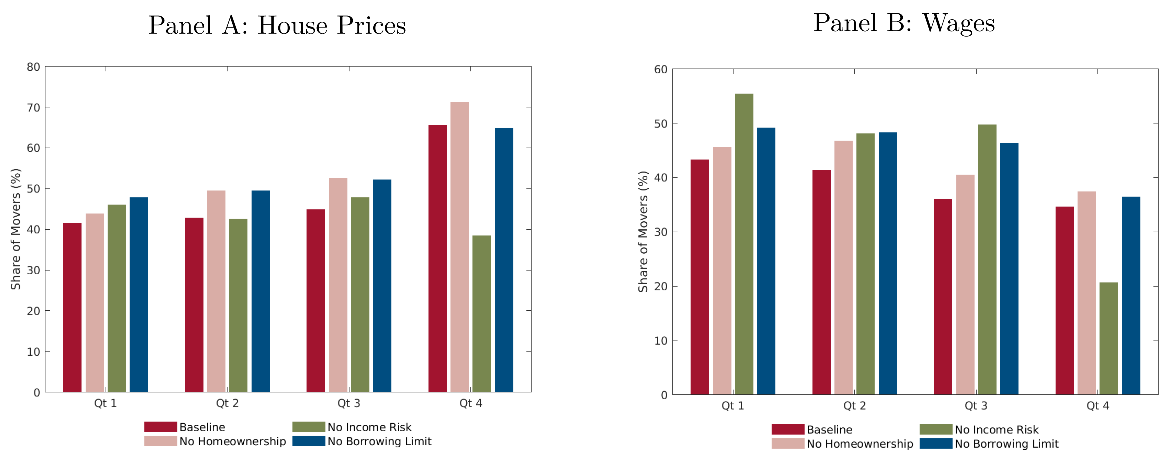
[23]As described in section 3.2, there are houses of different sizes which belong to a finite set.

[24]In Appendix E, Figures E.6 and E.7 report the shares of movers that move to locations that have higher population, median wages, amenities and productivities than the origin.

[25]In Bilal and Rossi-Hansberg (2021), constrained individuals downgrade their location as a result of a negative front-loaded income shock. The correlation between income and rents is 1, so moving to places with lower housing costs implies necessarily lower income locations. In our model, households can maximize under these two margins since the correlation between wages and house prices is 68% in the baseline economy against 64% in the data. The lack of perfect correlation between these two variables in our framework partially mutes the downgrading effect in their paper. Nevertheless, our framework also predicts that low-wealth individuals facing income risk and borrowing constraints are more likely to move to locations with lower house prices and income than they would otherwise do if they could perfectly smooth consumption without recurring to

Overall, these results show that forward-looking households take into account both labor market conditions and housing costs into their location choice. It also highlights that housing costs are particularly important for more constraint households.

Figure 9: Decomposition: Share of Movers that "Upgrade" by Wealth



Note: Figure 9 reports the share of households that move to locations with higher house prices (Panel A) and higher wages (Panel B) compared to their previous location by wealth quartile for different model specifications.

4.5 The Size of Moving Costs

Moving costs are often pointed out as the main driver of moving decisions. As previously discussed, different features of the model impact households moving propensities, which in turn lead to different model-implied moving costs estimates. We show that not accounting simultaneously for the precautionary moving and precautionary savings motives leads to higher model-implied moving costs estimates.

Methodology Given that the utility function is not linear, converting the utility moving costs into a dollar equivalent is not direct. Our procedure consists in solving for an individual specific change in consumption required to achieve the same individual location choices and allocations, and respectively life-time utility, in the absence of moving costs.[26] As derived in

"location as an asset".

[26]Given the flow utility depends on non-durable consumption and housing services, we re-write households life-time utility in terms of an "adjusted-consumption" measure, $\omega_{i,t}$, that delivers the same flow-utility (net of amenities) a household would obtain under the stationary equilibrium allocations.

Table 3: Migration Costs

	Baseline	No House	No IncRisk	No Borrow Const
Moving Costs (CAD 2016)	196,303	217,513	124,187	182,796

Note: Table 3 reports the values of migration costs in monetary terms for the baseline economy, for an economy without homeowners (*No House*), without income risk (*No Inc Risk*) and no borrowing constraints (*No Borrow Const*).

Appendix F, the moving cost in consumption-equivalent units of an average mover is given by:

$$\bar{\tau} = \frac{\sum_{k \neq l}^{L} \tilde{\mu}^{l,k} \tau^{l,k}}{\tilde{u}'(\bar{\omega})} + F$$

where $\tilde{u}'(\bar{\omega})$ is the marginal utility of the average mover in the stationary equilibrium, $\tau^{l,k}$ the utility moving costs from l to k, F the monetary moving cost and $\tilde{\mu}_i^{l,k} = \frac{\mu_i^{l,k}}{\sum_{i \neq k}^{L} \mu_i^{l,k}}$ is the probability of moving from l to k, conditional on moving, for the average mover with $\mu_i^{l,k}$ is defined in equation (11).

Results We find that the moving costs between Canadian cities are approximately 196,303 CAD (in 2016 units) in the baseline model, as reported in the first row of Table 3. A model with no homeownership that matches aggregate moving moments implies moving costs that are approximately 11% higher than in the baseline economy. The results change substantially when we remove income risk. Migration costs drop to approximately 124,187 CAD (in 2016 units). As mentioned before, households have a lower propensity to migrate in the absence of income risk. Thus, lower migration costs are needed to induce households to move at the rate observed in the data. This result is quantitatively large since it corresponds to a drop of 37% in migration costs relative to the baseline estimates. Similarly, the last column of Table 3 reports the results of migration costs for the model without borrowing constraint. In this case, the insurance channel of migration becomes less relevant and households are less likely to move. Under this specification, migration costs are estimated at 182,796 CAD (in 2016 units), 7% lower than in the baseline case. Table F.1 in the appendix section F reports the model implied parameters for each case in utility terms before being converted into dollar amounts. We find that the utility costs represent a larger fraction of the overall migration costs.

The model implied moving costs depend on the strength of the precautionary moving motive. Higher income risk and stronger financial frictions increase the incentive to move. Thus, these channels imply higher moving costs to match the observed ones in the data. Therefore, models where households can only smooth income risk through moving but not through financial markets might imply higher moving costs. Overall, the different estimates across specifications show that not accounting for the ability to smooth shocks simultaneously by either moving or through financial market increases moving costs estimates.

5 Policy Analysis: Moving Vouchers and Housing Restrictions

Exploiting the richness of our model for quantification and the fact that the mechanisms of "location asset" and "asset in a location" are embedded in it, we revisit some of the most discussed policies designed to attract low-income families to productive locations.

We start with moving vouchers followed by a housing affordability policy that resembles reducing zoning restrictions in Vancouver, one of North America's most expensive and productive cities. The main difference between these policies is that the latter reduces housing costs, which, as discussed in our mechanism section 4.4, is a crucial determinant of location choice, particularly for low-wealth families. We investigate the economic and welfare implications of these policies in the short and long-run at the aggregate level, by geography and by demographic groups. To perform welfare analysis, we need to solve transitional dynamics. The solution algorithm is discussed above.

Our framework is an ideal ground to compare the aggregate and distributional implications of this type of policies. The rich heterogeneity and the micro-found endogenous moving rates allow us to identify and compare the mechanisms through which different policies work. By considering uninsurable income risk that gives rise to both *precautionary savings* and *precautionary moving*, our framework gives a new perspective to the literature on how these policies work. Given that most of the household wealth is concentrated in housing, by considering homeownership choice, we can analyze policies that directly impact the housing market and bring a new perspective to the distributional impacts of different policies. Finally, we solve the full transition path induced by the policies consistent with equilibrium local house prices and wages. As we show, changes in relative prices across space are a crucial channel that drives welfare changes and reduces inequalities.

Welfare Measure To compute the welfare impact of a policy we follow the following procedure.

Let's denote agent i's value function under benchmark policy θ_b as $V_{i,t}(a(b), \epsilon, q, h(b); \theta_b)$. Consider an alternative policy θ_c, which goes into effect in period t + 1, with value function $V_{i,t+1}(a(c), \epsilon, q, h(c); \theta_c)$. Prices, asset valuations and wealth may be different under this new policy, hence the dependence of a and h on the policy. Because of endogenous migration, the set of households present in a city before and after the reform is implemented may differ. To ensure we compare the same set of households, the welfare measure averages over a fixed group of households living in a given city before the reform, the set g_t with cardinality G, and tracks them at time t + 1 regardless of their mobility decisions. We define groups in terms of age, homeownership status, and wealth. The welfare change ΔW is expressed in consumption equivalent units with the welfare measure for the short-run given by:

$$\Delta W = \frac{\sum_{i \in g_t} V_{i,t+1}(a'(c), \epsilon, q, h(c); \theta_c)^{\frac{1}{1-\sigma}}}{\sum_{i \in g_t} V_{i,t+1}(a'(b), \epsilon, q, h(b); \theta_b)^{\frac{1}{1-\sigma}}} - 1 \tag{16}$$

Equally, we develop a measure of welfare change for the long-run that considers compositional changes in the population across locations. It compares the initial steady-steady (SS) under the benchmark policy θ_b with the new steady-state that the economy reaches under an alternative policy θ_c. This long-run welfare measure can only be evaluated at the aggregate level and it is given by:

$$\Delta W = \frac{\sum_{i} V_{i,\infty}(a'(c), \epsilon, q, h(c); \theta_c)^{\frac{1}{1-\sigma}}}{\sum_{i} V_{i,SS}(a'(b), \epsilon, q, h(b); \theta_b)^{\frac{1}{1-\sigma}}} - 1 \tag{17}$$

In Appendix G we derive the welfare measures presented above.

5.1 Moving Vouchers' Policies

In this section, we analyze the impact of introducing moving vouchers at country level for moving across cities. The design of our experiment is based on the MTO experiment, in which a random set of households with income lower than 50% of the median income of their location were selected to receive a moving voucher to move to areas with less than 10% of poverty. Participants in the experiment received help to pay the rent in the new location.[27].

Given the obvious differences in design and goals between MTO and our experiment, our objective is not to evaluate or rationalize the results of MTO. Instead, we aim at analyzing the consequences of moving subsidies across cities applied at the county level through the

[27]Details about the MTO experiment and its empirical evaluation can be found in Chetty, Hendren and Katz (2016)

lens of our model. Therefore, after describing the design of the moving vouchers applied in our framework, we ask: i) Are eligible households using the moving vouchers? ii) What are the economic outcomes and welfare implications of these vouchers?

Moving Vouchers In our experiment, households in the whole of Canada with income lower than 50% of the median income of the current location are eligible to receive a moving voucher. The moving voucher consists of the payment of 70% of the median rent of the destination city during one model period (two years of life).[28] We analyze separately two variants of this policy. First, in the spirit of MTO experiment, we consider a *conditional* moving voucher, in which receiving the subsidy is conditional on moving to a city with a higher median income than the current one. Second, we analyze an *unconditional* moving voucher, in which participants receive the subsidy regardless of the characteristics of the destination city.

We assume the economy is at the initial stationary equilibrium when the unanticipated policy is implemented. The government commits to implement the policy in perpetuity. Given the moving frictions in our framework, the economy slowly transitions to a new stationary equilibrium under the voucher policy.

Participation and Outcomes Table 4 provides information on eligibility, participation and migration rates for different demographic groups. The reported values for the *conditional* and *unconditional* policies correspond to averages over the transition period.[29] The eligible share is the share of the population in a specific demographic group that can access the subsidy. Under the pre-policy case, the eligible share corresponds to the share of the population that would be eligible in the initial steady-state if the policies were available. The Participation rate corresponds to the total number of households that receive the subsidy over the total number of eligible households. The counterpart participation rate under the *Pre-Policy* corresponds to the share of potential eligible households moving to locations with a median income greater than the previous location in the stationary equilibrium. Regarding migration rates, we report the aggregate migration rate, and the migration rate for *Non-eligible* and *Eligible*.[30]

[28] In the MTO experiment, the maximum housing assistance is generally the lesser of the payment standard minus 30% of the family's monthly adjusted income or the gross rent for the unit minus 30% of adjusted monthly income. The payment standard, defined by the Public Housing Agencies (PHAs), corresponds to the amount generally needed to rent a moderately-priced dwelling unit in a given housing market. For computational simplicity, we assume that in our experiment, the moving subsidy is 70% of the median rent of the destination city.

[29] To be more precise, we compute the equilibrium allocation for 100 periods. Under both policies, the new stationary equilibrium is achieved within 100 periods. For each variable reported in Table 4 under *conditional* and *unconditional* policies, we compute the average of the variable for these 100 periods.

[30] For each period, we compute the ratio of eligible (non-eligible) households that move over the total number

Table 4: Moving Vouchers: Eligibility, Participation and Migration Rates

Demographics	Policy	Eligible share	Participation Rate	Migration Rates		
				Aggregate	Non-eligible	Eligible
All	PrePolicy	7.81	3.79	1.54	1.04	7.14
	Conditional	7.53	5.59	1.64	1.01	9.1
	Unconditional	7.42	10.1	1.7	0.99	10.1
Homeowners	PrePolicy	3.51	1.08	1	0.96	2.09
	Conditional	3.34	1.53	0.98	0.92	2.51
	Unconditional	3.3	2.77	0.97	0.9	2.77
Renters	PrePolicy	14.52	4.81	2.37	1.19	9.05
	Conditional	13.99	7.08	2.64	1.15	11.53
	Unconditional	13.79	12.82	2.81	1.15	12.82
Age 25-65	PrePolicy	9.81	5.08	1.85	0.98	9.35
	Conditional	9.5	7.47	1.99	0.96	11.94
	Unconditional	9.36	13.22	2.07	0.94	13.22
Age 65-85	PrePolicy	11.21	0.04	0.55	0.53	0.76
	Conditional	10.7	0.05	0.56	0.53	0.78
	Unconditional	10.52	0.92	0.58	0.54	0.92
Wealth - Qt1	PrePolicy	7.7	0.12	3.42	1.79	12.63
	Conditional	6.89	0.2	3.82	1.67	16.17
	Unconditional	6.97	0.47	4.03	1.66	17.69
Wealth - Qt2	PrePolicy	16.84	6.45	1.22	0.88	9.8
	Conditional	18.12	9.6	1.26	0.88	12.57
	Unconditional	17.69	17.22	1.3	0.87	14.2
Wealth - Qt3	PrePolicy	3.82	0.04	0.73	0.71	5.38
	Conditional	3.62	0.05	0.71	0.7	6.88
	Unconditional	3.55	0.93	0.7	0.67	7.62
Wealth - Qt4	PrePolicy	2.43	0.04	0.8	0.79	0.83
	Conditional	2.31	0.04	0.78	0.78	0.86
	Unconditional	2.27	0.82	0.78	0.76	0.98

Note: Table 4 reports the participation and migration rates for both conditional and unconditional moving vouchers. We report them for the average household "All", for homeownership status "Homeowners" and "Renters", by age group "Age 26-65" and "Age 65-85" and by Wealth from quartile one (Qt - 1) to quartile four (Qt - 4). The first column reports the eligibility share, the second column the participation or take-up rate, and the last three columns report migration rates at the country level, only among the non-eligible and among the eligible.

of eligible (non-eligible) households and average out over the 100 periods. Under the *Unconditional* policy, the average migration rate for *Eligible* matches by construction the participation rate. For the *Conditional* policy, the difference between the average participation rate and migration rate for *Eligible* is given by the eligible households that move to cities with lower median income than the origin city.

As reported in the first panel of Table 4, *All*, in the initial steady-state, 7.81% of households in Canada would be eligible for the moving voucher if such policy was in place. On average, the eligibility share under the *Conditional* and *Unconditional* policies are 7.53% and 7.42%, respectively.[31] Regarding the participation rate, only 5.6% of the eligible population takes up the conditional vouchers. This rate almost doubles for the unconditional policy (10.1%). The low participation rates translate into limited changes in aggregate moving rates. For the eligible group, the migration rate increases from 7.14% in the stationary equilibrium to 9.1% and 10.1% under the conditional and unconditional policies, respectively. In the *Conditional* case, 92% of the increase in migration rate in the *Eligible group* is driven by participants, *i.e.*, households that take the subsidy and move to cities with higher median income. General equilibrium effects impact the moving decisions of *Non-eligible* households that tend to move less when moving vouchers are implemented.

We observe substantial heterogeneity in participation rates across demographic groups. Participation rates are five times higher among renters than homeowners and are almost exclusively taken by working-age households. Regarding wealth, we find that eligibility and participation rates are low at the top of the wealth distribution. The eligibility rate in Quartile 2 is higher than in Quartile 1, which reflects households in the middle of the income distribution but with high debt. Migration rates for *Eligible* at the bottom two quartiles increase substantially with the policies. However, under the *Conditional* policy, this increase in migration for households at the second quartile is entirely driven by households that take advantage of the subsidy, but only 3% of the increase in the bottom quartile is due to households participating in the program. This interesting result shows that the general equilibrium effects driven by the movement of households of the second quartile induce eligible households in the first quartile to move more but to locations with lower median income.

These results rationalize the low take-up rates of the MTO experiment. Low-income households use low-cost locations as an insurance mechanism, especially those close to the borrowing limit. Despite the rent subsidy for several years in high-income areas, expensive locations do not provide enough insurance against income shocks for constrained households once the subsidy expires. Forward-looking constrained agents internalize the future higher housing costs.

[31] The eligibility criteria do not depend on the conditionality of the policies, so in the initial steady-state the eligible share is the same regardless of the policy type implemented. The reallocation of households induced by the policies impacts the income distribution across cities. Therefore, the eligibility share will be different under the two policies over time.

Long-Run Economic Changes Figure 10 reports the long-run changes in population, wages, house prices and homeownership rates by city and policy. Cities are ordered by ascending median income in the stationary equilibrium without moving vouchers. In the new stationary equilibrium, the population is relatively higher in higher-income cities with relatively higher concentration in higher-income cities under the *Conditional* policy. Wages move in the opposite direction of population growth as wages increase where the population decrease and vice-versa. House prices correlate positively with population change, while homeownership rates go up almost everywhere.

Figure 10: Moving Vouchers: Long-Run Economic Changes

Note: Figure 10 reports the percentage difference between the stationary equilibrium under the moving policy and the initial equilibrium for population (Panel A), wages (Panel B), house prices (Panel C) and homeownership rate (Panel D, in percentage points). Cities are ordered in ascending median income of the initial stationary equilibrium.

Welfare Impact Table 5 reports the welfare changes of moving vouchers in the short- and long-run. In the short-run, the aggregate welfare changes are small, approximately 0.03% and 0.05% for the conditional and unconditional vouchers, respectively. The positive effects are all driven by the eligible households while the policies generate modest negative effects for the non-eligible. These policies create an intra-generational conflict in the short-run.

Table 5: Moving Vouchers: Welfare Changes (%)

Demographics	Policy	Short-Run			Long-Run
		All	Eligible	Non-eligible	All
All	Conditional	0.03	0.38	-0.01	0.28
	Unconditional	0.05	0.71	-0.02	0.34
Homeowners	Conditional	0.03	0.22	0.02	0.17
	Unconditional	0.03	0.44	0.02	0.2
Renters	Conditional	0.03	0.41	-0.06	0.71
	Unconditional	0.08	0.75	-0.08	0.79
Age 25-65	Conditional	0.03	0.39	-0.01	0.29
	Unconditional	0.05	0.71	-0.03	0.37
Age 65-85	Conditional	0.03	0.18	0.01	0.22
	Unconditional	0.09	0.59	0.04	0.24
Wealth -Qt1	Conditional	0.11	0.58	0	0.45
	Unconditional	0.19	0.85	0.02	0.65
Wealth -Qt2	Conditional	-0.06	0.46	-0.08	0.05
	Unconditional	-0.08	0.84	-0.14	0.09
Wealth -Qt3	Conditional	-0.04	0.11	-0.03	0.06
	Unconditional	-0.04	0.43	-0.06	0.02
Wealth -Qt4	Conditional	0.09	0.17	0.09	-0.08
	Unconditional	0.12	0.51	0.11	-0.11

Note: Table 5 reports the welfare for both conditional and unconditional moving vouchers. We report them for the average household "All", for homeownership status "Homeowners" and "Renters", by age group "Age 26-65" and "Age 65-85" and by Wealth from quartile one (Qt - 1) to quartile four (Qt - 4). We estimate welfare changes both in the short-run using the expression in (16) and in the long-run using the expression in (17). In the short-run we compare welfare for the average household, for the eligible households to the policy and finally also for the non-eligible households.

Low-income renters, younger and low-wealth households benefit from the policies, while high-income renters, younger and low-wealth households are the biggest losers. Changes in income and house prices implied by the policies negatively impact high-income and high-wealth households. The largest gains and losses are concentrated in the second quartile of the wealth distribution. Despite the high participation rate among eligible households in this group, the average household loses. *Unconditional* policy amplifies welfare changes in the short-run, regardless of the direction of the welfare change.

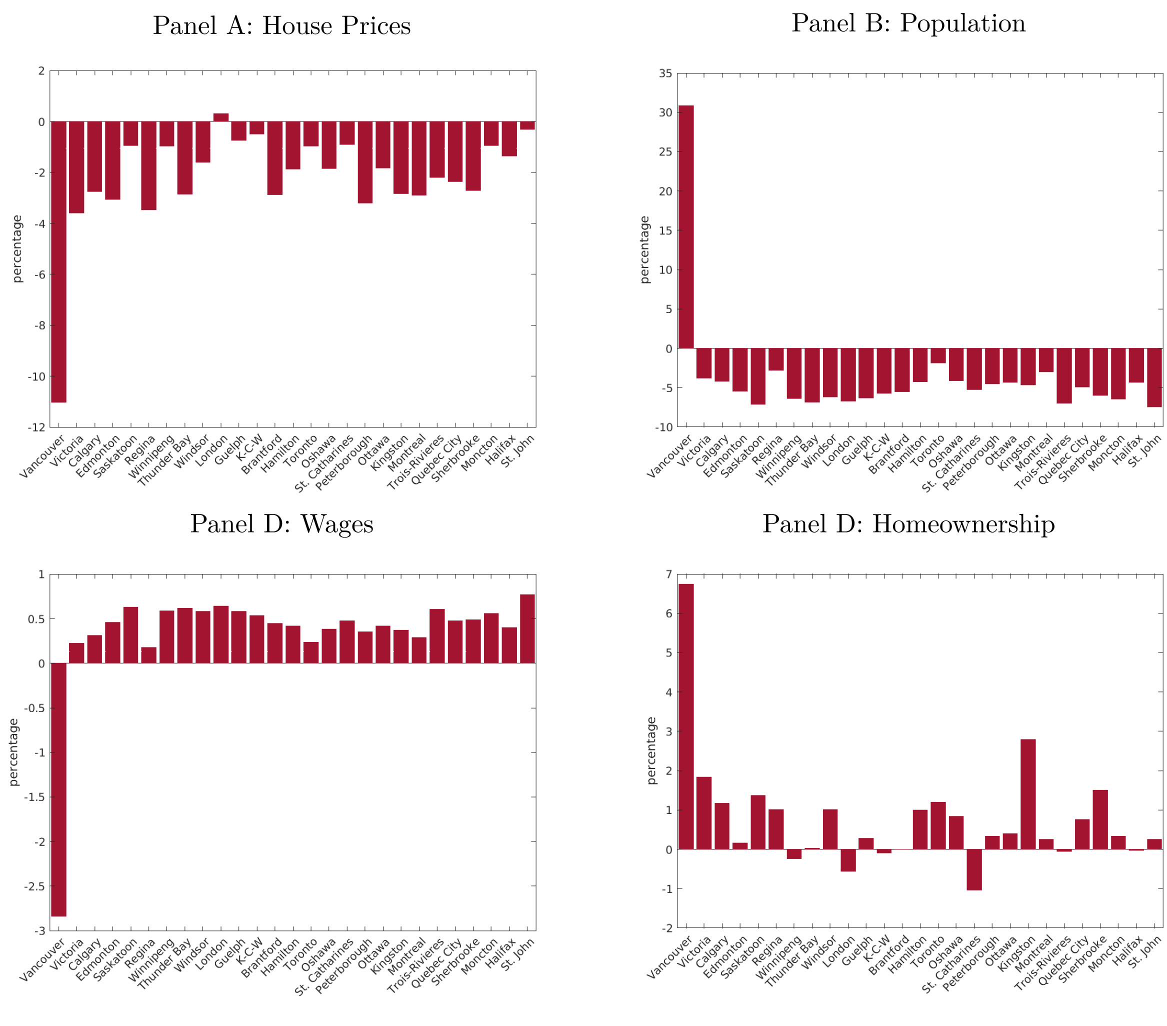
In the long-run, once the economy reaches the new steady-state, the aggregate welfare is 0.28% higher than in the initial steady-state with conditional policy and 0.34% with the unconditional one. Moving vouchers increase modestly the welfare of low-wealth households at the expense of high-wealth households. Overall, we conclude that moving vouchers, especially the conditional ones such as in the MTO experiment, mildly help to close the gap between rich and poor through internal migration.

Taking Stock Moving vouchers have modest take-up rates and welfare effects, particularly the *conditional* ones. In our model, low-income and low-wealth individuals tend to move to cheap locations to insure against income risk. For low-wealth families, the amount of insurance provided by temporary *conditional* vouchers does not compensate for the loss in insurance of not moving to cheaper locations. These results highlight the importance of housing costs for location decisions of low-wealth households. Policies that improve housing affordability in highly productive cities may limit the moving of constrained households to low-income cities. To test this hypothesis, we next analyze a reduction in housing regulations in Vancouver, one of North America's most expensive but productive cities.

5.2 Decreasing Housing Regulations in Vancouver

Often, policymakers, politicians, and economists discuss reductions of housing regulations in cities with very high house prices and affordability concerns (e.g., Favilukis, Mabille and Van Nieuwerburgh, 2023). Housing regulations, such as zoning, limit housing supply and have been pointed out as one of the main factors that explain the large increase in house prices in recent years and in sustaining inequality and segregation. Vancouver, alongside other North American cities such as Toronto, San Francisco and New York City, is among the most expensive cities in the world. In Vancouver, 52% of the land can only be allocated to single-family detached houses. What if such regulations were reduced? Exploiting the rich structure of our model, we implement a plausible counterfactual experiment that decreases housing regulations in Vancouver, leading to an increase in the housing supply of 30%. We map this potential change of housing regulations to our model by increasing the government land permits for construction, $\bar{L}$, by 30%.

Figure 11: Decrease of Housing Restrictions in Vancouver: Long-Run Changes



Note: Figure 11 reports the long-run changes in all the cities of Canada ordered by distance from Vancouver. The outcomes under consideration are house prices, wages, population and homeownership in Panel A, B, C and D, respectively.

Long-Run Economic Changes Figure 11 reports the long-run changes induced by this policy by comparing the post- and pre-policy stationary equilibria. In the new steady-state, house prices in Vancouver are approximately 11% lower than in the pre-policy policy steady-state (Panel A). The lower housing costs attract households to Vancouver from the entire country (Panel B). The increase in Vancouver's labor force leads to a wage decline in the long-run of approximately 2.8% (Panel C). The decrease in housing costs compensates for the decline in wages and the homeownership rate increases by almost 7p.p. Although the policy is only implemented in Vancouver, it impacts the entire country as households adjust their location. All cities lose population, particularly, Saskatoon and St. John, and wages increase accordingly. House prices decline everywhere with the size of the adjustment depending crucially on local housing supply elasticities. In most cities, homeownership increases. Due to general equilibrium effects and spatial reallocation, a policy that decreases housing costs in Vancouver has significant reallocation effects in the long-run on all the other Canadian cities by, on average, decreasing house prices and increasing wages. The transition dynamics between steady-states for the major Canadian cities are reported in Figure H.1 of Appendix H.

Welfare Changes Table 6 displays the welfare changes after relaxing housing restrictions in Vancouver. In the long-run, the policy is welfare improving for the entire country and all demographic groups. In the new steady-state, aggregate welfare is 1.06% higher. Homeowners, non-retired and households in the first three quartiles of the wealth distribution have the highest "welfare gains".

In the short-run, however, the impact is very heterogeneous. On average, households in Vancouver before the policy is implemented see their welfare increase by 0.25%, regardless of where they locate afterwards. In the rest of the country, the welfare of the average household declines by 0.03%. Overall, the policy is neutral in the short-run for the entire country. In Vancouver, house prices and rents drop immediately, but the wage decline is slower as it takes time for the spatial reallocation to occur. Young renters benefit as their housing consumption becomes cheaper and their wealth is not significantly impacted. Moreover, young households are more likely to move and take advantage of the lower housing costs in more productive cities, including Vancouver. Older households that tend to be homeowners lose as a decline in house prices decreases their wealth. Households aged between 25 and 35 benefit the most, with an increase in the average welfare of 0.85%. Those between 35 and 45 benefit only marginally, with a welfare increase of 0.05%, on average. The older groups, 46-65 and above 65 lose on average 0.33 and 0.53%, respectively. Regarding wealth, we observe welfare gains in Vancouver for the two bottom wealth quartiles of 0.85 and 0.12%, respectively. Those in the top two quartiles lose, respectively, 0.28 and 0.46%.

In the rest of the country, despite the increase in wages, homeowners also lose and renters win. The higher proportion of homeowners outside Vancouver, explains the drop in aggregate welfare of 0.03%. Households younger than 35 years old benefit as they are mainly renters. The other age groups lose and the loss is monotonic with age. Similar results in terms of wealth distribution. Households in the first quartile observe an increase in the welfare of 0.2% while those in the other quartiles face welfare losses, particularly the top quartile, with an average decline of 0.28%. Overall, this policy, while it only operates in Vancouver, through reallocation across the country, provides significant welfare gains and shrinks the welfare gap between the poor and rich.

Table 6: Decrease of Housing Restrictions in Vancouver: Welfare Changes (%)

	Short-run			Long-Run
Demographics	Vancouver	All cities but Vancouver	Canada	Canada
All	0.25	-0.03	0	1.06
Homeowners	-1.25	-0.24	-0.28	1.28
Renters	0.57	0.27	0.33	0.74
Age 25-35	0.85	0.2	0.27	0.93
Age 36-45	0.05	-0.15	-0.13	1.08
Age 46-65	-0.33	-0.25	-0.26	1.29
Age 65-85	-0.53	-0.28	-0.31	0.74
Wealth - Qt1	0.85	0.2	0.27	0.88
Wealth - Qt2	0.12	-0.14	-0.12	0.9
Wealth - Qt3	-0.28	-0.25	-0.26	0.91
Wealth - Qt4	-0.46	-0.28	-0.31	0.52

Note: Table 6 reports the welfare changes of the decrease in zoning regulations in Vancouver. The first three columns report the changes in the short-run for Vancouver, all cities except Vancouver and all of Canada (takes the weighted average for the whole country). The fourth column reports the changes in the long-run for the whole of Canada. We estimate welfare changes in the short-run using the expression in (16) and the long-run using the expression in (17).

Taking Stock Moving vouchers and reduction in housing restrictions operate through very distinct mechanisms. Moving vouchers, especially the conditional ones, induce households to move to expensive locations, leading to lower wages and higher prices in already expensive cities. These general equilibrium effects negatively impact high-income non-eligible households and reduce the incentive of eligible ones to take on such subsidies, which rationalizes the low take-up rates of these voucher programs. Instead, a policy, such as a reduction in housing restrictions that causes a decline in house prices in an expensive but productive city such as Vancouver is more desirable for low-wealth households. By decreasing house prices everywhere, this policy induces more moving for opportunities for constrained households that can now benefit more from higher wage cities at lower housing costs. Lower housing costs increase the insurance value of staying in high-income cities, reducing the incentive for low-wealth households to move precautionarily to low housing costs locations. A natural question arises. Why are policies like decreasing zoning restrictions rarely implemented despite potential significant welfare gains in the long-run? One reason could be the negative impact on certain demographic groups during the transition. This policy generates an inter-generational trade-off in the short-running by helping young and low-wealth households at the same time that hurts older and high-wealth households, which explains the observed lobbying against this type of policy.[32]

6 Concluding Remarks

By integrating a dynamic incomplete-markets life-cycle framework into a spatial equilibrium model, we provide a theoretical foundation and a quantitative validation for the observation that endogenous wealth accumulation and migration are significant substitute self-insurance mechanisms, which is also supported by empirical evidence.

Overall, the quantitative nature of the model sets the ground for a broader research agenda above and beyond the analysis performed in this paper. Our model can analyze the propagation of local shocks across space. Differences in city characteristics like industry composition imply heterogeneous exposure to technological changes, trade shocks, and transition to a greener economy, among others. In Canada, for instance, a decline in oil prices strongly affects oil-intensive regions, with documented impacts on migration rates. Empirical analysis of these episodes combined with a structural evaluation of these shocks can shed light on the potential distributional impact of a transition to a greener economy. This is of particular interest because it would provide insights into how individuals can adapt simultaneously through asset accumulation and by moving. Only a quantitative analysis containing all these ingredients can shed light on what accounts for the geographic adaptation to a greener economy.

Moreover, embedding human capital accumulation in this framework would permit assessing

[32] Appendix H shows how rapidly house prices fall in Vancouver decreasing dramatically the value of wealth for homeowners.

the trade-off between contemporaneous insurance gains of moving to cheaper locations and the future losses of lower levels of skill acquisition, including inter-generational implications.

Finally, another important structural change in recent decades has been the aging and depopulation of most developed countries, with a concentration in rural areas. Understanding how local versus aggregate policies, pension reforms and different types of subsidies can spur welfare and socio-economic equality will first-order in the upcoming years.

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Online Appendix for
"UNPACKING MOVING:
A Quantitative Spatial Equilibrium Model with Wealth"

December 2023

A Additional Analysis on the Empirical Evidence

Definitions

- *Migrants*: All the individuals in our dataset that report living in a different location than the one in the previous period.

- *Homeowners*: All the individuals with an active mortgage with positive outstanding or a home-equity line of credit above CAD 50,000 or had a fully-amortized mortgage associated with the current address.

- *Credit Usage*: Credit usage is defined as the total outstanding non-mortgage debt balance divided by the credit limit. We consider all open credit account in credit cards, installments, auto-loans and lines of credit.

Table A.1: Heterogeneous Migration Responses (Credit Score)

Panel A: Migration across CAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Move=100				
Homeowner	-0.900***			-0.571***	-0.900***			-0.571***
	(0.119)			(0.124)	(0.119)			(0.124)
Age [36-45]		-2.117***		-1.958***		-2.116***		-1.956***
		(0.229)		(0.208)		(0.229)		(0.208)
Age [46-65]		-2.859***		-2.615***		-2.859***		-2.615***
		(0.305)		(0.274)		(0.304)		(0.274)
Age [66-75]		-3.374***		-3.153***		-3.373***		-3.152***
		(0.370)		(0.350)		(0.370)		(0.349)
Age [76-85]		-3.659***		-3.529***		-3.658***		-3.528***
		(0.386)		(0.380)		(0.386)		(0.380)
Credit Score [640-759]			-1.052***	-0.760***			-1.055***	-0.762***
			(0.168)	(0.117)			(0.167)	(0.117)
Credit Score [760-799]			-1.341***	-0.884***			-1.344***	-0.887***
			(0.196)	(0.123)			(0.196)	(0.123)
Credit Score [800-900]			-1.975***	-1.119***			-1.977***	-1.121***
			(0.241)	(0.130)			(0.241)	(0.130)
Observations	146602877	146602877	146602877	146602877	146602877	146602877	146602877	146602877
Adjusted R^2	0.101	0.106	0.101	0.107	0.101	0.106	0.102	0.107
City Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
Year Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
City × Year Fixed-Effects	No	No	No	No	Yes	Yes	Yes	Yes

Panel B: Migration across CMAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Move=100				
Homeowner	-0.677***			-0.446***	-0.676***			-0.446***
	(0.090)			(0.095)	(0.090)			(0.095)
Age [36-45]		-1.548***		-1.435***		-1.548***		-1.435***
		(0.177)		(0.164)		(0.177)		(0.164)
Age [46-65]		-2.123***		-1.966***		-2.124***		-1.966***
		(0.221)		(0.204)		(0.221)		(0.204)
Age [66-75]		-2.449***		-2.331***		-2.448***		-2.330***
		(0.264)		(0.252)		(0.264)		(0.252)
Age [76-85]		-2.614***		-2.570***		-2.614***		-2.570***
		(0.282)		(0.279)		(0.282)		(0.279)
Credit Score [640-759]			-0.447***	-0.249***			-0.448***	-0.251***
			(0.064)	(0.044)			(0.064)	(0.044)
Credit Score [760-799]			-0.603***	-0.290***			-0.605***	-0.292***
			(0.076)	(0.059)			(0.076)	(0.060)
Credit Score [800-900]			-1.099***	-0.474***			-1.100***	-0.476***
			(0.121)	(0.083)			(0.121)	(0.083)
Observations	122045401	122045401	122045401	122045401	122045401	122045401	122045401	122045401
Adjusted R^2	0.100	0.104	0.100	0.105	0.100	0.104	0.100	0.105
City Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
Year Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
City × Year Fixed-Effects	No	No	No	No	Yes	Yes	Yes	Yes

Note: Table A.1 reports the OLS estimates of equation 1 for 2011–2019 period using Credit Score as a proxy for financial access. The dependent variable is a dummy variable that equals 100 in case of moving and zero otherwise. The sample is restricted to individuals in CAs in Panel A and CMAs in Panel B. Standard errors are presented in parentheses and clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels, respectively. *Data Source:* TransUnion.

Table A.2: Heterogeneous Migration Responses (Credit Usage)

Panel A: Migration across CAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Move=100				
Homeowner	-0.900***			-0.919***	-0.900***			-0.918***
	(0.119)			(0.127)	(0.119)			(0.127)
Age [36-45]		-2.117***		-1.971***		-2.116***		-1.969***
		(0.229)		(0.216)		(0.229)		(0.216)
Age [46-65]		-2.859***		-2.622***		-2.859***		-2.622***
		(0.305)		(0.286)		(0.304)		(0.286)
Age [66-75]		-3.374***		-3.132***		-3.373***		-3.130***
		(0.370)		(0.366)		(0.370)		(0.366)
Age [76-85]		-3.659***		-3.418***		-3.658***		-3.416***
		(0.386)		(0.391)		(0.386)		(0.391)
Credit Use - Qt2			0.409***	0.407***			0.409***	0.407***
			(0.037)	(0.037)			(0.037)	(0.037)
Credit Use - Qt3			0.846***	0.640***			0.844***	0.639***
			(0.099)	(0.079)			(0.099)	(0.079)
Credit Use - Qt4			1.319***	0.844***			1.319***	0.844***
			(0.150)	(0.117)			(0.151)	(0.117)
Credit Use - Qt5			0.670***	0.801***			0.672***	0.803***
			(0.077)	(0.082)			(0.077)	(0.081)
Observations	146602877	146602877	127821028	127821028	146602877	146602877	127821028	127821028
Adjusted R^2	0.101	0.106	0.102	0.108	0.101	0.106	0.102	0.108
City Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
Year Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
City × Year Fixed-Effects	No	No	No	No	Yes	Yes	Yes	Yes

Panel B: Migration across CMAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Move=100				
Homeowner	-0.677***			-0.653***	-0.676***			-0.653***
	(0.090)			(0.084)	(0.090)			(0.084)
Age [36-45]		-1.548***		-1.460***		-1.548***		-1.459***
		(0.177)		(0.170)		(0.177)		(0.170)
Age [46-65]		-2.123***		-1.996***		-2.124***		-1.996***
		(0.221)		(0.211)		(0.221)		(0.211)
Age [66-75]		-2.449***		-2.351***		-2.448***		-2.350***
		(0.264)		(0.263)		(0.264)		(0.263)
Age [76-85]		-2.614***		-2.545***		-2.614***		-2.544***
		(0.282)		(0.287)		(0.282)		(0.287)
Credit Use - Qt2			0.276***	0.272***			0.276***	0.271***
			(0.039)	(0.035)			(0.039)	(0.035)
Credit Use - Qt3			0.529***	0.375***			0.529***	0.374***
			(0.107)	(0.097)			(0.107)	(0.097)
Credit Use - Qt4			0.775***	0.426***			0.775***	0.426***
			(0.152)	(0.141)			(0.152)	(0.141)
Credit Use - Qt5			0.333***	0.441***			0.335***	0.442***
			(0.089)	(0.095)			(0.089)	(0.095)
Observations	122045401	122045401	106578851	106578851	122045401	122045401	106578851	106578851
Adjusted R^2	0.100	0.104	0.102	0.107	0.100	0.104	0.102	0.107
City Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
Year Fixed-Effects	Yes	Yes	Yes	Yes	No	No	No	No
City × Year Fixed-Effects	No	No	No	No	Yes	Yes	Yes	Yes

Note: Table A.2 reports the OLS estimates of equation 1 for 2011–2019 period using Credit Usage as a proxy for financial access. The dependent variable is a dummy variable that equals 100 in case of moving and zero otherwise. The sample is restricted to individuals in CAs in Panel A and CMAs in Panel B. Standard errors are presented in parentheses and clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels, respectively. *Data Source:* TransUnion.

B Equilibrium

Given a vector of individual states $\mathrm{x}_t = (a_t, \epsilon_t, q, \bar{h}_t)$, a competitive equilibrium of the economy consists of endogenous price vectors $\{w_t^l, p_t^l, R_t^l\}_{l=1}^l$, decision rules $\{c_t^l(\mathrm{x}), h_t^l(\mathrm{x}), b_t^l(\mathrm{x}), d_t^l(\mathrm{x}), \mu_t^l(\mathrm{x})\}_{l=1}^L$ and aggregate allocations for population, labor in the construction sector, housing stock, housing investment and government expenditures $\{\bar{N}_t^l, N_{c,t}^l, H_{t-1}^l, I_{h,t}^l, G_t^l\}_{l=1}^l$ such that:

1. The policy functions, $\{c_t^l(\mathrm{x}), h_t^l(\mathrm{x}), b_t^l(\mathrm{x}), d_t^l(\mathrm{x}), \mu_t^l(\mathrm{x})\}_{l=1}^L$, solve the household's problems (7)-(9). μ_t^l denote a matrix of moving probabilities $\{\mu_t^{l,k}(x)\}_{k=1}^L$ defined in equation (11).

2. Firms in the construction sector maximize profits with associated labor demand and housing investment functions $\{N_{c,t}^l, I_{h,t}^l\}_{l=1}^l$. Housing stock evolves according to equation (14).

3. Wage function determined in equation (12) clears the labor market in each location and the labor demand in the final good sector is determined as $N_{c,t}^l = (1 - \pi_u^l)\bar{N}_t^l - N_{h,t}^l$, where π_u^l denotes the unemployment rate in location l.

4. Population in each location is endogenously determined and consistent with the optimal individual moving decisions of survival households satisfying $\bar{N}_t^l = \sum_{j=1}^L \int_{\mathrm{x}} \lambda(\mathrm{x})\bar{N}_t^l(\mathrm{x})\mu_t^{k,l}(\mathrm{x}) + \bar{N}_{0,t}^l$, where $N_{0,t}^l$ denote newborns in location l and $N_t^l(\mathrm{x})$ the mass of households with individual state x. The population is constant and newborns are distributed across space in proportion to the mass of households of age between 25 ($q = 1$) and 35 ($q = 5$).

5. The rental markets clear at prices $\{R_t^l\}_{l=1}^l$ given by 15, and the equilibrium quantity of rental units in each location satisfies $H_t^{R,l} = \int_{\mathrm{x}} h_t(x)\mathbb{1}[d_t^l(x) = 0]N_t(x)$.

6. The equilibrium house price p_t^l clears the owning housing market: $(1 - \delta_h^l)H_{t+1}^l + I_t^l - H_t^{R,l} = \int_{\mathrm{x}} h_t(x)\mathbb{1}[d_t^l(x) = 1]N_t(x)$.

7. The government budget constraint holds and the expenditures G_t are determined residually as $G_t + \int_{x(q>20)} y(x)N(x) = \int_x \mathcal{T}(y(x))\, N(x) + \sum_{l=1}^L \left\{\tau_l p_t^l[H_{t-1}^l - H_{t-1}^{R,l}] + [p_{h,t}^l I_{h,t} - w_t^l N_{h,t}^l]\right\}$, where expenditures and pension payments are financed by income taxes, property taxes and revenues from selling new licenses to developers.

8. The aggregate state evolves according to rational expectations.

C Solution Algorithm in Detail

The household value and policy functions are solved via backward induction starting with the final period of life. We set a discrete grid space for wealth and housing. The discrete grid for wealth is uneven with higher concentration near the borrowing limit. Following Kaplan, Mitman and Violante (2020), we consider two grids space for wealth. A crosser grid over which we solved for the value and policy functions and a finer grid (by a factor of three) under which we define homeowners and renters distributions. To update such distributions we interpolate the value functions and associated policy functions. Conditional on moving and housing consumption decisions, we eliminate consumption via the budget constraint and back up liquid assets through the next period wealth equation defined in renters and homeowners problem. We verify ex-post that the upper bound of the wealth grid is not binding. We discretize the AR(1) process for the idiosyncratic component of income endowments using Rouwenhorst's method (Rouwenhorst, 1995). Taking the city-specific unemployment rate directly from the data, we build the city-specific first-order Markov chain. The distribution of new-born (age one in the model) across space is read from the data by matching the distribution of individuals with age between 22 and 25 years old across locations. They start their lives as renters and their distribution over assets is read directly from the SFS 2016 that it is assumed to be the same across locations but taking into consideration the correlation with income.

C.1 Stationary Equilibrium

To compute the stationary equilibrium, we follow the following steps.

Step 1. We start by guessing a vector of wages across locations, $\mathbf{w}^0$, homeowner and renters distributions, N^H and N^H, respectively, over locations, assets, age and income shock. Given these guesses, we obtain the median income by city. We then back up the house price vector across space $\mathbf{p}^0$ that matches the house price index to median income ratio obtained directly from the data. Using equation 15, we obtain the rental price vector across space $\mathbf{R}^0$.

Step 2. Given price vectors we solve for value functions and policy functions using backward induction. For each asset grid point, we obtain the value function for the last age group (Q) in closed-form defined by the bequest function (3). Using standard grid-search methods, we solve for the wealth, housing and tenure choice policy functions for the age groups $q < Q$ taking as given the value functions across locations for the age $q + 1$ group. For age $q < Q$, we compute expectation income shocks, mortality and location preference shocks as defined in equation (10). Given the value functions, the migration probabilities can be constructed using equation (11).

Step 3. Given the distribution of age one group, we solve forward from age one to age Q to obtain the updated distributions of homeowners and renters across space and individual state. The distributions are computed following the transition of endogenous states given by housing, savings, homeownership status and location policy functions and exogenous states, age and income and mortality shocks. Transition of endogenous states are computed by interpolating value functions to determine the optimal discrete choice, and then interpolate the associated moving probabilities and policy functions.

Step 4. Given the updated distributions N^H and N^H, we update wages, $\mathbf{w}^1$, using labor market clearing condition taking into account the exogenous local unemployment rate. House prices and rental rates are updated as defined in step 1.

Step 5. We repeat steps 2–4 until wages in all the locations converge. Given the equilibrium house price vector, we solve for housing demand in each location that by definition equates to housing supply. By inverting equation 14, we back up the local housing permits consistent with the stationary equilibrium.

C.2 Transition Path

We now present the procedure to compute transitional paths for unanticipated shocks. We assume that the shock is not anticipated in the stationary equilibrium but once it occurs, the full shock path is known by all forward-looking agents. We assume rational expectations.

To compute the transitional path after a given shock, we apply the procedure above to compute the pre-shock stationary equilibrium ($t = 0$) and the new stationary equilibrium consistent with the shock. In the new stationary equilibrium, we don't impose that house prices to median income matches the data. Instead we guess a house price vector and update such guess using local housing market clear conditions taking as given the housing-permits backed up from the pre-shock stationary equilibrium.

The economy starts with the population distribution in the pre-shock stationary equilibrium, and the shock occurs in period 1. We assume that the economy reaches the new stationary equilibrium before period T.

Step 1. We guess wage and house prices paths, $\{\mathbf{w}_t^0\}_{t=1}^T$ and $\{\mathbf{p}_t^0\}_{t=1}^T$, respectively. At period 0 and period T, wages and house prices are equal to those in the pre- and post-shock stationary equilibra, respectively. We use equation (15) to obtain the path of rental prices.

Step 2. Given guessed paths of wages, house prices and rents, we solve backward the value functions and policy functions along the path starting in period $T-1$ since in period T, value functions and policy functions are known, given by those in the new stationary equilibrium. Migration probabilities are constructed using equation (11).

Step 3. Given the population distribution in the pre-shock stationary equilibrium, we can compute the population distribution by iterating forward from $t = 0$ to $t = T$ following the procedure defined in point 3 of section C.1 .

Step 4. Given the path of of population distribution, we update wage and house prices path guesses, $\{\mathbf{w}_t^1\}_{t=1}^T$ and $\{\mathbf{p}_t^1\}_{t=1}^T$, using the labor market and housing markets clear conditions.

Step 5. We repeat procedures 2–4 until converge in wages and houses prices is obtained in all locations.

Step 6. We check whether wages and prices in period T reach the corresponding levels in the after-shock stationary equilibrium. If not, we increase T.

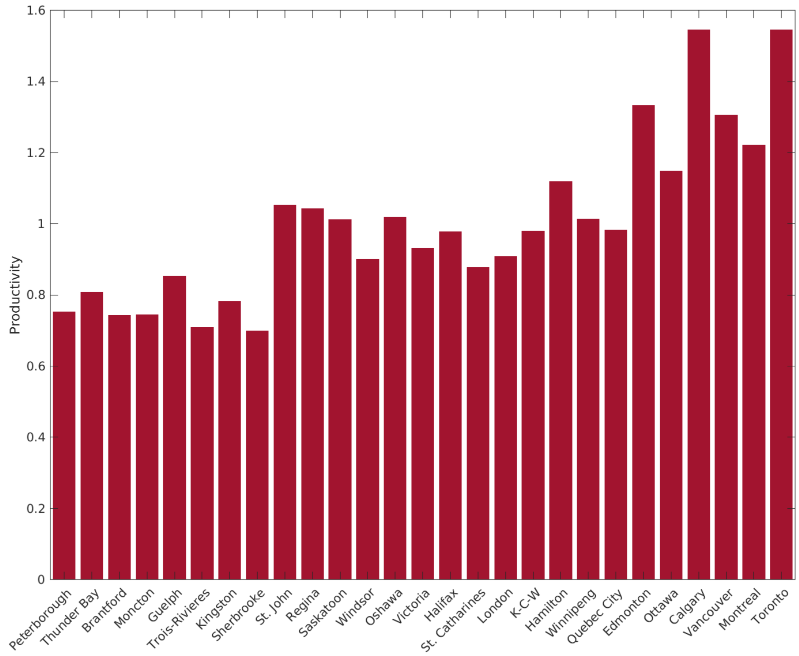
D Additional on Bringing Model to the Data

Table D.1: Parameter Values

Parameter	Interpretation	Internal	Value
Space			
L	Number of Locations	N	27
Demographics			
$\bar{Q}$, Q	Length of Life, Working Years	N	60, 35
λ_q	Survival probability	N	StatCan
Preferences			
α	Housing consumption share	N	0.15
β	Discount factor	Y	0.988
σ	Risk aversion	N	2
ω	Additional utility from owning	Y	1.72
e_q	Equivalence scale	N	Auclert et al. (2021)
$\bar{\varphi}$,$\underline{a}$	Bequest	N	900, 19
A	Amenities	E	Figure D.2
Endowments			
ρ_ϵ	Autocorrelation of earnings	N	0.91
σ_ϵ	S.D. of earnings shocks	N	0.2
χ_q	Life-cycle profile	N	SFS 2016
Migration			
υ	Income Dependence	Y	0.4
ν	Scale of Type 1 E.V. shocks	Y	0.9
τ_0, τ_1	Utility moving costs	Y	6.27; 0.008
F_m	Monetary moving cost	Y	0.26
Technology			
η	Labor Elasticity	N	0.75
ζ	Agglomeration Elasticity	Y	0.13
z^l	Local productivity	E	Figure D.1
Housing			
κ^l	Local housing supply elasticities	E	Figure D.4
F	Housing transaction Costs	N	0.07
Financial Instruments			
r	Interest rate	N	0.015
ι	Borrowing wedge	N	0.01
$\underline{b}$	Unsecured borrowing limit	Y	-1.2
ξ	Collateral constraint	N	0.8
τ_0, τ_1	Income tax	N	0.92, 0.87

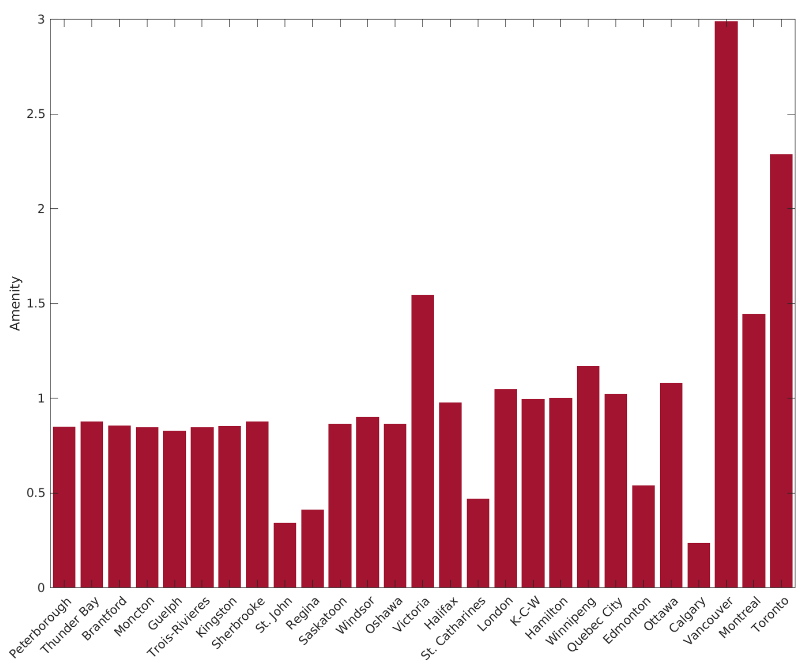
Note: Table D.1 reports the parameters' values used in the model parameterization. The third column, *Internal*, states whether the parameter was internally calibrated (Y) externally obtained (N) either by exogenous estimation or by taking directly from the literature. The model is calibrated at a bi-year frequency but all the parameters shown in this table are annualized. A unit of the final good in the model corresponds to CAD 67,700 (2016 Canadian median annual household income from Statistics Canada (StatCan)).

Figure D.1: TFP by City



Note: Figure D.1 reports the estimates of city-level TFP obtained by inverting the wage equation in equation (12). Cities in this figure are ordered increasingly by size. *Data Source:* Statistics Canada.

Figure D.2: Amenity Index by City



Note: Figure D.2 reports the estimate of the amenity index by city with the methodology explained in section 4. Cities in this figure are ordered increasingly by size.

D.1 Housing Supply Elasticities Estimation

We estimate the first the housing supply elasticities for the largest cities in Canada (census agglomerations, CA[1]) following the approach developed by Guren et al. (2021). This note presents these estimates and the procedure used. This novel approach exploits that house prices in some cities are systematically more sensitive to regional cycles than in other cities. This approach differs from the one used by Saiz (2010*a*) in estimating housing supply elasticities for most metropolitan areas in the United States. He does this by exploiting city-specific building regulations and land unavailability, specifically the land within a 50-kilometer radius of the city center unsuitable for construction due to geographic constraints such as steep slopes or bodies of water. His estimates are widely used in the economic literature in model calibrations and as an instrument for the change in house prices during the boom and bust cycle of the 2000s.

The approach developed by Guren et al. (2021) has two main advantages over the one of Saiz (2010*a*). First, the Saiz measure correlates with other city characteristics such as productivity and growth in demand (Davidoff, 2016). This raises the concern that higher house price volatility in some cities is not driven by inelastic housing supply, as estimated by Saiz, but by differences in other characteristics such as different industrial composition and different exposure to secular trends, for example, an increase in housing demand in coastal areas with inelastic supply. To address this shortcoming, Guren et al. (2021) employs a panel specification that allows them to control for city-specific trends, different sensitivity to regional business cycles, and changes in the city's population and industry structure. Second, by exploiting the systematic historical sensitivity of local house prices to regional house price cycles, this new approach allows us to estimate housing supply elasticities without resorting to geographical and regulation data across Canadian cities, data that are not currently available for most cities in Canada.

Guren et al. (2021) estimate housing supply elasticities by exploiting systematic differences in cities' responses to regional house price cycles. Sinai (2012) documents that house prices in some US cities are systematically more sensitive to regional cycles than those in other cities, which is also true for Canada. Let's consider Vancouver and Winnipeg. Figure D.4 plots the annual log change of real house prices in the West,[2] Vancouver and Winnipeg from 1992 to 2020. The West region experienced several regional boom-bust cycles throughout the sample

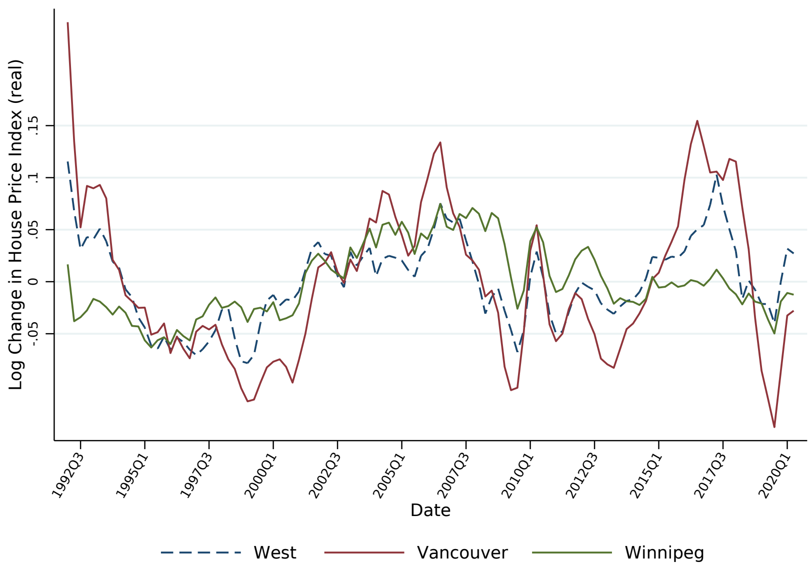
[1] https://www150.statcan.gc.ca/n1/pub/92-195-x/2011001/geo/cma-rmr/cma-rmr-eng.htm

[2] The West region includes all provinces west of Ontario.

period. Vancouver and Winnipeg also experienced several cycles that tended to correlate with the regional ones. However, house prices in Vancouver tended to increase more than those in Winnipeg when regional house prices were booming. They also decreased by more when regional prices were contracting.

This systematic difference in the sensitivity of house prices in different cities to the regional house price cycles is crucial for the identification strategy described in the next section.

Figure D.3: House prices in Vancouver, Winnipeg and the West region



Note: All time series correspond to the annual log change in the House Price Index. All series are demeaned relative to the city or region average. The West region includes all provinces west of Ontario. Source: Teranet

D.1.1 Empirical strategy

A simple approach to estimating the sensitivity of house prices in different cities to regional house price movements, γ_i, consists of running the regression:

$$\Delta p_{i,r,t} = \phi_i + \chi_{r,t} + \gamma_i \Delta P_{r,t} + \epsilon_{i,r,t} \tag{D.1}$$

where $\Delta p_{i,r,t}$ denotes the log annual change of real house prices of city i in region r, and $\Delta P_{r,t}$ stands for the log annual change in regional house prices.[3] This specification includes city fixed effects, ϕ_i, to control for unobserved city heterogeneity, and region-time fixed effects, $\chi_{r,t}$, to control for trends at the regional level. Cities with higher $\hat{\gamma}_i$, the estimate of γ_i, are

[3]Throughout this note, I follow the same notation simplification as in Guren et al. (2021), where $\gamma_i \Delta P_{r,t}$ is used to denote $\sum_i \gamma_i \Delta P_{i,r,t} I_i$, where I_i is an indicator for city i.

cities that systematically respond to regional shocks with higher fluctuations in higher prices and, therefore, cities with more inelastic housing supply. Therefore, $\hat{\gamma}_i$ denotes the proxy for the inverse of the housing supply elasticity.

This simple approach, however, assumes that local house prices respond differently to regional house price shocks only because of differences in the housing supply elasticity. This assumption seems too restrictive because differences in the structure of the local economy may cause different responses. Applying the example in Guren et al. (2021) to the Canadian context, we suppose that Vancouver has an industrial structure tilted toward highly cyclical durable goods relative to that of Winnipeg. A positive aggregate demand shock would consequently lead to higher increases in employment and house prices in Vancouver than in Winnipeg. Therefore, γ_i would be estimated to be higher in Vancouver than in Winnipeg purely due to reverse causality. Then, variation in $\hat{\gamma}_i$ would reflect not only differences in housing supply elasticities across cities but also potentially other confounding factors.

To address these concerns, we apply a refined version of equation D.1 similar to the one proposed by Guren et al. (2021):

$$\Delta p_{i,r,t} = \phi_i + \gamma_i \Delta P_{i,r,t} + \delta_i \Delta y_{i,r,t} + \mu_i \Delta Y_{r,t} + \Gamma X_{i,r,t} + \epsilon_{i,r,t} \tag{D.2}$$

This version augments equation D.1 with local and regional changes in per capita retail, construction and manufacturing employment with city-specific coefficients. The vectors with these changes in employment at the city and regional levels are $\Delta y_{i,r,t}$ and $\Delta Y_{r,t}$, respectively. This specification controls for the different impact across cities of different demand shocks reflected in these industries.[4] It also includes another set of controls, $X_{i,r,t}$, specifically two-digit industry code shares multiplied by time dummies. This structure allows for non-parametrically controlling for all variation that is correlated with industry structure in the cross-section. I also depart from Guren et al. (2021) by controlling for population growth at the city and regional levels and for real mortgage rates.

Overall, this refined approach implies that $\hat{\gamma}_i$ is estimated using local house price variation that is independent of local and regional changes in employment and all other controls included in $X_{i,r,t}$. It is therefore not subject to the bias resulting from the reverse causality explained

[4] Guren et al. (2021) control for local and regional changes in retail employment only. The correlation between the baseline estimates and the γ_i estimates using this less strict specification is 97 percent. If instead of controlling for changes in employment per capita in these three industries separately, I control only for aggregate changes in per capita employment, the correlation drops to 95 percent. More importantly, if I don't control for any changes in the employment growth across different industries at the city level, the correlation drops to 23 percent, which reflects the importance of controlling for changes in industry composition.

before. The key identifying assumption is that, conditional on controls, there are no other aggregate factors sensitive to house prices as captured by γ_i that are correlated with regional house prices in the time series and that differentially impact employment per capita in the same city. However, this approach does not require exogenous variation in regional house prices. Common factors can drive regional house prices, regional economic activity and even local prices and activity.

D.1.2 Data

We estimate the elasticities using the House Price Index developed by Teranet at the forward sortation area (FSA) level. City and regional house prices are built by aggregating them using the 2011 FSA populations as weights.[5] House prices are converted into a real index by using the gross domestic product (GDP) deflator from Statistics Canada. Following the methodology in Guren et al. (2021), we consider quarterly house prices and calculate annual changes of the log of the House Price Index in real terms. Annual two-digit industry employment codes and population at the CA level are obtained from Statistics Canada. Real monthly mortgage rates are from the Bank of Canada.

Guren et al. (2021) consider four regions when estimating the elasticities for US cities. Given the significant differences in size between Canada and the United States, we consider three regions in Canada: east, west and northern territories.

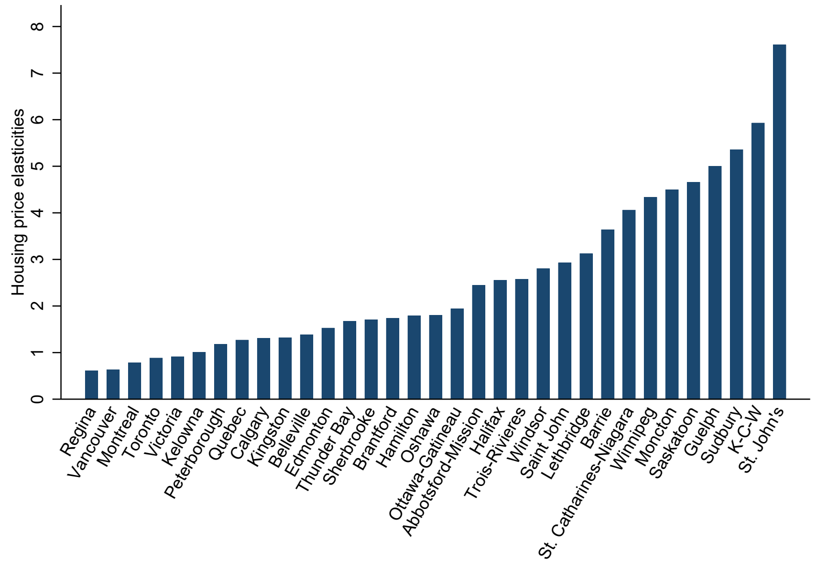
D.1.3 Results

Figure D.4 plots the estimated housing supply elasticities for Canadian census metropolitan areas (CMAs), specifically, the inverse of $\hat{\gamma}_i$ estimated from equation (D.2).[6] The median housing supply elasticity is 2.2 among all CAs and 1.94 if I restrict the sample to CMAs. These estimates imply that a 1 percent increase in house prices in the median Canadian city is associated with an increase in housing supply of 2.2 percent. Alternatively, we can think that, all else equal, a 1 percent increase in housing demand leads to an increase in house prices in the median city of 0.45 percent (1/2.2).

[5] Very similar results are obtained if total dwellings or total occupied dwellings are used as weights.

[6] The procedure estimates housing supply elasticities for 151 CAs, but for clarity the Figure is restricted to the CMAs. For better visualization, London and Saguenay are also excluded from the figure. The elasticities for these two CMAs are 19.6 and 21.6, respectively.

Figure D.4: Housing supply elasticities for Canadian census metropolitan areas



Note: Figure D.4 plots the estimated housing supply elasticity, $1/\hat{\gamma}_i$, estimated from equation (D.2). London and Saguenay are excluded for vizualization purposes. The elasticities for these two CMAs are 19.6 and 21.6, respectively. K-C-W stands for Kitchener-Cambridge-Waterloo.

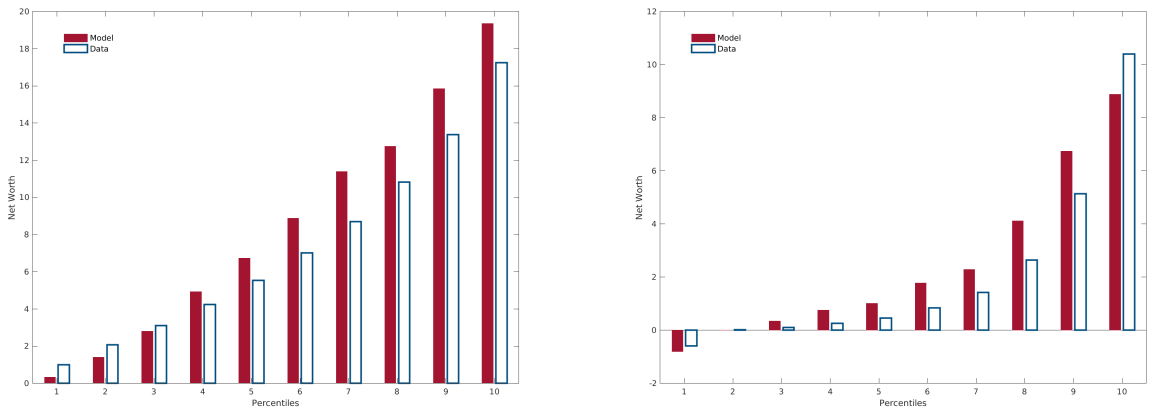
Figure D.4 also shows significant heterogeneity across cities. Going back to the previous example, elasticities in Vancouver and Winnipeg are 0.63 and 4.34, respectively. Assuming that both cities face a 1 percent increase in housing demand, house prices are predicted to increase 1.57 percent in Vancouver and 0.23 percent in Winnipeg. For comparison, the median housing supply elasticity among US metropolitan areas estimated in Saiz (2010*a*) is 2.26, very close to the median elasticity in Canada. Saiz also estimates elasticities of 0.63 and 0.72 in New York and San Francisco, respectively. These values compare closely with Vancouver and Toronto, where estimated elasticities in this note are 0.64 and 0.89, respectively. However, the distribution of elasticities in Canada is more skewed to the right than it is in the United States. A larger share of cities in Canada have very elastic housing supplies.

E Additional on Model Matching Data

Figure E.1: Wealth Distribution by Homeownership Status

Panel A: Homeowners

Panel B: Renters

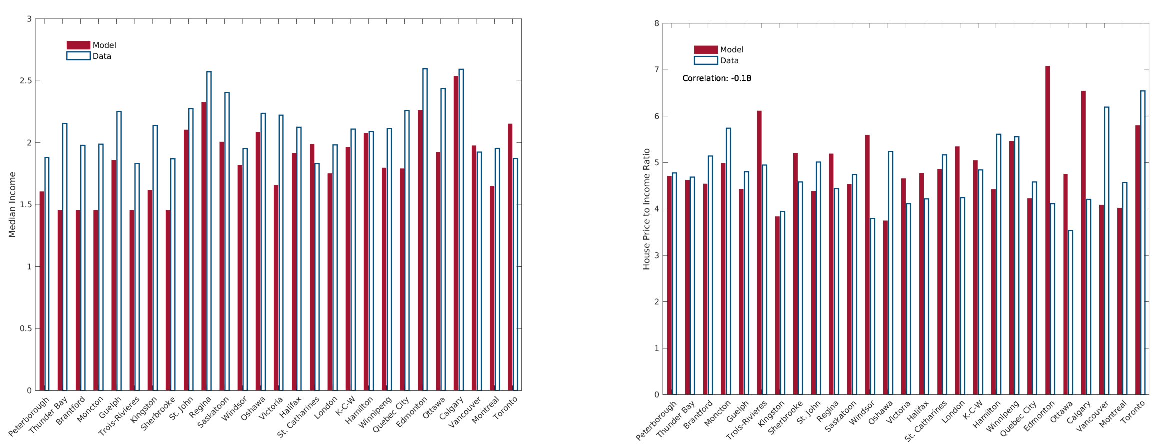


Note: Figure E.1 plots the wealth to income ratio and the house value to income ratio by CMA both in the data and in the model for homeowners (Panel A) and renters (Panel B). *Data Source:* Statistics Canada.

Figure E.2: Model vs Data: Median Income and House Prices across cities

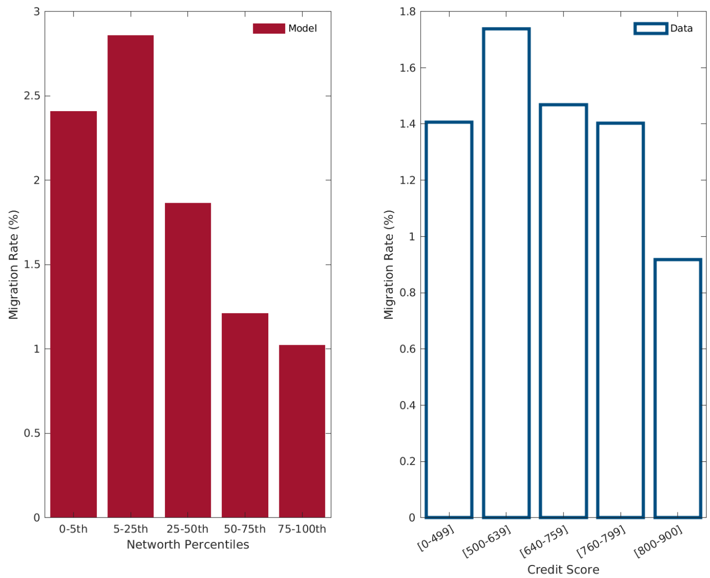
Panel A: Median Income

Panel B: House Prices/Average Income



Note: Figure E.2 plots the median income (Panel A) and house prices over average income (Panel B) by CMA both in the data and in the model. In both panels cities are ordered increasingly by size. *Data Source:* Statistics Canada.

Figure E.3: Migration by Wealth Quintiles



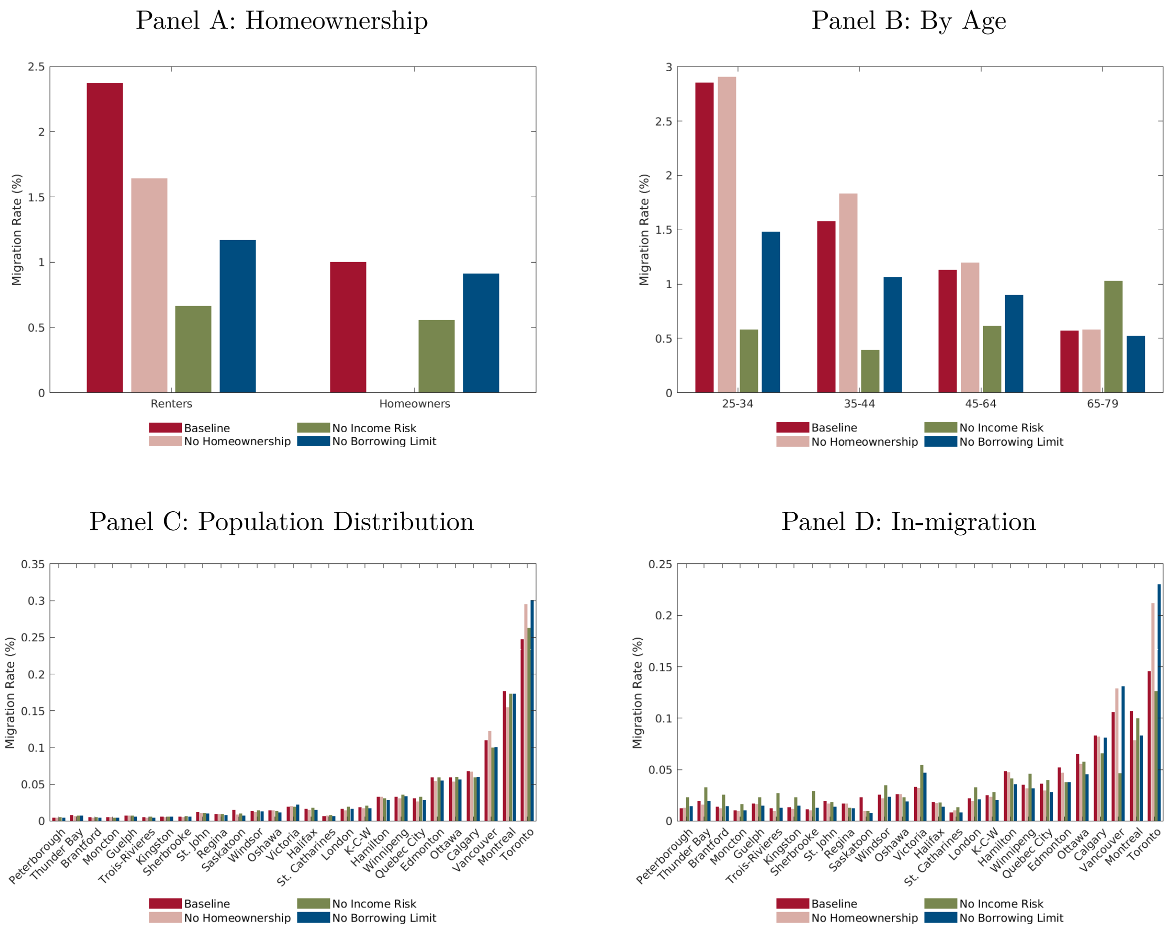
Note: Figure E.3 plots the annual migration rates from the model (red bars) and from the data (hollow blue bars) by wealth quintiles on the left (model outcomes) and by credit score on the right (data outcomes). *Data source:* TransUnion.

Table E.1: Correlations between City's Characteristics

	House prices	Wages	Av Income	Pop	TFP	Amenities
Model						
House Prices	1	0.68	0.68	0.37	0.59	0.16
Wages	0.68	1	0.97	0.22	0.79	-0.24
Av Income	0.68	0.97	1	0.1	0.69	-0.34
Population	0.37	0.22	0.1	1	0.71	0.66
TFP	0.59	0.79	0.69	0.71	1	0.25
Amenities	0.16	-0.24	-0.34	0.66	0.25	1
Data						
House Prices	1	0.64	0.46	0.55	0.61	0.42
Wages	0.64	1	0.91	0.34	0.75	-0.02
Av Income	0.46	0.91	1	0.19	0.62	-0.1
Population	0.55	0.34	0.19	1	0.7	0.67
TFP	0.61	0.75	0.62	0.7	1	0.25
Amenities	0.42	-0.02	-0.1	0.67	0.25	1

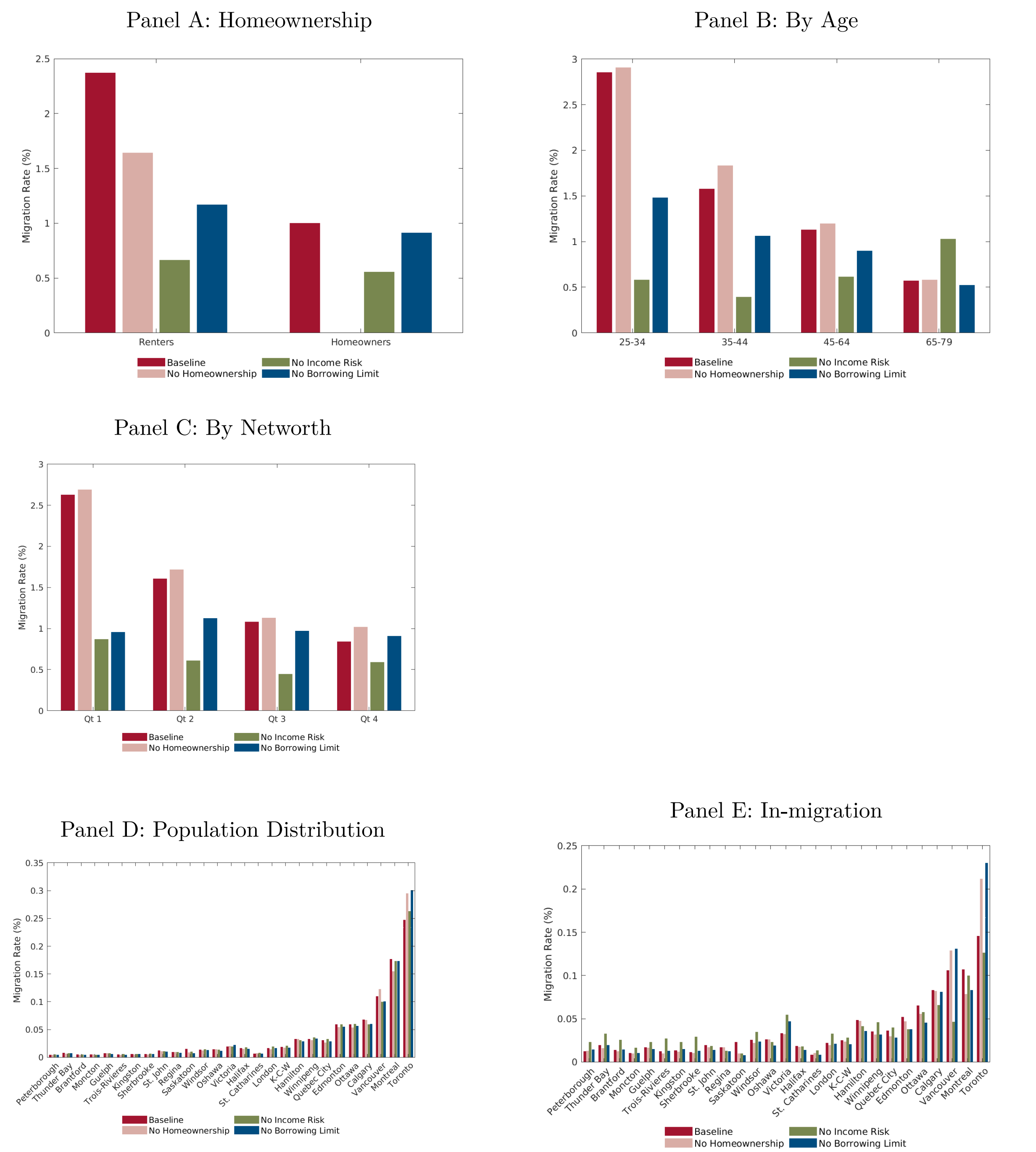
Note: Table E.1 reports the correlation between different characteristics of the cities in the model (first panel) and in the data (second panel). *Data source:* TransUnion, Statistics Canada and TERANET.

Figure E.4: Migration rates by Homeownership and Age; Population Distribution and In-Migration



Note: Figure E.4 reports the migration rates by homeownership (Panel A) and age (Panel B) for several model specifications. In panel C, we report the population distribution and in panel D the in-migration share. Each bar corresponds to alternative model specifications: baseline economy (red bar), economy with no homeownership (light red bar), economy with no income risk (green bar) and economy with no borrowing limit (blue bar).

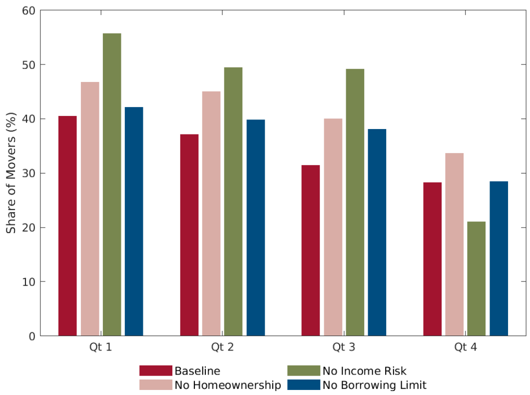
Figure E.5: Migration rates by Homeownership and Age; Population Distribution and In-Migration (Matched Aggregate Migration Rate)



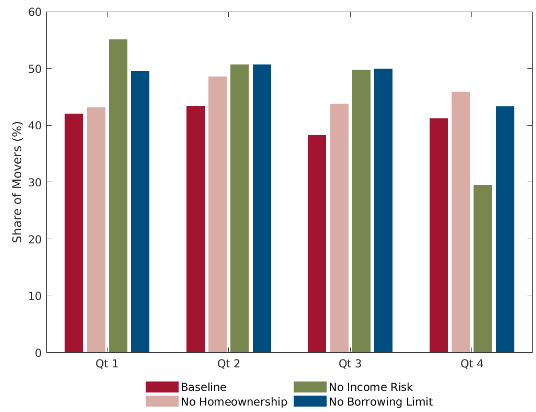
Note: Figure E.5 reports the migration rates by homeownership (Panel A), age (Panel B) and wealth quartiles (Panel C). In panel D, we report the population distribution and in panel C the in-migration share. Each bar corresponds to alternative model specifications: baseline economy (red bar), economy with no homeownership (light red bar), economy with no income risk (green bar) and economy with no borrowing limit (blue bar). For each model specification, utility migration costs are re-paramaterized to match the average migration rate and the correlation between out-migration and city distance observed in the data.

Figure E.6: Share of movers that “Upgrade ¨by Networth

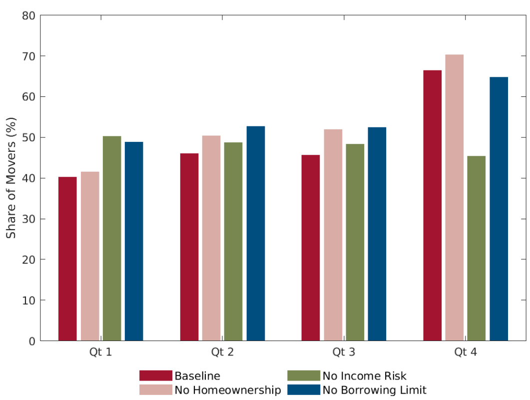
Panel A: Median Income



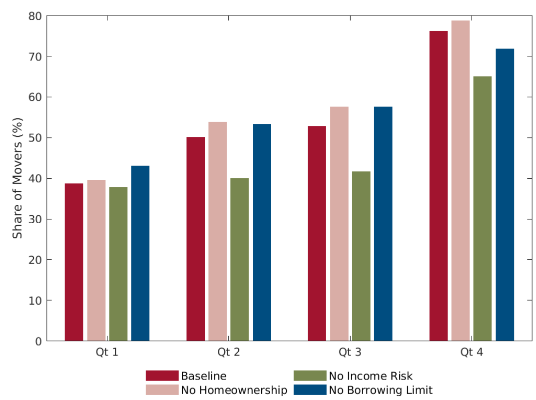
Panel B: Productivity



Panel C: Population

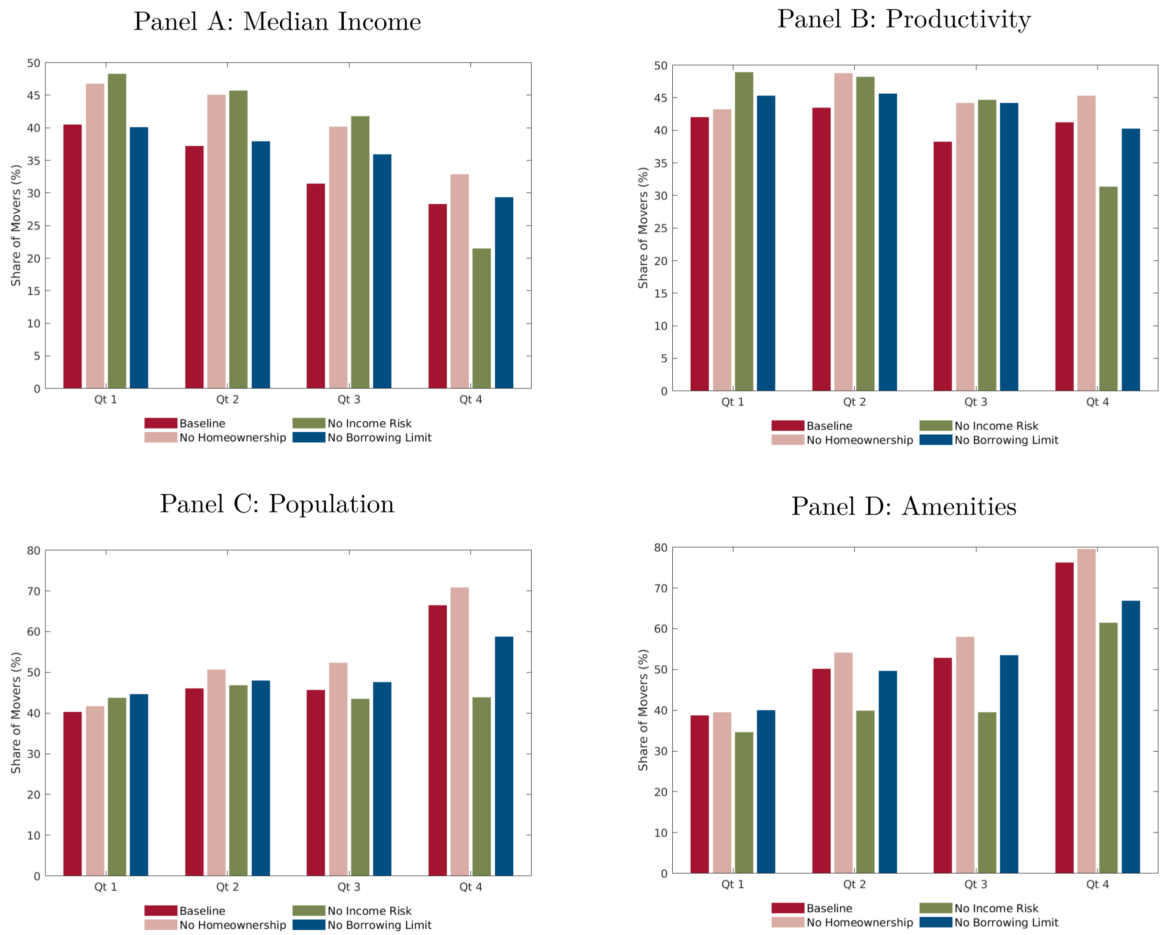


Panel D: Amenities



Note: Figure E.6 reports the share of individuals that move to locations with higher median income (Panel A), productivity (Panel B), population (Panel C) and amenities (Panel D) than the original location. Each bar corresponds to alternative model specifications: baseline economy (red bar), economy with no homeownership (light red bar), economy with no income risk (green bar) and economy with no borrowing limit (blue bar).

Figure E.7: Share of movers that "Upgrade" by Wealth - Adjusting Migration Costs



Note: Figure E.7 reports the share of individuals that move to locations with higher median income (Panel A), productivity (Panel B), population (Panel C) and amenities (Panel D) than the original location. Each bar corresponds to alternative model specifications: baseline economy (red bar), economy with no homeownership (light red bar), economy with no income risk (green bar) and economy with no borrowing limit (blue bar). For each model specification, utility migration costs are re-paramaterized to match the average migration rate and the correlation between out-migration and city distance observed in the data.

F Derivation of Moving Costs

In this section, we show how we convert utility moving costs into monetary units. Given the flow utility depends on non-durable consumption and housing services, we re-write households life-time utility in terms of an "adjusted-consumption" measure, $\omega_{i,t}$, that delivers the same flow-utility (net of amenities) a household would obtain under the stationary equilibrium allocations. For an individual i with housing status d in location l at time t that optimally chooses c_{it} and s_{it} in the stationary equilibrium, the "adjusted-consumption" measure, $\omega_{i,t}$, is given by:

$$u^d(c_{it}, s_{it}, A^l) = \tilde{u}(\omega_{i,t}) + A^l = \frac{\omega_{i,t}^{1-\sigma}}{1-\sigma} + A^l$$

The re-write value functions in terms of $\omega_{i,t}$ given by:

$$V_{i,t}^{d,l} = \tilde{u}(\omega_{i,t}) + A^l + (1-\lambda_i)\varphi(a'_{i,t}) + \lambda_i \nu \log\left(\sum_{k=1}^{L} \exp\left(\beta \mathbb{E}_t V_{i,t+1}^k - \beta \tau^{l,k}\right)^{\frac{1}{\nu}}\right)$$

deliver the same life-time utility for household i in location l with housing status d than the value functions defined in equations (8) and (9).

We now present our procedure to convert the estimated utility moving costs into a dollar equivalent. Contrary to Kennan and Walker (2011), the utility function is not linear, so the conversion is not direct. Instead, we solve for δ_i, the change in "adjusted-consumption" measure $\omega_{i,t}$ required to achieve the same individual location choices and allocations, and respectively life-time utility, in the absence of moving costs. A household that survives and moves from location l to location j must be indifferent between paying utility cost $\tau^{l,k}$ or facing a cut in "adjusted-consumption" of $\delta_i^{l,k}$:

$$\tilde{u}(\omega_{i,t}) + \mathbb{E}_t V_{i,t+1}^k - \tau^{l,k} + A^l + \nu \tilde{\epsilon}_{t+1}^{i,k} = \tilde{u}(\omega_{i,t} - \delta_i^{l,k}) + A^l + \mathbb{E}_t V_{i,t+1}^k + \nu \tilde{\epsilon}_{t+1}^{i,k}$$

which can be re-written in the stationary equilibrium as

$$\delta_i^{l,k} \frac{\tilde{u}(\omega_i) - \tilde{u}(\omega_i - \delta_i^{l,k})}{\delta_i^{l,k}} = \tau^{l,k}$$

The left-hand side can be approximated by marginal utility evaluated at the "adjusted-consumption" measure ω_i consistent with the stationary equilibrium. Therefore, the utility moving costs evaluated at consumption-equivalent units, $\delta_i^{l,k}$ is given by

$$\delta_i^{l,k} = \frac{\tau^{l,k}}{\tilde{u}'(\omega_i)}$$

As in Kennan and Walker (2011), we compute the moving costs for the average mover, $\bar{\tau}$, given by:

$$\bar{\tau} = \frac{\sum_{k \neq l}^{L} \tilde{\mu}^{l,k} \tau^{l,k}}{\tilde{u}'(\bar{\omega})} + F \tag{F.1}$$

where $\tilde{u}'(\bar{\omega})$ is the marginal utility of the average mover in the stationary equilibrium, $\tau^{l,k}$ the utility moving costs from l to k, F the monetary moving cost and $\tilde{\mu}_i^{l,k} = \frac{\mu_i^{l,k}}{\sum_{i \neq k}^{L} \mu_i^{l,k}}$ is the probability of moving from l to k, conditional on moving, for the average mover with $\mu_i^{l,k}$ is defined in equation (11).

Table F.1: Decomposition of Migration Costs

	Baseline	No House	No Income Risk	No Borrow Const
τ_0	6.2	6.32	5.05	5.65
τ_1	0.01	0.01	0.01	0.01
F_m	0.26	0.26	0.26	0.26
CAD 2016				
Moving Costs	196,303	217,513	124,187	182,796
Moving Costs - Males	234,086	259,378	148,089	217,979
USD 2010				
Moving Costs	164,259	182,006	103,915	152,957
Moving Costs - Males	196,460	217,686	124,286	182,942

Note: Table 3 reports the values of migration costs in monetary terms for the baseline economy, for an economy without homeowners (*No House*), without income risk (*No Income Risk*) and no borrowing constraints (*No Borrow Const*) The top part of the table reports the corresponding value of the migration costs, τ_0, τ_1 and F_m. The second part of the table reports the values of migration costs in monetary terms. "CAD 2016" is Canadian dollars in 2016 units. "USD 2010" is US dollars in 2010 units.

G Derivation of Welfare Measure

In this section, we show how we obtain the welfare measured defined in equation (17). We follow the standard approach that measures welfare in terms of consumption units. We start by converting the life-time utility into more interpretable units by calculating the constant consumption ω_i a household would need to receive every period in order to achieve the life-time utility attained under the stationary equilibrium allocations. Let's denote by $V_i^{d,l}$ the life-time utility of household i in location l with housing status d that solves renters and homeowners problems defined in equations (8) and (9), respectively. The constant consumption ω_i is the solution to

$$V_i^{d,l} = \sum_{t=q}^{Q} \beta^t \tilde{u}(\omega_i) = \sum_{t=q}^{Q} \beta^t \frac{\omega_i^{1-\sigma}}{1-\sigma} \tag{G.1}$$

where the sum is defined over the remaining life years of a household currently q years of age.

As pointed out in Boar and Midrigan (2022), ω_i corresponds also to a measure of welfare adjusted for risk and intertemporal substitution that allows for interpersonal comparisons.

We aim at computing the welfare change associated with policy changed. Let's denote agent i's value function under benchmark policy θ_b as $V_i(\theta_b)$ and $V_i(\theta_c)$ the value function under an alternative policy θ_c.

We consider a social planner that cares equally about everyone, so the total welfare of a fixed group of households, the set g_t with cardinality G, as

$$W = \sum_{i \in g_t} \omega_i$$

where ω_i is the solution to equation G.1 that can be expressed as:

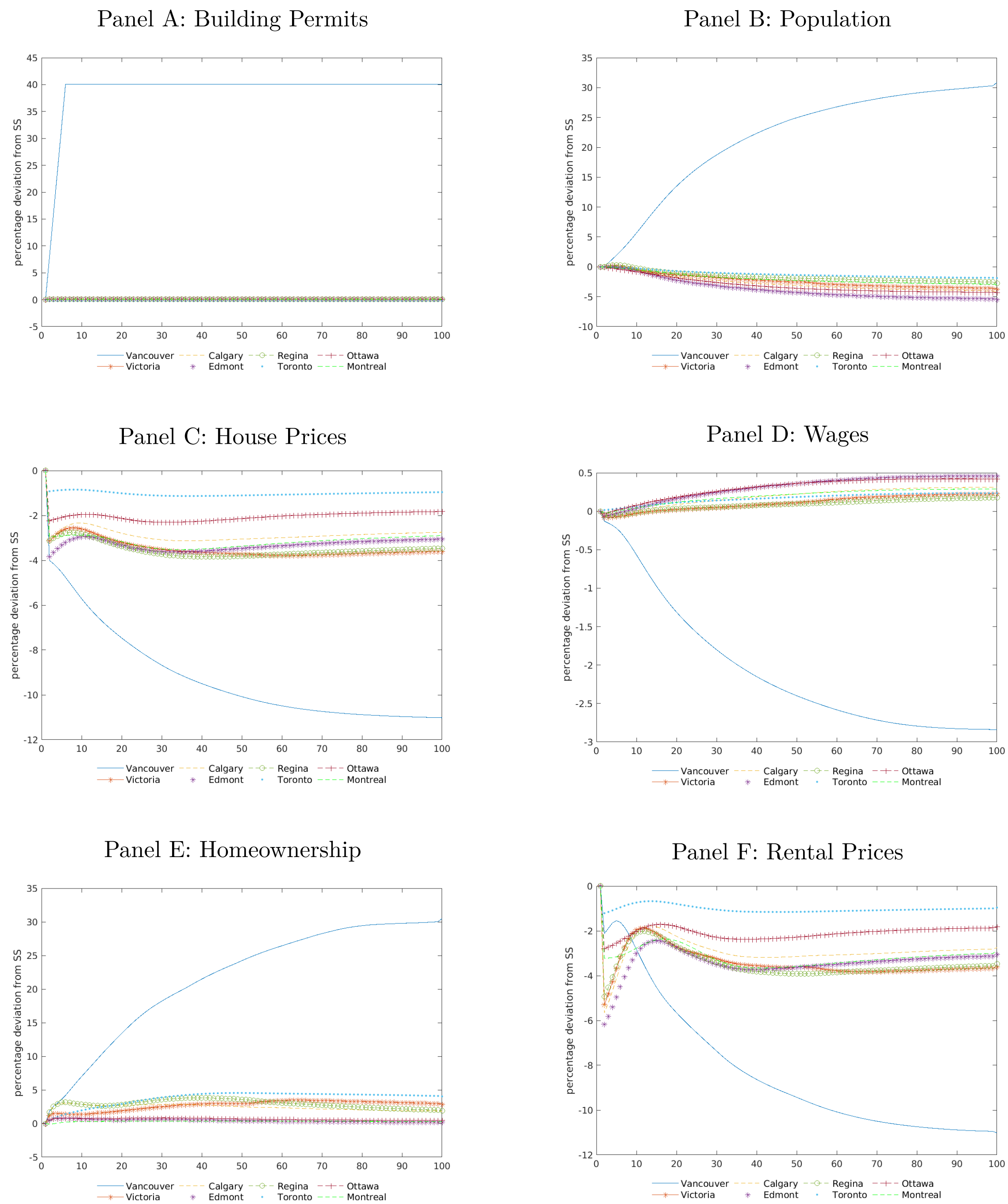
$$\omega_i \propto V_i^{\frac{1}{1-\sigma}}$$

Then, the welfare change can be written as:

$$\Delta W = \frac{\sum_{i \in g_t} \omega_i(\theta_c)}{\sum_{i \in g_t} \omega_i(\theta_b)} - 1 = \frac{\sum_{i \in g_t} V_i(\theta_c)^{\frac{1}{1-\sigma}}}{\sum_{i \in g_t} V_i(\theta_b)^{\frac{1}{1-\sigma}}} - 1$$

H Additional on Policy Counterfactual Analysis

Figure H.1: Transition Dynamics of Decrease in Zoning Regulations



Note: Figure H.1 reports the evolution across main cities, including Vancouver, of building permits (Panel A), population (Panel B), house prices (Panel C), wages (Panel D), homeownership rate (Panel E) and rental prices (Panel F).