# UNPACKING MOVING*


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**Abstract**

We develop a dynamic spatial equilibrium model to capture the role of wealth in moving decisions. The model's features are motivated by novel evidence on heterogeneous mobility patterns by ability to borrow. Less able to borrow tend to move more but are less likely to move to "opportunity". We show that by introducing consumption-saving decisions, the model is able to generate heterogeneous migration patterns consistent with the data without imposing different migration costs across demographic groups. We perform counterfactual analysis: i) we compare sources of mobility restrictions and find that utility vs monetary moving costs shape the migration-wealth relationship in opposite ways; ii) a moving subsidy to unemployed in the Canadian "Rust Belt" increases welfare by 0.4% and most of it comes from poorer individuals; iii) if, in Vancouver, housing regulations, such as zoning, were less stringent, welfare in the long-run would increase by approximately 5% in Vancouver and 0.57% in Canada, overall.



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# 1 Introduction

Location choice is a life-shaping decision as the place of residence determines current and future job opportunities, access to education and health care, among others. Living in a location with poor economic and social conditions not only impacts the current living standards but also affects family prospects. Therefore, understanding individuals' location choices and the main mobility barriers is a crucial question, specially given that only some individuals move to "opportunity" or use migration as a way to buffer income shocks.[1] A large body of empirical and quantitative research has studied different factors that determine household's location decisions. However, how wealth impacts migration has been analyzed at a much lesser extent due to the complexity of the problem and lack of data. This gap in the literature is troubling since migration as a response to income shocks and a way to alleviate inequality and spur growth is paramount for macroeconomists and policy makers.

The main contribution of this paper is to close this gap by developing a theoretical and quantitatively feasible framework to study the interaction between wealth and location decisions guided by novel empirical evidence. Empirically, we find a large degree of heterogeneity in migration propensities by ability to borrow. On the theoretical side, a novel model with common migration costs across households generates as key insight that wealth is crucial to generate heterogenous migration patterns across different demographic characteristics as homeownership and age. Indeed, wealth allows to reconcile the heterogeneity in the data and location-choice models without imposing heterogeneous moving costs. In turn, because of the group-specific endogenous migration elasticities this framework is the ideal ground to study endogenous several publicly debated policies. We study, quantitatively, *housing regulations* and *moving subsidies*, that are welfare improving, foster the move to "opportunity" and reduce inequality.

The paper consists of three parts. First, we exploit a rich individual credit bureau dataset for Canada to give motivational evidence of heterogeneous migration patterns by different demographic groups in terms of how much they move as well as the destination they pick.[2] We study the characteristics of those that move. In particular, to get evidence on we look at home-ownership, age and ability to borrow since these are the factors driving the main migration hypotheses above. We find that homeowners move less than renters, younger individuals move more and those that are less able to borrow move more. On average, higher credit score, younger and renters are more likely to move to locations with higher house prices,

[1] See recent work from Autor et al. (2014) that looks at the migration response of the China shock and Chetty, Hendren and Katz (2016) that looks at evidence on heterogeneous moving to "opportunity".

[2] In the Appendix we study the migration response to an international oil shock that affected heterogeneously different regions of Canada in 2014.

higher wages and higher amenities.[3]

In the second part of the paper, motivated by the findings above, we develop a dynamic life-cycle spatial model with incomplete markets, consumption-saving and housing stock to understand and quantify the disaggregated labor market effects resulting from changes in the local economic environment. The model recognizes the role of labor mobility frictions, geographic factors, amenities, housing demand, heterogeneous housing supply, age and unemployment in shaping the effects of shocks across different labor markets. Hence, our model delivers consumption-saving, housing and labor market dynamics. Our framework allows us to "unpack moving" by decomposing and quantifying how different migration frictions affect the moving decisions in the steady-state and also in response to a negative income shock. Our model is structural in the sense that it generates rich heterogeneity in moving probabilities and moving directions across different groups of individuals without imposing different moving costs. Last but not the least, it allows us to examine the heterogeneous welfare implications of local policies such as housing regulation changes and moving subsidies for targeted locations.

In the third part of the paper, we solve and bring the model to the data by calibrating it using a mix strategy of reduced form estimation and simulated method of moments, similarly to a growing recent macro literature (i.e., Nakamura and Steinsson (2014), Beraja, Hurst and Ospina (2016), Acemoglu and Restrepo (2017) and Jones, Midrigan and Philippon (2011)). Taking a model with all these features to the data might sound unfeasible due to the high-dimensionality of the problem. Our methodological contribution consists in combining solution methods from the quantitative spatial literature and the macro literature on heterogeneous agents. This allows us to develop an algorithm that generates a feasible solution that can be easily modified to account for extra layers of dimensionality. In our setting, the main ingredients and mechanisms present in the model are strongly informed by the empirical evidence on heterogeneous migration behaviour. We estimate the production function using regional variation to obtain a series of city-level productivities and we collect information on local amenities to build an amenity index. The other salient parameters of the model are estimated using simulated method of moments. Overall, they match the data quite satisfactorily.[4] To understand how the model's mechanisms work, we reduce migration

[3]We also exploit an unanticipated drop in international oil prices, following Kilian and Zhou (2018), to study the characteristics of those that responded to such income shock. As a response to the shock, instead, homeowners move less than renters, younger individuals move more and less able to borrow move more. We interpret the latter result as suggestive of the fact that the more credit constrained have harder time buffering the shock locally, so they have to move, incurring the monetary and utility cost of doing so. We then look at the characteristics of the new location chosen by the movers.

[4]To validate the model, we also replicate our oil shock experiment to check whether it reproduces our empirical results and so it does. We complement the empirical findings by looking at the transition path.

frictions' elements such as monetary migration costs and bilateral moving utility losses. We find that reducing utility moving costs by 10% doubles the migration rates in Canada but makes migration less selective reducing the amount of individuals that move to "opportunity". Instead, reducing monetary moving frictions by 50% barely changes migration rates but it has a positive effect on the moving to "opportunity". Finally, we analyze two main policy counterfactuals: (i) what would be the impact of migration voucher for the unemployed in the Canadian "Rust Belt" on the overall mobility patterns and the moving to "opportunity"? We find that in the long-run it would increase welafare in the "Rust Belt" by .4% and most of it would come from the lower end of the netwoth distribution, the younger and the renters; (ii) how would the welfare gains change if *housing regulations* were less stringent in Vancouver? We find evidence that a 50% increase in landing permits for construction in Vancouver would increase welfare gain in the long-run by 5% in higher in Vancouver and 0.57% higher in overall Canada. Most of the welfare gains would accrue to low networth individuals.

**Literature Review** This paper relates to several branches of the quantitative spatial and macro literatures. The most related works are recent papers that develop dynamic quantitative spatial equilibrium models such as Desmet and Rossi-Hansberg (2014), Desmet, Nagy and Rossi-Hansberg (2018), Giannone (2017), Lagakos, Mobarak and Waugh (2018), Lyon and Waugh (2018), Bilal and Rossi-Hansberg (2018) and Caliendo, Dvorkin and Parro (2019) and Eckert and Kleineberg (2019). We complement this class of models by accounting explicitly for life-cycle, location choices by heterogeneous agents with borrowing constraint and housing as durable illiquid asset. Specifically, our model allows us to evaluate how agents with different levels of assets, age and homeownership status sort across different locations and how they respond to individual and local shocks differently. Among other dimensions, we depart from the above by considering a life-cycle component, which is crucial to identify and quantify the role of age in the migration decisions, which we find, both empirical and theoretically, very relevant. This framework sets the ground for a variety of counterfactuals and policy evaluations such as aging population and housing policies. In contemporaneous work, Greany (2019) develops a related model focused on understanding how regional inequality affects the wealth distribution.

This paper also relates to empirical analyses that aim at quantifying migration patterns and responses to negative demand shocks such as Topalova (2010), McCaig (2011), Autor et al. (2014), Dix-Carneiro and Kovak (2017), Kilian and Zhou (2018) and Greenland, Lopresti and McHenry (2019). We highlight two main differences from these papers to ours. First, the fact that besides looking at the response of the shock, using the panel feature of our data, we analyze what are the characteristics associated with those that moves more. Second, thanks to the large size and geographic and longitudinal details of the data, we unpack which locations they decide to go based on house prices, wages, amenities and unemployment rates of the locations.

Overall, we highlight three main departures of our paper from the previous literature. First, most of the existing papers rely on heterogeneous moving costs among different demographic groups in order to obtain migration effects that vary by groups. Our model allows us to have the same monetary and non-monetary moving cost for all groups, but still obtain different moving responses, which is a more realistic feature of the data. This behaviour comes from incorporating the consumption-saving decision. Second, relative to other recent dynamic discrete choice models of labor reallocation, we include a wide range of mechanisms such as housing stock, life-cycle, amenities and sorting by assets, and we endogenously determine local house prices and wages. The resulting framework allows us to study a wider range of policy experiments compared to previous work. This allows us to take the model to data at a highly disaggregated level as we do. Finally, our paper complements reduced-form studies on the effects of the unemployment shocks, at regional or individual level. Besides measuring the differential impact across labor markets, we can also compute employment effects and measure the welfare effects taking into account general equilibrium channels. At the same time, it allows us to make welfare comparisons of policies, often discussed by policymakers, such as moving vouchers or changes in housing regulations, among others.

The rest of the paper is divided in the following sections. Section 2 describes the Canadian *Transunion* data, the rest of the data and the empirical regularities on migration patterns. Section 3 develops the theoretical framework and establishes some theoretical predictions of the model. Section 4 reports the estimation and the calibration strategy. Section 5 reports counterfactual analysis by reducing the moving frictions, giving a moving voucher and decreasing housing regulations. Finally, section 6 concludes.

# 2 Empirical Motivation

In this section, we present motivational evidence of heterogeneous migration patterns along the following dimensions: age, home-ownership and ability to borrow. We start by describing the data used and then we present stylized evidence of heterogeneous migration rates by the demographic groups under consideration. We, then, analyze how locations to which people move to compare to the origin locations. Specifically, we sort cities in several dimensions, as house prices, income, amenities, among others, and identify which demographic groups are more likely to move to different locations based on the cities' characteristics. These empirical regularities show a great degree of heterogeneity across groups both in terms of the decision to migrate and of the chosen destination. Appendix D shows evidence of heterogeneous response by demographic groups to an oil shock that affected the labor demand disproportionally more in certain cities.

## 2.1 Data description

Our main data source is *Transunion* in Canada. *Transunion* is one of the two credit reporting agencies in Canada and collects individual credit history on about 35 million individuals which covers nearly every consumer in the country with a credit report. The data are available from 2009 onwards at monthly frequency. The consumer credit reports include information on borrowers' characteristics such as age, credit scores and Forward Sortation Area (FSA) that corresponds to the first 3 digits of the individual's postal code, which allows us to track individual's change of residence within Canada. It also reports for each month a snapshot of the consumer's balance sheet. Specifically, we observe credit limits, balances, payments, and delinquency status for different credit accounts 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 it has a current mortgage account with a positive outstanding balance or if the mortgage was fully paid and the consumer kept residing in the same FSA.

In order to characterize the place of residence we obtained, from several data sources, statistics on house prices, income and employment, among others. FSA level house price index at a quarterly frequency is obtained from the Teranet-National Bank House Price Index dataset. This house price index is constructed using a repeat-sales method for single-family homes and covers 82% of all Canadian FSAs. From *Statistics Canada*, we obtain city[5] level information on total population, unemployment rate and income. Following the methodology in Diamond (2016), we construct a city level amenity index for Canada. To build this index we complement the income statistics with the mean residential fine particulate matter (PM2.5) exposure, several incident-based crime statistics, government spending on different education levels, sales revenues at retail stores and eat and drinking places.

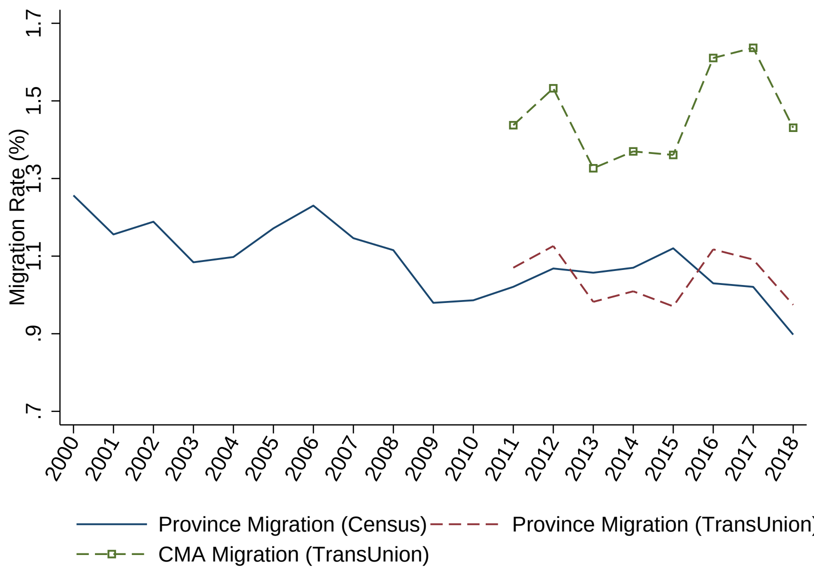
## 2.2 Heterogeneous Migration Patters in Canada

Before describing the migration patterns in Canada for different demographic groups using *TransUnion* in the recent years, we show that the *Transunion* dataset is able to track the

[5] A city is defined as a census metropolitan area (CMA) or a census agglomeration (CA) that are formed by one or more adjacent municipalities centered on a population core. A CMA must have a total 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 have a high degree of integration with the core, as measured by commuting flows derived from previous census place of work data.

aggregate movement of people across space in Canada consistently with the official statistics. Figure 1 shows the inter-provincial migration rates obtained using individual data from *Transunion* and aggregate statistics from Statistics Canada. Both migration rates are very similar both in terms of magnitudes and time. The green dashed line presents the migration rates between CMAs, which, unsurprisingly, are clearly higher than the migration rates between provinces by approximately .4p.p..

Figure 1: Migration Patters in Canada: Census vs TransUnion Data

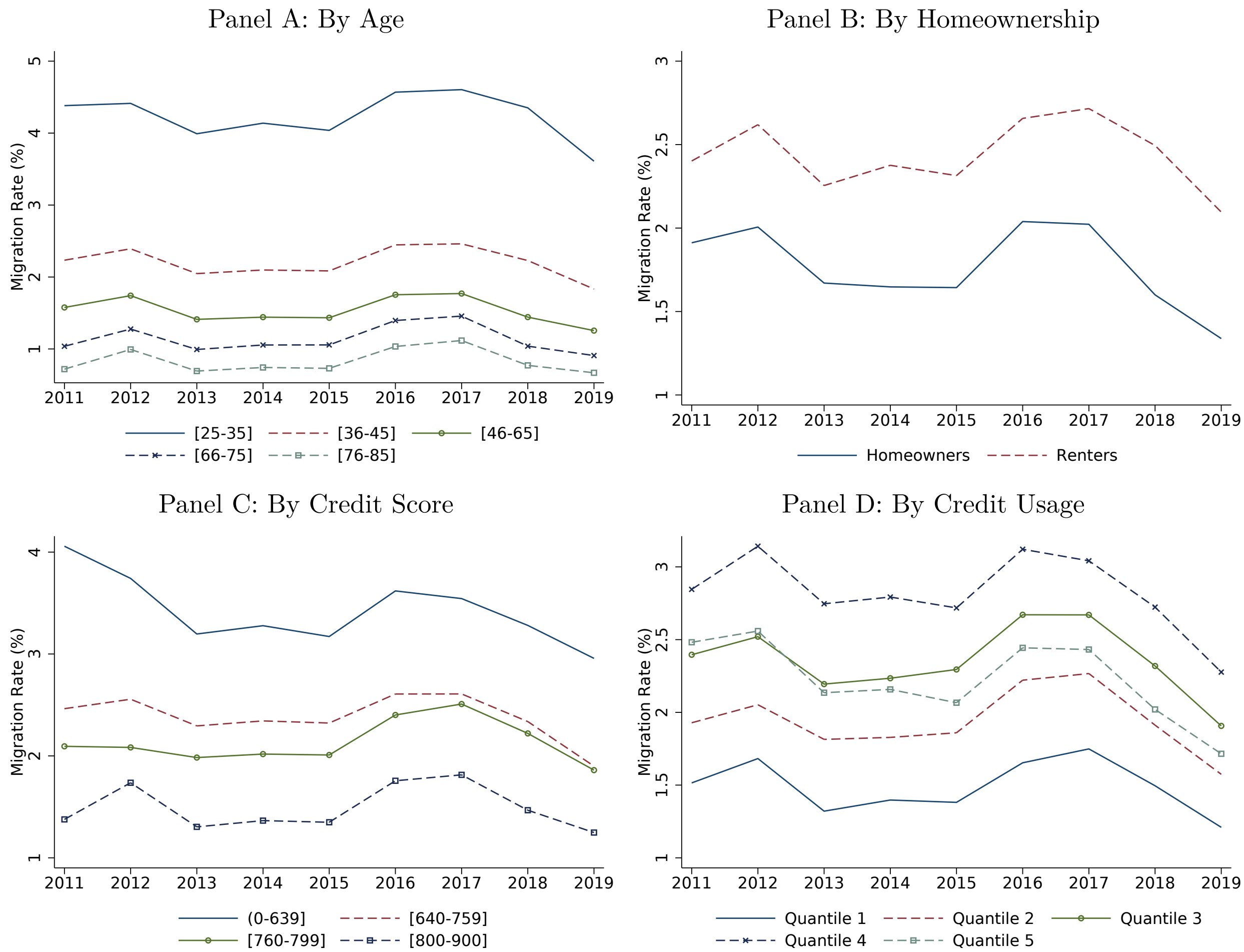



*Note:* Figure 1 plots the migration rates between Canadian provinces between 2000 and 2018 using Census data (blue solid line) and TransUnion (red dashed line). Migration rate is defined by the number of people leaving a certain province divided by the total population in the year before. The green dashed-squared line plots the migration rates among CMAs, defined by the total number of people moving across CMAs divided by total CMA population in the year before. *Source:* Statistics Canada and *TransUnion*.

Figure 2 presents the migration rates across Canadian Cities (CAs) for different individuals characteristics: homeownership status (renter vs homeowner), age (25-35, 36-45, 46-55, 66-75, 76-85) and credit score (0-639, 640-759, 760-799, 800-900) and five quantiles of credit usage. Credit Usage is defined as the total outstanding debt balance divided by the credit limit. We consider any open credit account besides mortgages. Specifically we consider credit cards, installments, auto-loans and lines of credit.

Panel A 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, average, roughly twice as much as people between 36 and 45 and more than four times individuals above 65. Panel B shows the difference in migration rates between homeowners and renters. Renters, on average across the whole sample, are 25% more likely to move than homeowners. Both of these results are consistent with findings for migration flows across US states as in Molloy, Smith and Wozniak (2014). Panel C and panel D show evidence of differential migration rates by two measures of credit access. According to both measures, more constraint individuals tend to move more. Specifically, panel C shows migration rate is monotonically decreasing with credit score. Panel D shows that individuals with higher credit usage rate (more constraint) also move mre on average, although the monotonic relationship no longer holds. These last two results are new to the literature since standard survey or census data generally used to study flows of population in a country do not have information on individual's finances and credit score.

Figure 2: Migration Patters in the Canada by Demographic Groups




*Note:* Figure 2 plots the migration rates between Canadian Cities (CAs) between 2000 and 2018 by age (panel A), homeownership status (panel B), credit score (panel C) and credit usage (panel D). 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.

### 2.2.1 Regression Framework

In order to account for potential joint effects of the different variables and to formally assess these correlations, we regress the moving decisions on individual characteristics. Specifically, we run specification 1:

$$Move_{i,z,t} = \beta_0 + \beta_1 X_{i,t-1} + \delta_z + \theta_t + \epsilon_{i,z,t} \tag{1}$$

where $\text{Move}_{i,z,t}$ is a dummy variable that equals 100 if individual $i$ in location $z$ at time $t$ moves to a different city. $X_{i,t-1}$ are individual characteristics such as age, homeownership and credit score. Our main specification also includes quarter fixed effects and city fixed effects. The quarter fixed effects, $\theta_t$, absorb overall trends in migration rates and any potential aggregate shock to the economy. The city fixed effects, $\delta_z$, control for city characteristics as amenities, long-run productivity levels, quality of life, among others. We also employ alternative empirical specification where we include city-by-quarter fixed effects to absorb any other potential local shock or changes in local economic conditions that occur simultaneously to the oil shock. We cluster our standard errors at city level.

The main coefficients of interest for our analysis is $\beta_1$ that measures how individuals with different characteristics migrate differently. In other words, it characterizes how different demographics, $X_{i,t-1}$, relate with the probability of moving out of a certain location. Specifically, we look at homeownership status, five age group categories (26-35, 36-45, 45-55, 56-65 and 66-85) and four credit score brackets (0-6639, 640-759, 760-799 and 800-900). We interpret that higher the credit score individuals are able to access credit more easily than those with lower credit scores, and therefore, they have higher ability to smooth shocks through borrowing. Similarly, those that have on average a permanent higher credit balance out of their credit limit have less room to adjust their effective borrowing when faced by any shock. In other words, we interpret that lower credit scores or higher credit usage correlate with tighter financial constraints.

Table 1 reports the results of the main specification described in equation 1 for individuals live and move across CAs. Columns differentiate based on the set of explanatory variables and fixed effects implemented. In the first 4 columns we use City and year Fixed Effects while in the last four we use City×Year Fixed Effects. The results are unchanged with the different Fixed Effects implemented. Overall, the regression framework confirms the graphical analysis before both in sign of the differences and magnitudes. This suggests that the propensity to migrate across different individual characteristics is similar across cities and not driven by a subset of large cities. Columns (4) and (8) show that the likelihood of a homeowner moving is, on average, 0.57p.p. smaller than for renters. Regarding age, the probability of moving is lower as individuals become older. Individuals between 36 and 45 have a probability of moving 1.96p.p. lower than those between 25 and 35. This difference increases monotonically up to 3.53p.p. in the group 76-85. When using the credit score as proxy for borrowing constraints, we conclude that constraint individuals tend to move more. The probability of moving for individuals with credit score 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.

Table 1: Heterogeneous Migration Responses

| | (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 |

*Note:* This table reports the OLS estimates for the regressions in 1. The dependent variable is the decision on whether to move or not. The sample is restricted to individuals in CAs. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

In Appendix A, we produce a battery of robustness checks for the findings in table 1. In table 11 we used credit usage as a definition of credit access rather than credit score. Tables 12 and 11 replicate, respectively, 1 and 11 but restricting the sample only to CMAs. Due to data limitations, we calibrate the model to the Canadian CMAs, so this exercise makes the data and the model comparison closer. Overall, the results are qualitatively similar and go in the same direction.

## 2.3 Who Moves Up?

In this section, we analyze how the characteristics of the destination cities compare to their city of the origin across different demographic groups. Are individuals more likely to move to places with higher income than their previous locations? First, we conduct a decomposition by destination and migrants characteristics. Second, we test formally in a regression setting which characteristics determine the type of location they choose to move to. We do so by running the following specification:

$$MoveTO_{i,z,z',t} = \alpha + \beta_1 X_{i,t-1} + \delta_z + \theta_t + \epsilon_{i,z,t} \tag{2}$$

where $MoveTO_{i,z,z',t}$ equals 100 if the new location $z'$ can be considered a “move up" than the previous location $z$. We define “move up" if the new location has higher income (or wages, amenities, TFP) or lower unemployment (or housing prices). Although we observe the FSA code, we consider most of the labor market variables at the city level since individuals may commute within the city. However, housing prices are determined at FSA level.

## 2.4 Results

Table 2 reports the results of specification 2. In column (1), the dependent variable is a dummy equal 100 when individual $i$ moves to a location with lower median housing price. Overall, homeowners are .574% more likely to places with lower housing prices conditional on moving. Older people are between 3 and 5% more likely to move to place with lower housing prices. Individuals with lower credit score are approximately 2% less likely to move to places with lower housing prices.

When we look at unemployment rate, we observe that homeowners are more likely to move to place with larger unemployment than their counterparts. Older people are less likely to move to places with lower unemployment while there are no statistical differences across credit score bins. In column (3), we look at amenities where the only statistically significant difference is between age group 25-25 and 36-45 where it suggests that individuals in 36-45 are .6% more likely to move to locations with higher amenities. In column (4), the dependent variable is a dummy equal to 100 if population is higher at the destination than the place of origin. Homeowners are 2.35% less likely to move to higher populated locations. Younger individuals in the 25-35 range move .91% more than those in 36-45 range to larger cities. This relationship monotonically increases with age. When we look at credit score, individuals with credit score in the 640-759 range are 3.77% more likely to move to higher populated locations than those with lower credit score. The relationship monotonically increases with credit score and individuals with credit score between 800 and 900 are 5.3% more likely to move to bigger cities than those with a credit score below 640.

In column (5), we look at individuals that move to locations with higher total income than the origin. The estimates are similar to the ones about population. In column (6), the dependent variable is whether an individual moves to a location with higher average wages than the origin. Homeowners are 1.15% less likely to move to places with higher wages. Individuals in the 25-35 range are 1.18% more likely to move there than those in the 36-35 range and the relationship monotonically increases with age. Individuals with credit score less than 640 are 1.88% less likely to move to locations with higher wages than those with credit score in the 640-759 range. This difference stays relatively constant even for higher levels of credit score.

In columns (7) and (8), we analyze the ratios between average income and average wage in a city and the median house price in the zip code of residence. These ratios proxy for "real" income and wages, respectively. They also speak for heterogeneity within city. Although homeowners are more likely to go to cities with lower income, we do not find find statically significant differences between homeowners and renters in terms of real income. When we look at age differences, we find that individuals in the 45-65 range are 1.87% and 1.33% more likely to move to locations with higher income to house prices and wages to house prices. This relationship monotonically increases with age. When we look at credit score, we find that individuals with credit score in the 640-759 range are 1.49% and 1.56% more likely to move to locations with higher income and wages to house prices, respectively, although they tend to move to cities with lower income. These relationships monotonically increase with credit score.

In Appendix A, we run the same robustness tests as above. Table 13 reports a change in the definition of “move up". Our "Definition II" considers moving up as moving to a location with weakly higher characteristics than the origin. Tables 14 and 15 report the results for CMAs only, for the strict and weak definition of "moving up", respectively. Table 23, 18 and 19 report the results of a decomposition exercise showing the different migration patterns by homeownership, age and credit access.

Table 2: Moving Where?

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| Homeowner | 0.574** | 0.557*** | -0.991 | -2.347*** | -0.482 | -1.155** | 0.427 | 0.277 |
| | (0.275) | (0.195) | (0.908) | (0.595) | (0.476) | (0.578) | (0.337) | (0.399) |
| Age [36-45] | 0.483 | -0.506** | 0.606* | -0.910*** | -1.180*** | -1.455*** | 0.090 | -0.126 |
| | (0.320) | (0.211) | (0.332) | (0.284) | (0.233) | (0.239) | (0.332) | (0.338) |
| Age [46-65] | 3.217*** | -1.386*** | -0.490 | -4.394*** | -4.682*** | -6.184*** | 1.932*** | 0.512 |
| | (0.611) | (0.495) | (0.762) | (0.912) | (0.885) | (0.924) | (0.617) | (0.663) |
| Age [66-75] | 5.218*** | -2.384*** | -1.474 | -6.912*** | -7.338*** | -10.154*** | 3.169*** | 0.524 |
| | (0.870) | (0.769) | (1.593) | (1.392) | (1.301) | (1.439) | (0.795) | (0.840) |
| Age [76-85] | 3.963*** | -2.330*** | -1.545 | -6.182*** | -6.605*** | -8.787*** | 2.255*** | 0.299 |
| | (0.825) | (0.655) | (1.835) | (1.307) | (1.252) | (1.440) | (0.779) | (0.818) |
| Credit Score [640-759] | -1.868*** | -0.028 | 0.623 | 3.768*** | 1.955*** | 1.876*** | -1.785*** | -1.706*** |
| | (0.318) | (0.461) | (0.851) | (0.772) | (0.489) | (0.483) | (0.356) | (0.369) |
| Credit Score [760-799] | -2.320*** | 0.188 | 0.649 | 5.231*** | 2.319*** | 1.997*** | -2.414*** | -2.512*** |
| | (0.444) | (0.700) | (1.144) | (1.143) | (0.675) | (0.644) | (0.557) | (0.591) |
| Credit Score [800-900] | -2.296*** | 0.695 | 0.134 | 5.321*** | 2.902*** | 1.846*** | -2.347*** | -2.660*** |
| | (0.524) | (0.681) | (1.084) | (1.156) | (0.688) | (0.554) | (0.663) | (0.710) |
| Observations | 3270066 | 2410812 | 1768011 | 3242807 | 3188731 | 3188532 | 2785001 | 2784668 |
| Adjusted $R^2$ | 0.306 | 0.396 | 0.339 | 0.407 | 0.358 | 0.350 | 0.279 | 0.273 |
| City × Year Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: This table reports the OLS estimates for the regressions in 2 at CA level. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

# 3 Model

Motivated by the empirical evidence above, we now analyze migration through the lens of a life-cycle model with incomplete markets, consumption-saving decisions and housing tenure choice. The model can be portrayed as a quantitative spatial equilibrium model that meets Kaplan, Mitman and Violante (2017) in the characterization of the housing sector. The first subsection presents the household's optimization problem. The second subsection describes production of the final good and the housing sector. The third subsection characterizes the equilibrium. The fourth subsection establishes theoretical predictions of the model.

## 3.1 Households and Directed Migration

**Space** The economy is defined by $L$ locations (cities) indexed by $l \in \{1, 2, ..., L\}$. Below, location subscripts are omitted unless necessary. Locations differ in four dimensions: productivity ($z^l$), amenities ($A^l$), labor market risk ($\pi^l$,$M^l$) and housing supply characteristics ($\bar{L}^l$, $\kappa^l$).

**Demographics** The economy is populated by a measure-one continuum finitely-lived households. Age is indexed by $q = \{1, 2, ..., \bar{Q}\}$. In each period, a measure of $1/\bar{Q}$ agents are born and their initial location is distributed according to $G^0(l)$. Agents face mortality risk with the survival probabilities, $\{\lambda_q\}$, varying over the life-cycle. Agents live at most $\bar{Q}$ periods, work in the initial $Q$ periods and retires after that.

**Preferences** Agents in our model value non-durable consumption $c$, housing services, $h$ and location-specific amenities $A$. The instantaneous utility function $u^j(c, h, A)$ is given by:

$$u_q(c, h, A) = \frac{e_q[(1-\alpha)c^{1-\gamma} + \alpha h^{1-\gamma}]^{\frac{1-\sigma}{1-\gamma}} - 1}{1-\sigma} + A, \tag{3}$$

where $\alpha$ 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. The instantaneous utility function is age-specific since it includes $\{e_q\}$, an exogenous equivalence scale that captures deterministic changes in household size and composition over the life cycle.

Households leave a bequests to the future generations when they die. They are captured by a warm-glow bequest motive a la De Nardi (2004):

$$\varphi(a) = \bar{\varphi}\frac{(a + \underline{a})^{1-\sigma} - 1}{1-\sigma} \tag{4}$$

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.

**Income** During the working ages, households receive either an idiosyncratic labor income endowment $y_{i,q}^{\epsilon,j}$ given

$$\log\, y_{i,q}^{\epsilon,j} = \begin{cases} \log\, w^j + \chi_q + \epsilon_i & \text{if } \epsilon > 0 \\ \log\, \tilde{w}^j + \chi_q & \text{if } \epsilon = 0 \end{cases}$$

where $w^j$ and $\tilde{w}^j$ are city-specific endogenous wage and unemployment subsidy, respectively. Individual productivity has a deterministic age profile $\chi_q$ common across individuals and an idiosyncratic component $\epsilon_i$ that follows a Markov chain on the space $\{\epsilon^1, \epsilon^2, ..., \epsilon^S\}$. We assume that $\epsilon^1 = 0$ and interpret this realization of the shock as unemployment. When a household first enters a location, say $l$, her initial employment status is drawn from distribution $\pi^l$. Afterwards, the employment status evolves according to the Markov transition matrix $M^l$, which is city-specific. The Markov chain is common across cities for positive $\epsilon$. Upon retired, an agent receives a fixed retirement benefit of $\bar{w}_q$, regardless of her location. Unemployment and retirement benefits are funded by the government and we allow the government to run an unbalanced budget.

**Housing** Housing services can be acquired through either renting ($I_h = R$) or owning ($I_h = H$). We allow agents to have intrinsic preference for homeownership: owning a house of size $h$ provides $\omega h$ units of effective housing services, while a rental property of same size only provides $h$ units of housing services. Owner-occupied and rental housing sizes belong to two finite sets, $H^H$ and $H^R$ , respectively. Rental units are weakly smaller than the owner-occupied houses.

To rent a house of size $h$, an agent in location $l$ pays a rent of $p_r^l h$ and to purchase a house of size $h$, an agent pays a price of $p^l h$. Ownership carries a maintenance cost of $\delta p^l h$ and a property tax of $sp^l h$ per period. When buying a house, the household faces a proportional transaction cost of $Fp^l h$. Renters can adjust their housing consumption at no cost.

**Liquid Asset and Networth** Agents can borrow or save through an one-period financial asset $b$ in the international financial market at the exogenous interest rate $r$. Renters face a limit to unsecured borrowing of $\underline{b}$. Homeowners can use their housing as collateral but borrowing cannot exceed $\underline{b} + \kappa p^l h$. The borrowing constraint is summarized by:

$$b' \geq \underline{b} + \mathbb{1}[I_h = H]\xi p^l h$$

Owners' total net worth $a$ is the sum of household's financial wealth $b$ and housing value $p^l h$:

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

**Location Choice** Households receive idiosyncratic location preference shocks and decide where to reside. Specifically, we assume that every period agents draws a vector of $L$ independent Type 1 extreme value location shocks with a scale parameter $\nu$. In case households decide to move, they incur in a monetary moving cost $F_m$ and an utility moving cost, $\tau^{l,l'}$, which depends on origin and destination locations. Moving costs are common to all agents, regardless their individual state. However, the interaction of these two types of moving costs with individual states, allows us to generate distinct migration patterns for different demographic groups.

### 3.1.1 Household Decisions

The timeline of agents' decision-making is as follows:

1. At the beginning of the period, households in location $l$, after observing their idiosyncratic income shock, $\epsilon$ choose between renting and owning;
2. Households choose non-durable consumption, housing consumption and liquid saving $b$. Homeowners pay maintenance cost and property tax and transaction cost in case housing consumption differs from the previous period or moving have occured;
3. At the end of the period, the death shock is realized. For those that survive, a vector of idiosyncratic preference shocks realizes and location choices are made. Moving costs are paid if moving occurs;
4. State variables evolve according to exogenous processes for age and income and individual decisions.

We now formalize the individual's problem. At the beginning of the period, after the realization of the income shock, the household's individual state is given by $(l, a, \epsilon, q, \bar{h})$, where $l$ is her location, $a$ is her asset holding, $\epsilon$ is her income shock, $q$ is her age and $\bar{h} = \mathbb{1}[I_h = H \cap l_{-1} = l]h$ is the amount of housing carried over in case she was a homeowner in location $l$ in the previous period and zero otherwise. The households chooses between renting ($I_h = R$) and owning ($I_h = H$). Then,

$$V_t(l, a, \epsilon, q, \bar{h}) = \max \left[ V_t^R(l, a, \epsilon, q), V_t^H(l, a, \epsilon, q, h) \right], \tag{5}$$

where $V_t$ is her value function at the beginning of the period, $V_t^R$ is the value of renting and $V_t^H$ is the value of owning.

Those that choose to rent solve:

$$V_t^R(l,a,\epsilon,q) = \max_{c,b,h',\{a'\}} u_q(c,h',A^l)+\lambda_q\nu\log\left[\sum_k \exp\left[\beta\mathbb{E}^k V_{t+1}(k,a'_k,\epsilon',q+1,0)-\tau^{l,k}\right]^{\frac{1}{\nu}}\right]+(1-\lambda_q)\varphi(a'_l)$$

$$s.t. \quad c+b+p^l_{r,t}h' = y^{\epsilon,l}+a$$

$$a'_k = (1+r)b - F_m(k\neq l)$$

$$b \geq \underline{b}$$

Households that decide to be homeowners solve:

$$V_t^H(l,a,\epsilon,q,\bar{h}) = \max_{c,b,h',\{a'\}} u_q(c,\omega h',A^l)+\lambda_q\nu\log\left[\sum_k \exp\left[\beta\mathbb{E}^k V_{t+1}(k,a'_k,\epsilon',q+1,h'(k=l))-\tau^{l,k}\right]^{\frac{1}{\nu}}\right]$$
$$+(1-\lambda_q)\varphi(a'_l)$$

$$s.t. \quad c+b+p^l_t h'[1+F(h'\neq\bar{h})] = y^{\epsilon,l}+a$$

$$a'_k = (1+r)b + p^l h'(1-\delta-s) - F_m(k\neq l)$$

$$b \geq \underline{b} - \xi p^l h'$$

Following McFadden (1973), Type 1 Extreme value assumption on location preference shock implies a closed-form solution to the migration probabilities. In particular, the probability of moving to location $k$ for an agent with individual states $(l,a,\epsilon,q,\bar{h})$ is

$$\mu_t(k;l,a,\epsilon,q,\bar{h}) = \frac{\exp\left[\beta\mathbb{E}^k V_{t+1}(k,\tilde{a}_{k,t},\epsilon',q+1,\tilde{\bar{h}}_t)-\tau^{l,k}\right]^{\frac{1}{\nu}}}{\sum_{l'=1}^{L}\exp\left[\beta\mathbb{E}^{l'} V_{t+1}(l',\tilde{a}_{l',t},\epsilon',q+1,\tilde{\bar{h}}_t)-\tau^{l,l'}\right]^{\frac{1}{\nu}}} \tag{6}$$

where $\tilde{a}_t$ and $\tilde{\bar{h}}_t$ are optimal savings and housing consumption choices derived from agents' optimization problems.

## 3.2 Production

There are two production sectors in each location: a final goods sector which produces the nondurable consumption good and a construction sector which produces new houses.

Productivities are location specific and labor is perfectly mobile across sectors within location.

**Final Good Sector** Each location produces an uniform final good that can be traded across location. 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:

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

where $N^{y,l}$ is the total employment in the final good sector in location $l$. The equilibrium city-level wage in location $l$ is then given by

$$w^l = \eta e^{z^l} \left(N^{y,l}\right)^{\eta-1} \left(\bar{N}^l\right)^{\zeta} \tag{7}$$

**Construction Sector** As in Kaplan, Mitman and Violante (2017), there is a foreign-owned competitive construction sector that operates in each location a the following production technology:

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

where $N^{h,l}$ is the labor employed in the construction sector and $\bar{L}^l$ is the amount of new available buildable land.[6] The housing investment that solves a profit maximization of a developer is given by:

$$I^l = \left(\frac{\kappa^l p^l e^{\kappa^l z^l}}{w^l}\right)^{\frac{\kappa^l}{1-\kappa^l}} \bar{L}^l \tag{8}$$

where $w^l$ is given by equation (7) 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

$$H_t^l = (1-\delta)H_{t-1}^l + I_t^l. \tag{9}$$

**Rental Sector** Following Kaplan, Mitman and Violante (2017), we assume that risk-neutral foreign investors can arbitrage between the owned-housing market and the rental market,

[6] Government issues and sells new permits equivalent to $\bar{L}^l$ units of land in a competitive market price to developers as assumed in Kaplan, Mitman and Violante (2017).

which connects housing prices and rents in the following way[7]:

$$p_{r,t}^{l} = p_{t}^{l} - (1 - \delta - s)\,\frac{p_{t+1}^{l}}{1 + r} \tag{10}$$

We assume the profits from all productions accrues to foreign agents.

## 3.3 Equilibrium

The stationary equilibrium of the economy consists of: price vectors $\mathbf{w}, \mathbf{p}, \mathbf{p}_r$; policy functions $\tilde{c}, \tilde{b}, \tilde{h}, \tilde{a}, \tilde{I}_h, \mu$; a law of motion $\Gamma^*$, a housing stock $H$ and a stationary distribution over individual states $m$ such that:

1. Given $\mathbf{w}, \mathbf{p}, \mathbf{p}_r$, the policy functions, $\tilde{c}, \tilde{b}, \tilde{h}, \tilde{a}, \tilde{I}_h, \mu$, solve the agent's problems;
2. Labor markets clears according to $N_y^l + N_k^l = (1 - \pi_u^l)\bar{N}^l$, where $\pi_u^l$ denotes the unemployment rate in location $l$;
3. Housing markets clear[8]
4. The law of motion of individual states $\Gamma^*$ is consistent with policy functions $\mu, \tilde{a}, \tilde{I}_h, \tilde{h}$ and exogenous processes for $q$ and $\epsilon$ ;
5. The distribution over individual states $m$ is invariant with respect to $\Gamma^*$, i.e.,

$$m = \Gamma^* m.$$

## 3.4 Model Solution

Computationally, we use two embedded loops to obtain the stationary equilibrium of our model. In the inner loop, we compute the law of motion $\Gamma^*$ and the stationary distribution $m$ for a given set of market prices $\mathbf{w}, \mathbf{p}, \mathbf{p}_r$. To get $\Gamma^*$, we need to obtain policy functions from households' optimization problem and combine them with the exogenous processes for age and income shock. After getting $\Gamma^*$, $m$ can be found by iterating from the distribution of individual states of the newborns. In the outer loop, we use iterative approach to find equilibrium prices $\mathbf{w}, \mathbf{p}, \mathbf{p}_r$. We first guess two vectors $\mathbf{w}, \mathbf{p}$ and back out $\mathbf{p_r}$ from $\mathbf{p}$ using

[7]As presented in Kaplan, Mitman and Violante (2017), 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.

[8]Housing market clears by equating the location specific housing stock given by (9) and total housing demand (rental and owner-occupied units) given by: $H_t^l = \int \cdots \int_{a,\epsilon,q,I_h,h} \tilde{h}_t(l, a, \epsilon, q, h) dm_t(l, a, \epsilon, q, h)$

(10). Under a guess of $\mathbf{w}, \mathbf{p}, \mathbf{p}_r$, we use the inner loop to obtain the stationary distribution $m$. Final, we compute excess demands for labor and housing under our guess of $\mathbf{w}, \mathbf{p}$ and update our guess accordingly until convergence. More details on the computation algorithm can be found in Appendix E.

Outside of the stationary equilibrium, we can characterize the transition path of the economy for any initial distribution over individual states $m_0$. In this case, the equilibrium of the economy consists of: the path of price vectors $\{\mathbf{w}_t, \mathbf{p}_t, \mathbf{p}_{r,t}\}_{t=0}^{\infty}$; a path of policy functions $\{\tilde{c}_t, \tilde{b}_t, \tilde{h}_t, \tilde{a}_t, \tilde{I}_{ht}, \mu_t\}_{t=0}^{\infty}$; a path of housing stock $\{H_t\}_{t=0}^{\infty}$, and a path of distributions over individual states $\{m_t\}_{t=0}^{\infty}$ such that for each $t$ that satisfy the equilibrium conditions.

## 3.5 Qualitative Predictions

In this subsection, we focus on the qualitative predictions of our model and compare it with the existing literature. To prioritize the intuition behind the results, we consider a simplified partial equilibrium model to make analytical derivation feasible. Specifically, we assume individuals live two periods ($\bar{Q} = Q = 2$) and choose between two locations ($N = 2$). We also shut down housing adjustment cost and the preference for home-ownership by assuming $F = 0$ and $\omega = 0$. Under these assumptions, agents are indifferent between renting and owning absent of shocks to housing costs. Specifically, we have

$$V(l, a, \epsilon, q, h) = V^R(l, a, \epsilon, q).$$

In what follows, we drop $h$ as an argument of the value function.

**Networth and Migration** We show that, under the assumptions explained below, move-out probability from the low-wage/high-rent city decreases in networth, and move-out probability from the high-wage/low-rent city increases in networth.

Let us show how we derive this result. In the simplified model, migration only happens at the end of the first period. Take a young individual with individual states $x_1 = (l, a_1, \epsilon_1, 1)$ and let us assume he chooses to rent.[9] The effect of networth on migration can be found by taking the partial derivative of the policy function:

[9] If the agent was a homeowner, the house would constitute another saving channel but the overal sensitivity of saving to initial networth will be constant. Thus, the effect of a change in networth on the moving probability would not be altered.

$$\frac{\partial \mu(k;x_1)}{\partial a} = \frac{\beta(1+r)}{\nu}\frac{\partial b_1(x_1)}{\partial a_1}\mu(k;x_1)\mu(l;x_1)$$
$$(\mathbb{E}^k[V_a(k,(1+r)b_1 - F_m, \epsilon_2, 2)] - \mathbb{E}^l[V_a(l,(1+r)b_1, \epsilon_2, 2)]), \quad (11)$$

where $k, l$ are the two different locations. From consumption Euler equation $\frac{\partial b_1(x_1)}{\partial a_1} \geq 0$, with equality if $b_1 = \underline{b}$. When credit constraint does not bind, the partial derivative is positive as long as location $k$ has a larger expected marginal value of wealth. Intuitively, people with more wealth tend to choose a location where the expected marginal value of wealth is higher.

Assuming individuals are not borrowing constrained at the end of their life,[10] we can compute the expected marginal value of wealth for an old individual in location $l' \in \{k, l\}$ with asset

$$a_2^{l'} = (1+r)b_1 - F_m(l' \neq l):$$

$$\mathbb{E}^{l'}V_a(l', a_2^{l'}, \epsilon_2, 2) = \sum_{\epsilon \in \{1, \epsilon_l\}} \mathbb{P}(\epsilon_2 = \epsilon | \epsilon_1, l')\left(\frac{[\alpha^\alpha(1-\alpha)^{1-\alpha}(A^{l'})^\gamma / p_r^{l'}]^{\frac{1-\sigma}{\sigma}} + \theta^{\frac{1}{\sigma}}(1+r)^{\frac{1-\sigma}{\sigma}}}{w^{l'}(2)\epsilon + a_2^{l'} + \phi/(1+r)}\right)^\sigma.$$

The expected marginal value of wealth at age 2 depends on location-specific wage, housing rent, labor market risk, amenity, and the level of wealth. In the following paragraphs, we discuss separately the implications of wages, housing rent and labor market risk on the sign of equation (11).[11]

First, let us focus on the effect of wages. Assuming two locations are otherwise identical, the location with a lower wage will have a higher expected marginal value of wealth. When credit constraint does not bind, $\frac{\partial \mu(k;x_1)}{\partial a} > 0$ if $w^l(2) > w^k(2)$, and $\frac{\partial \mu(k;x_1)}{\partial a} < 0$ if $w^l(2) < w^k(2)$. This result suggests that, everything else being equal, compared to wealthy individuals, the poor are more likely to move out of a low-wage city. Compared to quantitative spatial models that abstract from consumption-saving choice, such as Caliendo, Dvorkin and Parro (2019), our model generates distinct migration patterns by asset. In particular, the wealthy and the poor have different incentives to upgrade to a city with higher wages.

Second, we explore the effect of house prices. As suggested by Bilal and Rossi-Hansberg (2018), reducing housing related cost can be a big driving force for mobility. To analyze the effect of housing rent in the context of our model, let us assume the two locations are otherwise identical. When $\sigma > 1$, i.e., the substitution effect dominates, the location with a higher rent will have a higher expected marginal value of wealth. Thus, as long as credit constraint is not binding, $\frac{\partial \mu(k;x_1)}{\partial a} > 0$ if $p_r^l < p_r^k$, and $\frac{\partial \mu(k;x_1)}{\partial a} < 0$ if $p_r^l > p_r^k$. This is to say

[10]This is guaranteed as long as the bequest incentive is sufficiently strong, i.e., $\phi \leq -(1+r)\underline{b}$.

[11]In the following analysis, we shut down monetary migration cost by assuming $F_m = 0$. Introducing a positive monetary migration cost will not change the conclusions.

that compared to wealth-rich individuals, wealth-poor individuals are more likely to move out of a location with a higher rent.x

Third, we consider how labor market risk affects the sign of equation (11). Labor market risk is also important in determining migration decision. To highlight the effect of labor market risk, let us assume the two locations only differ in unemployment probability. In this case, the location with a higher unemployment probability will have a higher expected marginal value of wealth. When credit constraint does not bind, $\frac{\partial \mu(k;x_1)}{\partial a} > 0$ if $P(\epsilon_2 = \epsilon_l | \epsilon_1, k) > P(\epsilon_2 = \epsilon_l | \epsilon_1, k)$, and $\frac{\partial \mu(k;x_1)}{\partial a} < 0$ if $P(\epsilon_2 = \epsilon_l | \epsilon_1, k) < P(\epsilon_2 = \epsilon_l | \epsilon_1, k)$. Thus, everything else being equal, low networth individuals are relatively more likely to move out of a location where their unemployment probability is high.

More generally, if we have more than two locations, the model also predicts how the relative propensity to move to different locations depends on networth. That is to say, we can determine the sign of

$$\frac{d}{da} \log[\frac{\mu(k;x_1)}{\mu(k';x_1)}]$$

in different scenarios, where $k, k'$ are two distinct locations other than $l$. From equation (6), we have

$$\frac{d}{da} \log[\frac{\mu(k;x_1)}{\mu(k';x_1)}] = \frac{\beta(1+r)}{\nu} \frac{\partial b_1(x_1)}{\partial a_1} (\mathbb{E}^k[V_a(k, a^k, \epsilon_2, 2)] - \mathbb{E}^{k'}[V_a(k', a^{k'}, \epsilon_2, 2)]).$$

Analogous to what we argued before, if locations $k, k'$ only differ in wage, then

$$\frac{d}{da} \log[\frac{\mu(k;x_1)}{\mu(k';x_1)}] > 0$$

only if location $k$ has a lower wage. If locations $k, k'$ only differ in rent, then

$$\frac{d}{da} \log[\frac{\mu(k;x_1)}{\mu(k';x_1)}] > 0$$

only if location $k$ has a higher rent, assuming substitution effect dominates. Finally, if the two locations only differ in labor market risk, then

$$\frac{d}{da} \log[\frac{\mu(k;x_1)}{\mu(k';x_1)}] > 0$$

only if location $k$ has a riskier labor market.

**Migration Cost and Migration** Different from utility moving cost, the effect of monetary moving cost is naturally heterogeneous across the population as individuals differ in their marginal value of wealth. People with a higher marginal value of wealth have reduced incentive to move because moving is more costly to them. Another distinct feature of our model is that we introduce a monetary moving cost in additional to classical utility moving costs. Our setup allows us to discuss the effect of moving subsidy, which is a focus of recent policy discussions.

***Utility Cost*** Let us discuss the effect of a change in utility moving cost. Consider the following parametrization of the utility moving cost

$$\tau^{l,l'} = \tau_0(l' \neq l).$$

Take a young individual with individual states $x_1 = (l, a_1, \epsilon_1, 1, 0)$. The derivative of $\mu$ with respect to $\tau_0$ will be

$$\frac{d}{d\tau_0}\mu(k; x_1) = -\frac{1}{\nu}\mu(k; x_1)\mu(l; x_1).$$

We can see that an increase in utility moving cost, unambiguously, reduces the probability of moving, and the effect solely depends on the original migration probability.

***Monetary Cost*** An increase in the monetary moving cost also reduces migration, *but* its effect increases with the marginal value of wealth. Taking the derivative of $\mu$ with respect to $\tau_0$, we have

$$\frac{d}{dF_m}\mu(k; x_1) = -\frac{1}{\nu}\mu(k; x_1)\mu(l; x_1)\beta\mathbb{E}^k V_a(k, a_2^k, \epsilon_2, 2) = \frac{d}{d\tau_0}\mu(k; x_1)\beta\mathbb{E}^k V_a(k, a_2^k, \epsilon_2, 2).$$

The latter depends on the level of wealth of the agents. This implies an important distributional consequences: compared to the wealthy, low-net-worth individuals are more affected by the monetary migration cost and policy efforts to reduce it.

**Home-ownership and Migration** We show that, a change in the rent of a given location will have differential effects on the move-out probability depending on whether individuals own a house or not. For example, when the rent goes up in Vancouver, the balance sheet of a current homeowner improves as the value of his house goes up. On the other hand, renters in the city will experience an increase in their cost of living due to the rent hike. Thus, to study the effect of changing housing regulations, it is indispensable to consider home-ownership.

Let us consider two young individuals with individual state $x_1 = (l, a_1, \epsilon_1, 1, 0)$. One of them decides to rent while the other decides to own. Suppose that, before these two young individuals make their migration decision, they become aware that the rent of location $l$ will increase permanently starting next period. The rent hike will increase the renter's moving probability because the continuation value of staying in $l$ becomes smaller. Analytically,

$$\frac{d}{d\log p_r^l}\mu(k;x_1) = -\frac{\beta}{\nu}\mu(k;x_1)\mu(l;x_1)\frac{d\mathbb{E}^l V(l,a_2^l,\epsilon_2,2)}{d\log p_r^l} > 0 \tag{12}$$

A permanent increase in the rent of location $l$ also drives up the housing price proportionally. As a result, the individual who owns will experience a gain in net worth. Specifically,

$$\begin{aligned}\frac{d}{d\log p^l}\mu(k;x_1) = &-\frac{\beta}{\nu}\mu(k;x_1)\mu(l;x_1)\frac{d\mathbb{E}^l V(l,a_2^l,\epsilon_2,2)}{d\log p_r^l} \\ &+\frac{\beta}{\nu}\mu(k;x_1)\mu(l;x_1)p^l h_1(\mathbb{E}^k[V_a(k,a_2^k,\epsilon_2,2)] - \mathbb{E}^l[V_a(l,a_2^l,\epsilon_2,2)])\end{aligned}$$

The additional wealth effect is captured by the second term on the right hand side of the equation e discuss before, a higher wealth reduces moving probability if $l$ is a low-wage/high-rent city. Thus, a marginal increase in the rent of a location has an ambiguous effect on the moving probability of homeowners.

# 4 Taking the Model to the Data

This section provides a summary of the data sources and measurements used to take the model to the data, with further details provided in the Appendix. We report the mix of reduced-form analysis and internal calibration that we pursued to determine some of the parameters of the model.

We calibrate the model to the Canadian economy in 2016, the last Census year in Canada. The geographic units of analysis are the 27 largest Census Metropolitan Areas (CMAs) in Canada. There are about 35 CMAs in Canada with more than 100,000 inhabitants, but due to data limitations we restrict our analysis to 27 CMAs.

We obtain estimates for location specific productivities, $z^l$, amenities, $A^l$, labor market risks, $\{\pi^l, M^l\}$, and housing supply elasticities, $\kappa^l$. Then, we internally calibrate several household utility parameters, $\{\beta,\nu,\omega\}$, bequest parameters, $\{\bar{\varphi},\underline{a}\}$, bilateral utility moving costs and monetary moving costs, $\{\tau^{l,l'},F_m\}$, borrowing limit, $\{\underline{b}\}$ and land permits $\bar{L}^l$. We target ten aggregate moments: the homeownership rate, the share of individuals with negative assets, 20th and the 50th percentile of the net worth-to-income ratio distribution, the ratio of net worth at age 85 to net worth at age 65, the 50th percentile of the housing equity to worth-to-income ratio distribution of homeowners, the average migration rate, the correlation between in-migration and distance and the correlation between out-migration and distance and the location-specific wage to house price ratio. Table 3 reports the value of each of these targeted moments both in the data and the ones generated by the model. Overall, the differences are small and they allow us to pin down the parameters in table 4 below. The rest of the parameters are taken from the literature or read directly from the data as explained below in further details.

Finally, in the last subsection, we report the main results of simulating the calibrated model and we check how some non-targeted moments match the data.

**Amenities** We construct a measure of amenities at CMA-level following Diamond (2016). We run a principal component analysis using information on government spending on K-12 education per capita, availability of restaurants, level of pollution measured as particles in the air and crime rates. All this data is extracted from Statistics Canada. For robustness, we also conducted a factor analysis and the results are unchanged. Diamond (2016) amenity's index is much richer than ours. Unfortunately, for Canada there are not as many available variables as in the US. We report the distribution of amenities by city in panel A of Figure 15.

**Housing Elasticities** We estimate CMA-level housing price elasticities following Guren et al. (2018). Their approach exploits systematic differences in cities responses to regional house price cycles. As pointed out by the authors, when a house price boom occurs in a given region, some cities systematically experience larger house prices increase than others. The reserve is true for downturns. Therefore, the authors regress change in city house prices on changes in region house prices and control for city and region×time fixed effects. The housing supply elasticity corresponds then to the inverse of the estimated city-level sensitivity parameter.[12] We report the distribution of housing elasticities by city in panel C of figure 15.

**Employment Shocks** We select the CMA-specific employment shock transition matrices $M^l$ to meet two requirements. First, the steady state unemployment rate in each CMA equals the average unemployment rate between 2014 and 2017 in the data; second, the average monthly employment-to-unemployment (EU) rate equals 1.5% following Statistics Canada.[13]

**Productivity** Following the literature, we set the elasticity of labor demand $\eta$ to 0.765, that sits right in within the range of values used for this parameter. Following, Giannone (2017), we set the coefficient of agglomeration forces, $\zeta$, to 0.22. We then estimate the city-specific exogenous component of productivity, by inverting equation (7). We obtain average employment income, total employment and total population with age between 25 and

[12]An alternative approach would be to use land availability, geographic characteristics and housing regulation to build housing supply elasticities for Canadian cities following Saiz (2010). However, data limitations prevent us from doing so.

[13]https://www.bankofcanada.ca/wp-content/uploads/2019/01/san2019-4.pdf

85 years old in 2016 from Statistics Canada. We report the distribution of TFP by city in panel A of figure 15.

Table 3: Results of Internal Calibration

| **Moment** | Data Value | Model Value |
|---|---|---|
| av.out-migration | 0.0154 | 0.0156 |
| corr.(distance,out-migration) | -0.225 | -0.271 |
| corr.(prod,in-migration) | 0.894 | 0.79.3 |
| sh. pop. negative assets | 0.057 | 0.094 |
| 20th perc. networth/income distribution | 0.62 | 0.91 |
| 50th perc. networth/income distribution | 4.33 | 4.22 |
| 50th perc. home equity/networth distribution | 0.68 | 0.77 |
| networth age 85/networth age 65 | 0.88 | 1.17 |
| homeownership share | 0.69 | 0.687 |

Notes: This table reports the seven targeted moments that we use to perform simulated method of moments. The data moment for comparison are taken from Statistics Canada.

**Demographics** We assume that individuals enter the model when they are 25 years of age and they live at most 60 periods at the age of 85 years old ($\bar{Q}$). Agents retire when they are 65 years old ($Q$). Age-dependent survival rates are obtained directly from Statistics Canada. The distribution of newborns in each period matches the distribution of people with age between 20 and 25 years old across cities.

**Preferences** Following Kaplan, Mitman and Violante (2017), we set $\sigma$ to 2, which gives an elasticity of intertemporal substitution equal to 0.5, and $\frac{1}{\gamma}$, the elasticity of substitution between nondurable consumption and housing to 1.25. The relative taste for housing services, $\alpha$ is set to 0.15. The consumption expenditures equivalence scale $\{e_q\}$ reproduces the McClements (1977) scale, a commonly used consumption equivalence measure. We internally pin down $\omega$, the extra utility an agent receives from owning a house, by matching a homeownership rate of 69%. The parameter value is 1.05.

We also internally calibrate the discount rate $\beta$ and we find that it is equal to 0.96. The This is a key parameter to match the 50th percentile of the net-worth to income ratio distribution of 4.33. Networth, income and housing equity distributions are obtained from the Survey of Financial Security (SFS) of 2016. We exclude the the top 10% of the net-worth to income ratio when computing all these moments.

The bequests' parameters are chosen to match the ratio of net worth at age 75 to net

Table 4: Parameter Values

| Parameter | Interpretation | Internal | Value |
|---|---|---|---|
| **Space** | | | |
| $L$ | Number of Locations | N | 27 |
| **Demographics** | | | |
| $\bar{Q}$ | Length of Life (years) | N | 60 |
| $Q$ | Working Life (years) | N | 35 |
| **Preferences** | | | |
| $\alpha$ | Housing consumption share | N | 0.15 |
| $\beta$ | Discount factor | Y | 0.96 |
| $\sigma$ | Risk aversion | N | 2 |
| $\bar{\varphi}$,$\underline{a}$ | Bequest | N | 30; 1.5 |
| $\omega$ | Additional utility from owning | Y | 1.138 |
| **Migration** | | | |
| $\nu$ | Scale of Type 1 E.V. shocks | Y | 1.45 |
| $\tau_0$, $\tau_1$ | Utility moving costs | Y | 7.7; 0.0263 |
| $F_m$ | Monetary moving cost | N | 0.27 |
| **Technology** | | | |
| $\eta$ | Labor Elasticity | N | 0.765 |
| $\zeta$ | Agglomeration Elasticity | N | 0.22 |
| $z^l$ | Local productivity | N | |
| **Housing** | | | |
| $\delta$ | Housing maintenance cost (depreciation) | N | 0.015 |
| $\kappa^l$ | Local elasticities | N | |
| $\bar{L}^l$ | Local land permits | Y | |
| $F$ | Housing transaction Costs | N | 0.07 |
| **Financial Instruments** | | | |
| $r$ | Interest rate | N | 0.01 |
| $\underline{b}$ | Unsecured borrowing limit | Y | -0.182 |
| $\xi$ | Collateral constraint | N | 0.8 |
| $s$ | Property tax rate | N | 0.01 |

Note: This table reports the parameters' values used in the calibration stating whether they are internally calibrated with simulated method of moment or calibrated externally. The model is calibrated at a bi-year frequency but all the parameters shown in this table are annualized.

worth at age 50 and the 50th percentile of the net-worth to income ratio distribution of 0.62.

**Income** The stochastic component of employment earnings,$\epsilon_i$, is modeled as an AR(1) process in logs with annual persistence of 0.91, annual standard deviation of innovations of 0.21 as in Berger et al. (2018). The deterministic component of earnings $\{_q\}$ is determined by match the average earnings profile over the life-cycle from SFS. The unemployment subsidy is set to 0.9 of the lowest employment income in each city, matching the average income from unemployed in SFS.

The initial distribution of bequests matches the asset distribution of individuals in SFS with age between 22 and 25 years old.

The real interest rate, $r$, is set to 1%. We internally calibrate $\underline{b}$, the maximum unsecure debt, to match the 5.9% share of households with negative networth. We find a value of $-0.182$.

**Housing** As in Kaplan, Mitman and Violante (2017), we set the housing maintenance cost, $\delta$, and the housing tax, $s$, to 0.015 and 0.01 per year, respectively. The fixed transaction costs that homeowners pay when purchasing a new property is set to 7% of the value of the house. At last, we impose in the stead-state the median house price to income in each city, which allow us to back-up the location-specific land permits $\overline{L}^l$. We normalize the land permits in order to match the 50th percentile of the empirical distribution of home equity-to- networth ratio distribution.

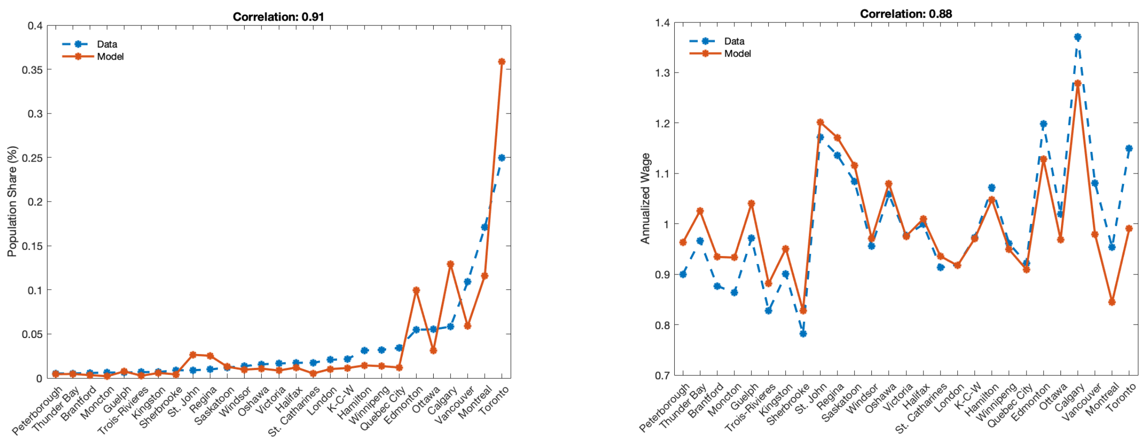
**Migration** We internally calibrate $\nu$ that shapes the variance of the T1EV and we found it to be equal to 1.45. In order to account for the bilateral utility moving costs, $\tau^{l,l'}$, we linearize the expression to $\tau^{l,l'} = \tau_0(l' \neq l) + \tau_1 dist^{l,l'}$, where $dist^{l,l'}$ is the distance between any two pair of locations. The intercept $\tau_0$ and the slope, $\tau_1$, are internally calibrated to 7.7 and 0.0263, respectively. The monetary moving costs, $F_m$, are internally calibrated to approximately CAD 5,660.00, which corresponds to 27% of average annual income.

## 4.1 Model Matching Data

In this section, we report the results of the calibrated model with the parametrization above to analyze how the model matches the data on some non-targeted moments of interest. We are both interested in understanding how the networth to income distribution and the house value to income distribution is matched. At the same time, given our focus on heterogeneous migration patters by demographic groups, we test a battery of migration moments by homeownership, age and networth groups.

Figure 3: Population and Income

Panel A: Population | Panel B: Income

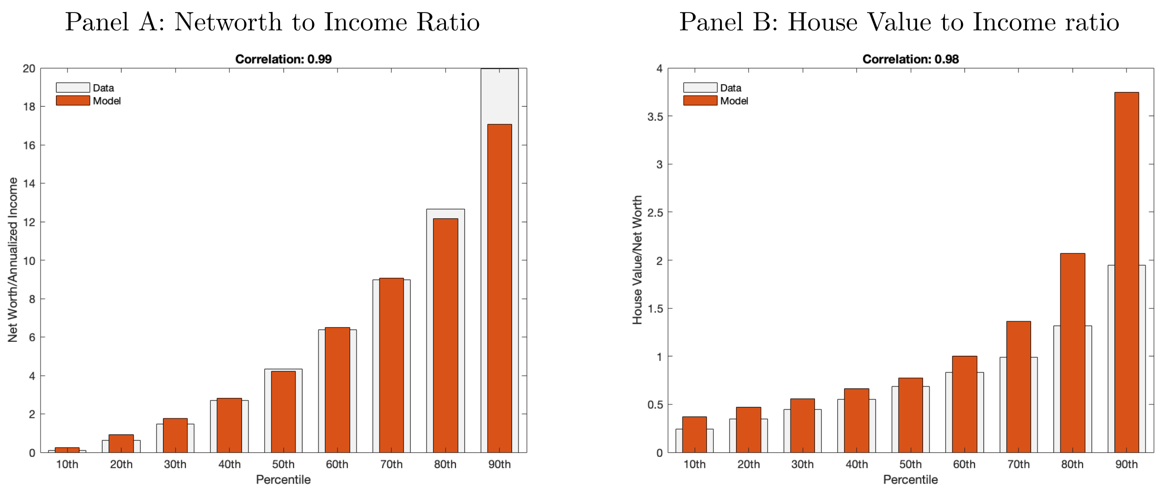



Notes: Figure 3 plots the population and income by CMA both in the data and in the model. Panel A plots population and Panel B plots income. Population and income in the data are computed using official migration rates from Statistics Canada and TransUnion.

**Population and Income** Panel A and panel B of figure 3 show how the model matches population and income per capita by location. The model matches population quite closely to the data. The city that diverges the most is Ottawa where the model suggests that Ottawa should be smaller than it actually is. One reason could be that being Ottawa the capital of Canada, there are forces outside the model that induce population and higher wages there. The match between data and model related to income per capita is also quite close. As for population, the city that differs the most is Ottawa.

**Networth and House Value** The distribution of networth to income and the distribution of house value to income ratio are shown in panel A and panel B of figure 4, respectively. The model matches closely the networth to income distribution for all of the income percentiles, except the 90th percentile. This might be due to the fact that we do not have any force in the model that generates households to keep extremely high levels of networth. Similarly to the networth to income ratio, we match the distribution of house price to income ratio well outside the 90th percentile. The two panels suggest that in the model people have higher housing networth to income than in the data but lower financial wealth. This is a direct consequence of housing being the only illiquid asset in the model.

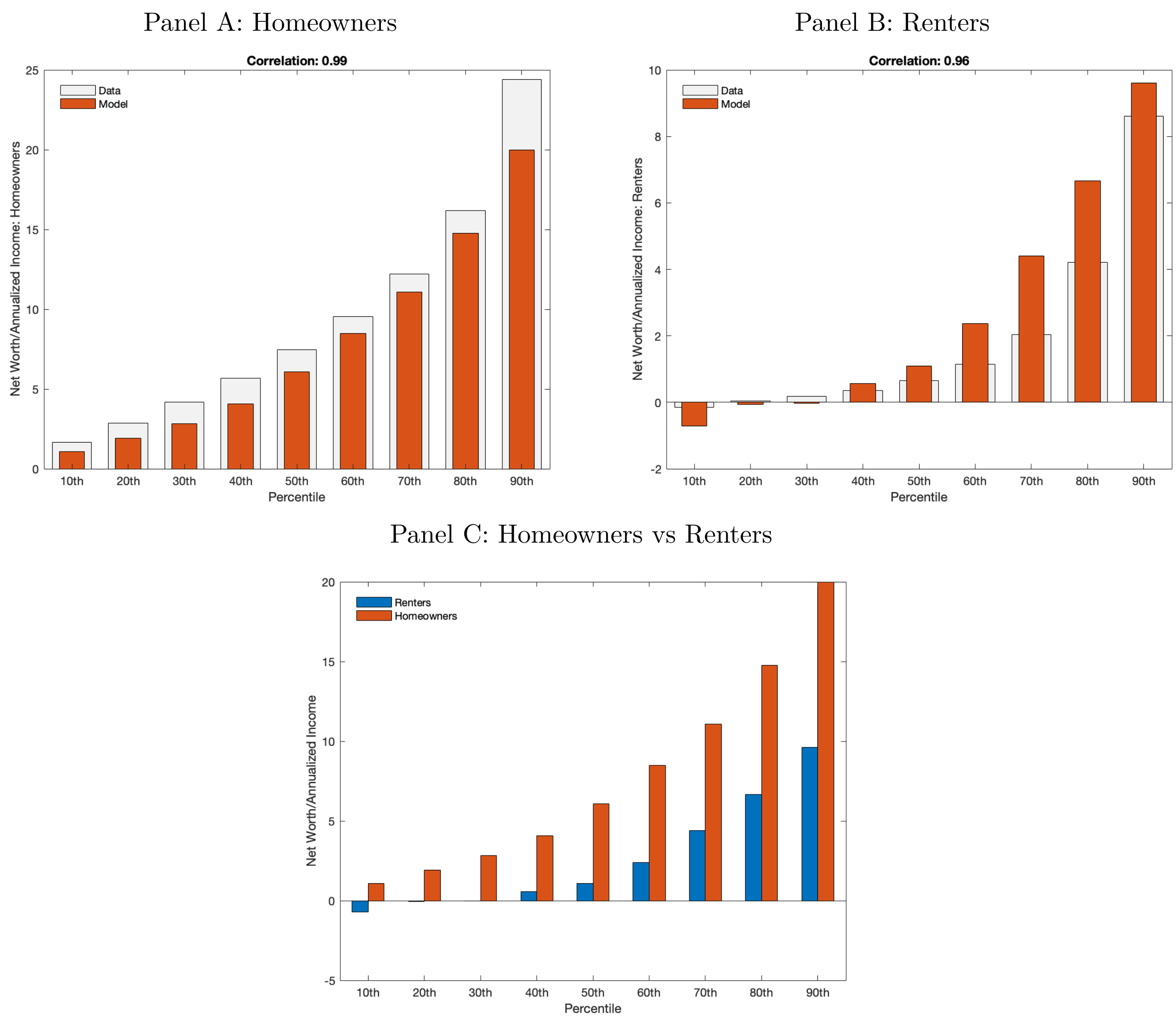
Figure 4: Distributions of Networth and House Value (divided by Income)




Notes: Figure 4 plots the networth to income ratio and the house value to income ratio by CMA both in the data and in the model. Panel A plots networth to income ratio and Panel B plots house value to income ratio. Networth to income ratio and the house value to income ratio are computed using official data from Statistics Canada.

To validate the model on the networth distribution moments by different groups of agents, we compare data and model on networth to income distribution by homeownership status and age group. Panel A of Figure 5 shows that the model and the data have a positive correlation in the networth distribution of the homeowners but the model produces a lower level of networth for homeowners than the data. Panel B shows the same distribution for renters where the correlation between model and data is 0.91. Although the model overstates the networth distribution for renters when compared to the data, panel C shows that the networth is always higher for homeowners than renters. Overall, homeowners have a distribution much more skewed to the right than the renters.

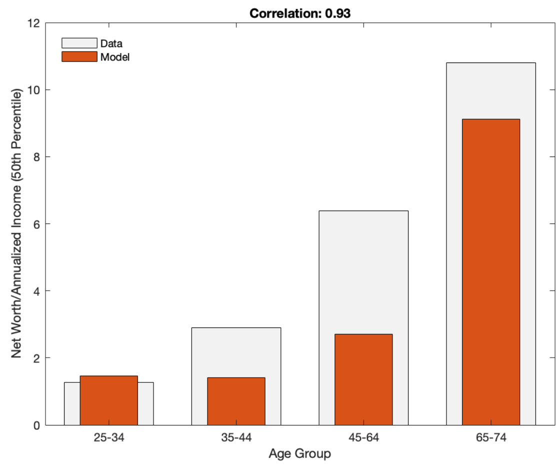
Figure 5: Data Matching Model: Networth-to-Income Ratio by Homeownership Status




Notes: Figure 5 plots the networth to income distribution for homeowners and renters, respectively, in panel A and in panel B. It compares the distributions both in the data and in the model. Panel C plots the comparison data vs model.

In figure 6 we report the 50th percentile of the networth to income distribution by age group. The correlation between data and model is 0.97 and the two distribution follow each other closely, especially for the older age groups.

Figure 6: Data Matching Model: Networth-to-Income Ratio (50th Percentile) by Age Groups

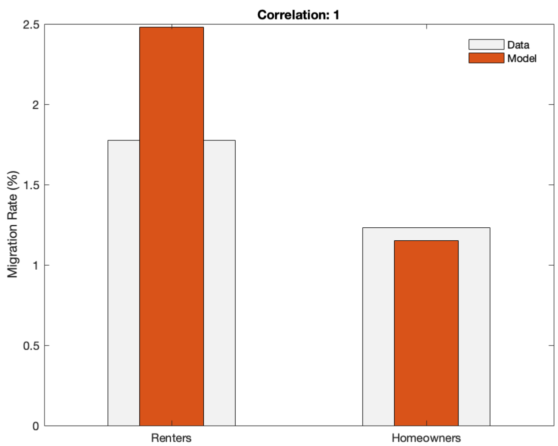



Notes: Figure 6 plots the 50th percentile of the networth to income distribution by age group and compares the distributions both in the data and in the model.

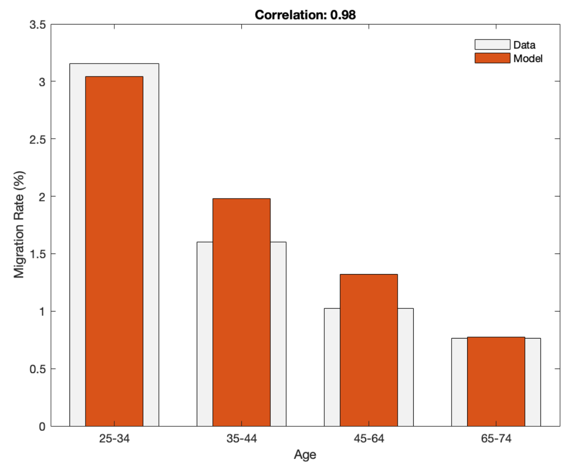
**Heterogeneous Migration Patterns** We now replicate our empirical evidence regarding migration patterns by demographic groups both in the data and in the model. We separately describe migration patterns by homeownership status, age and networth. Panel A of figure 7 depicts the migration probabilities by homeownership status. Overall, the differences between data and model are in the second decimal after the comma. As in the data, migration rate is higher for renters than homeowners. Panel B reproduces the migration rates by age group. The patterns suggest that there is much more variation in the data than in the model. The correlation is positive but the magnitudes differ, especially for the youngest group that seem to move more in the data than in the model. The left figure of Panel C shows the distribution of migration rates by networth in the model. We observe that individuals with higher networth move monotonically less than individuals with lower networth. We cannot directly compare this distribution with the data since we do not have data on networth. Our approach is to consider credit score as our measure of ability to borrow such networth is in the model. The right figure of panel C shows the migration rates in the data as in the empirical section. Both the model and the data suggest that migration rates decline with ability to borrow.

Figure 7: Data Matching Model: Migration

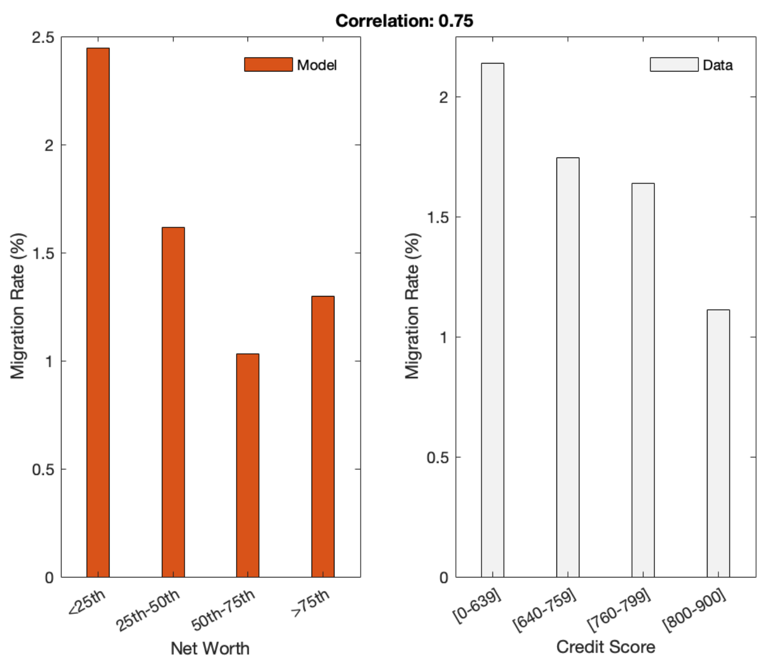
Panel A: By Homeowner




Panel B: By Age




Panel C: By Assets




Notes: Figure 7 plots the migration rates in the model by each of the demographic group of interest. Panel A plots it by homeowner status, panel B by age and panel C by networth on the left and by credit score on the right.

**Where are the movers going?** Given our interest on differential sorting of individuals to different locations based on the destination's characteristics, we analyze now in a more systematic way the city's characteristics that attract more agents.

Figure 8 shows how the model matches the data in terms of city “attractiveness". Which cities have the highest levels of in-migration rates? The attraction of cities, measured in terms

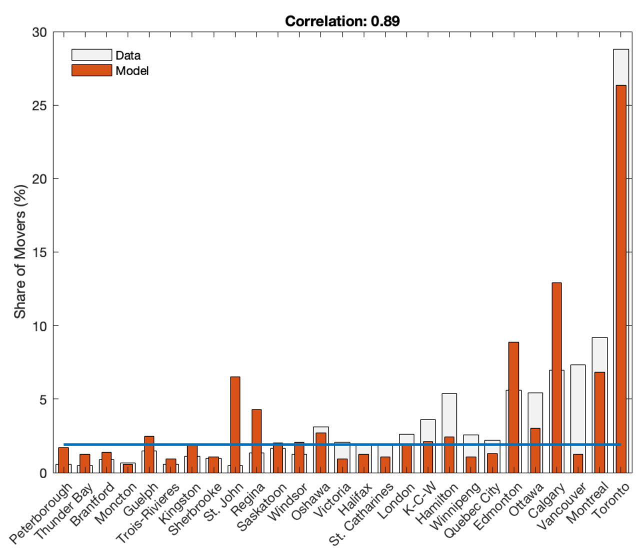
Table 5: Share of Migrants and Cities' Characteristics

| | Correlation | |
|---|---|---|
| Characteristics | Data | Model |
| Housing Prices | .46 | .24 |
| Housing Expenditures | -.04 | 0.01 |
| Population | .94 | .97 |
| Wages | .41 | .33 |
| TFP | .15 | .43 |
| Amenities | .89 | .79 |

Notes: This table reports the correlation between share of movers and characteristics of the cities where they move to. The same moment from data and model is reported.

of in-migration rates, is very heterogeneous. Overall, we observe that Toronto is the city that receives most migrants followed by Montreal. The red horizontal line indicates the average of in-migration rates. The model tends to underestimate in-migration in the cities with the highest median house prices as Toronto and Vancouver. This goes in line with the fact that house prices are a stronger determination of moving decisions in the model than in the data. This may reflect, in part, the house price heterogeneity within cities that is not present in the model. In fact, in the data, migrants tend to move to cities with higher median house prices, but choose to live in neighborhoods with house prices below the median.

Figure 8: In-Migration by cities




Notes: Figure 8 plots the in-migration rates in the model and in the data by destination. Cities are ordered in ascending order by population.

**Are Movers Upgrading?** An important part of our analysis is related to the *upgrading* or *downgrading* behaviour of agents. In other words, comparing two agents that move, they might choose different destinations which might affect the future stream of wages. In order to make the right policies, it is important to understand what are the characteristics of the agents that upgrade. We define upgrade in terms of housing prices and income as in the data section. In figure 9 we plot the upgraders based on their assets and age. Consistently with the data, we observe that middle age seem to upgrade more than young and old. In panel B, when we plot wages, younger upgrade consistently more than older and the relationship is monotonic. In panel C, we plot upgrading by asset level. When it comes to housing prices, the relationship is not very strong, but in the case of wages, it is clear that agents with higher levels of assets upgrade more to cities with higher wages.

# 5 Counterfactual Analysis

In this section, we conduct counterfactual analysis in several dimensions. First, we decrease migration costs, either monetary or non-monetary, by the same percentage. This could be interpreted as a moving subsidy. Second, we give a *moving voucher* to individuals in the Canadian Rust Belt. Third, we decrease housing regulations in Vancouver, replicating a potential decrease in zoning regulations.

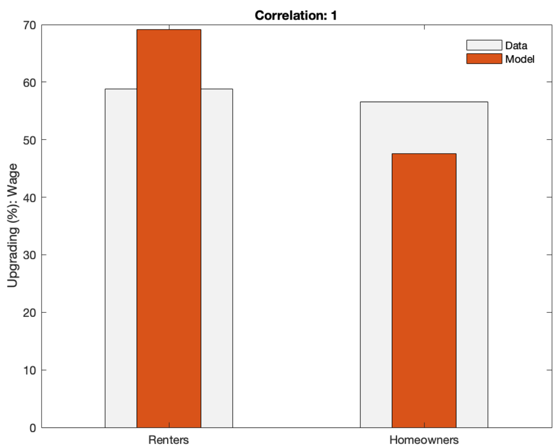
## 5.1 Decomposing the Moving Choice

In this section, we unpack moving choices by looking at the implications of reducing the migration costs, both monetary and non-monetary, on the moving probabilities and on the share of population moving to locations with better prospects. We do so by comparing steady-states with different moving costs in figure 10. The orange line with circle in each panel reports the steady-state computed above (baseline). The yellow line with crosses reports a steady-state with monetary moving costs set to 0 (Zero Monetary Cost). The black line with stars reports a steady-state with utility moving costs set to 0 (Zero Utility Cost).

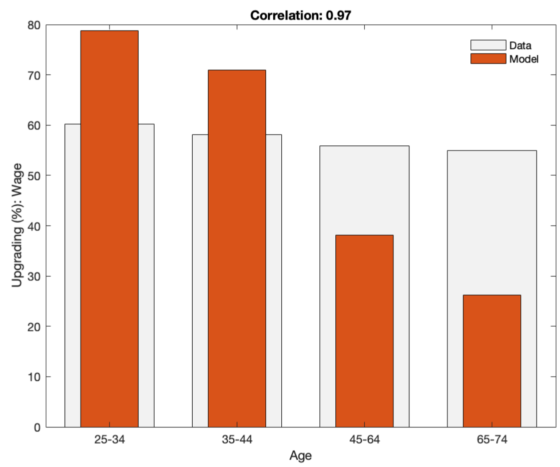
Panel A and B show the migration probabilities, by wealth and age, respectively. We observe that compared to the baseline changing monetary and utility moving costs has a completely different effect on the slope of the relationship both by wealth and by age. Specifically, when , when setting the utility moving cost to zero the slope becomes positive since agents now start moving much more randomly due to the preference shock becoming

Figure 9: Upgrading On Wages

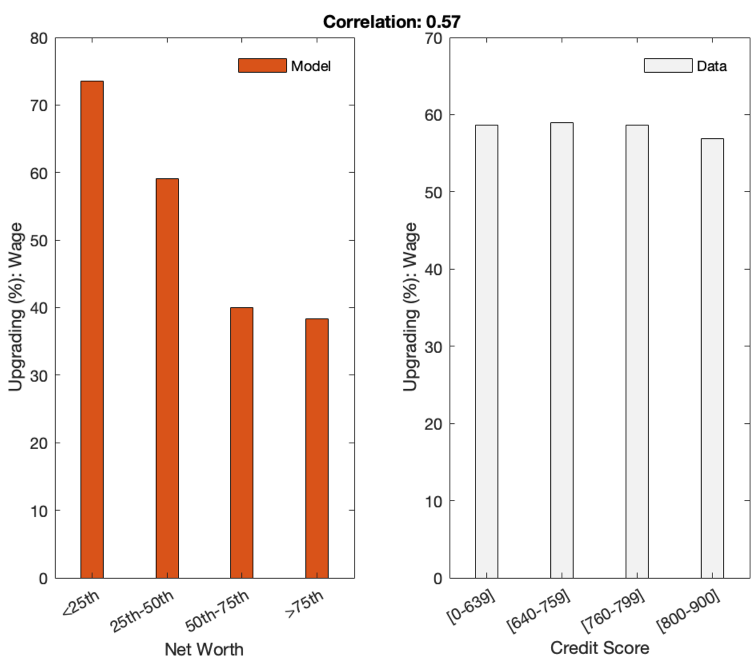
Panel A: By Homeowner




Panel B: By Age




Panel C: By Assets



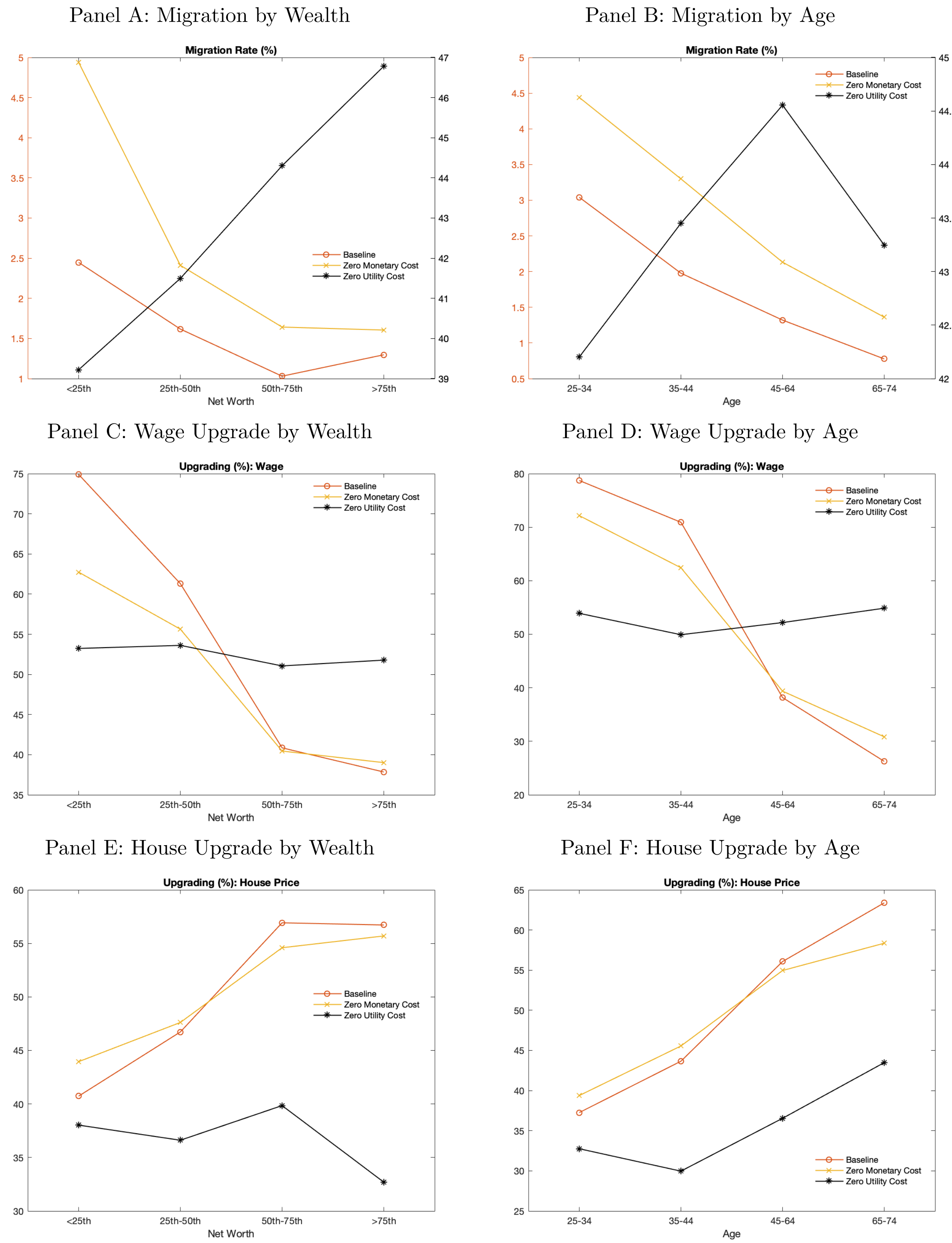

Notes: This figure 9 plots the upgrading share over wages by each of the demographic group of interest. Panel A plots it by homeowner status, panel B by age and panel C by networth on the left and by credit score on the right.

more relevant. Instead, when setting the monetary moving cost to 0 the slope becomes even more negative since the poorer and the wealthier get less constrained and their marginal value of wealth increases even more.

Panel C and D show the percentage of upgrading by wage conditional on moving by wealth and age, respectively. Compared to baseline when setting utility moving cost to zero the relationships become completely flat. This is because the main reason to move is just a random preference shock, so no endogenous motive for different groups. Instead, when removing the monetary moving costs, we find that the biggest changes largely happen for the poor and the young, who now upgrade less.

In the bottom two panels, we describe the upgrading patters over house prices by wealth and age, respectively. Compared to baseline the effect of a reduction in utility moving cost is similar to the one above for the same reasons. However, the effect of a reduction in monetary moving costs pushes the poor to move more to opportunity and the rich less. This is because now the poor are marginally richer so they can move to places that are more expensive conditional on moving.

Figure 10: Monetary vs Utility Moving Cost




To compare how differently moving costs behave in our model, we consider an economy with the monetary moving costs, $F_m$, 50% lower than in the baseline case for all the individuals in Canada. We find that the overall out-migration increases but only marginally. We find that migration rate remains almost unchanged, or decreases slightly, for homeowners, but increases almost 0.05p.p. for renters.

More interesting, we find that the patterns of moving to “opportunity" go in opposite direction of those find in an economy with lower utility moving costs. Overall, a moving subsidy to everyone in the country increases the share of individuals moving to locations with lower house prices by 0.21p.p. and with higher pages by 0.25p.p. Unsurprisingly, a lower monetary moving costs impacts mostly homeowners, younger and low networth individuals. Since the change in monetary cost is not high enough to induce more people to move than in the baseline economy, those that move use the monetary benefit to move to cities with higher wages and higher house prices. Therefore, people are more likely to choose new locations that gives them higher future wage streams, which cities that have usually higher house prices. This effect is stronger for younger and low networth individuals.

## 5.2 Moving Voucher from the Canadian “Rust Belt"

Ontario, as north-eastern the United States, was industrialized until 1980ies. Cities like London, Windsor, Thunder Bay and Peterborough were industrial powerhouses. With desindustrialization, poverty, crime, drug abuse, homelessness have been issues affecting these areas and job stagnation has been a severe issue. Similar issues have been rising in the US, in cities like Detroit and Cleveland, among others. Policymakers have been discussing changes in policy to lift individuals out of these areas to move to better “opportunity". Recently, during the US democratic presidential campaign, a former candidate, Andrew Yang, proposed a moving voucher to each individuals that decided to move out of unemployment areas. Through the lens of our model, we evaluate a related policy change giving a moving voucher to those unemployed living in what we define as the Canadian “Rust Belt". The experiment consists in giving a moving voucher for the value of $F_m$ to the unemployed individuals in London, Windsor, Thunder Bay and Peterborough.

Table 6 reports the results of in terms of migration rates out of these regions. Out-migration rates from these regions increase slightly, but when we decompose by demographic groups, we observe some degree of heterogeneity. For instance, homeowners seem to be more responsive than renters. The out-migration increases the most also for groups in the middle quartile of the networth distribution. When looking at age, we observe that younger people are the ones that react the most.

Table 6: Moving Voucher from the “Rust Belt": The Unemployed

| | **Baseline** | **Moving Subsidy**<br>Remove $F_m$ |
|---|---|---|
| Av. Out-migration | 3.1444% | 3.1626% |
| Av. Out-migration: Homeowners | 3.0248% | 3.1064% |
| Av. Out-migration: Renters | 3.3021% | 3.2566% |
| Av. Out-migration: Net Worth ($<$ 25th) | 3.2794% | 3.2974% |
| Av. Out-migration: Net Worth (25th-50th) | 3.2239% | 3.2495% |
| Av. Out-migration: Net Worth (50th-75th) | 2.9580% | 2.9864% |
| Av. Out-migration: Net Worth ($>$ 75th) | 2.7374% | 2.7510% |
| Av. Out-migration: Age $[25-34]$ | 3.0836% | 3.1116% |
| Av. Out-migration: Age $[35-44]$ | 3.1265% | 3.1255% |
| Av. Out-migration: Age $[45-64]$ | 3.1825% | 3.2055% |
| **Moving to “Opportunity" Share** | | |
| House Price | 23.78% | 23.25% |
| House Price, Homeowners | 23.98% | 23.18% |
| House Price, Renters | 22.92% | 23.68% |
| House Price, Net Worth ($<$ 25th) | 22.83% | 21.21% |
| House Price, Net Worth (25th-50th) | 22.77% | 22.41% |
| House Price, Net Worth (50th-75th) | 25.27% | 25.36% |
| House Price, Net Worth ($>$ 75th) | 27.14% | 26.83% |
| House Price, Age $[25-34]$ | 25.20% | 24.86% |
| House Price, Age $[35-44]$ | 24.75% | 23.61% |
| House Price, Age $[45-64]$ | 23.20% | 22.78% |
| Wage | 68.16% | 68.29% |
| Wage, Homeowners | 66.67% | 67.70% |
| Wage, Renters | 74.42% | 71.67% |
| Wage, Net Worth ($<$ 25th) | 73.74% | 75.40% |
| Wage, Net Worth (25th-50th) | 69.86% | 69.98% |
| Wage, Net Worth (50th-75th) | 60.87% | 59.79% |
| Wage, Net Worth ($>$ 75th) | 67.00% | 65.87% |
| Wage, Age $[25-34]$ | 70.79% | 70.10% |
| Wage, Age $[35-44]$ | 69.70% | 70.43% |
| Wage, Age $[45-64]$ | 67.16% | 67.20% |
| In-migration to Toronto | 16.52% | 16.33% |

Note: This table reports the results of moving rates generated in the steady state in the model as in the previous section in the baseline column (1). In column (2) reports the results for an economy where $F_m$ is set to 0 for all the unemployed that move out from the “Rust Belt" cities.

In the bottom part of table 6, we describe how individuals would move to “opportunity" by upgrading to locations with lower house prices or higher wages than the ones were they are originally from. Since, cities in the rust belt tend to have lower house prices and wages, people tend to move to places with higher house prices and wages. Overall, we observe that there is a 0.5p.p. increase in individuals that would move to locations with higher house prices. At the same time, there is a .13p.p. increase in individuals that would move to locations with higher wages.

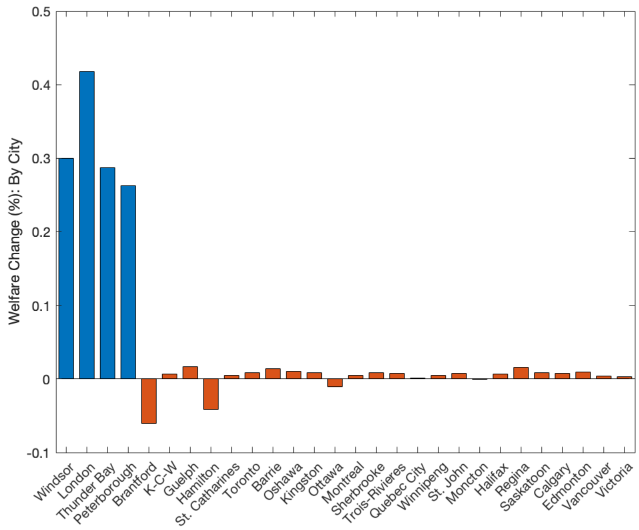
Table 7: Welfare Change(%): Moving Voucher from the “Rust Belt"

| | Whole Canada | Whole Ontario | Rust Belt |
|---|---|---|---|
| All | 0.0242 | 0.0467 | 0.3927 |
| Homeowners | -0.1386 | -0.2786 | -0.2790 |
| Renters | 0.2438 | 0.4906 | 0.9593 |
| Low Net Worth | 0.0656 | 0.1041 | 0.4714 |
| High Net Worth | -0.0421 | -0.1070 | 0.0668 |
| Young (<45) | 0.0119 | 0.0275 | 0.3366 |
| Mature ($\geq 45$) | 0.0301 | 0.0550 | 0.3475 |

Note: This table reports the welfare changes by different demographic groups generated in the new steady state in the model where $F_m$ is set to 0 for all the unemployed that move out from the “Rust Belt" cities.

Table 7 reports the estimates of welfare changes for the whole country in column (1) and for the “Rust Belt" cities in column (2) overall and by demographic groups. Overall, welfare for individuals from “Rust Belt" areas would increase, on average, by 0.39% while Canadian welfare would increase by only 0.0242%. This small number is not surprising given the small weight of these cities in the overall Canadian economy. Individuals with low networth would benefit the most and renters as well. When examining figure 11, we observe that the large increase in welfare are coming mostly from the “Rust Belt" cities, however, the large cities, especially the closest ones, are impacted negatively.

Figure 11: Welfare Changes by City (%): Moving Voucher from the “Rust Belt"

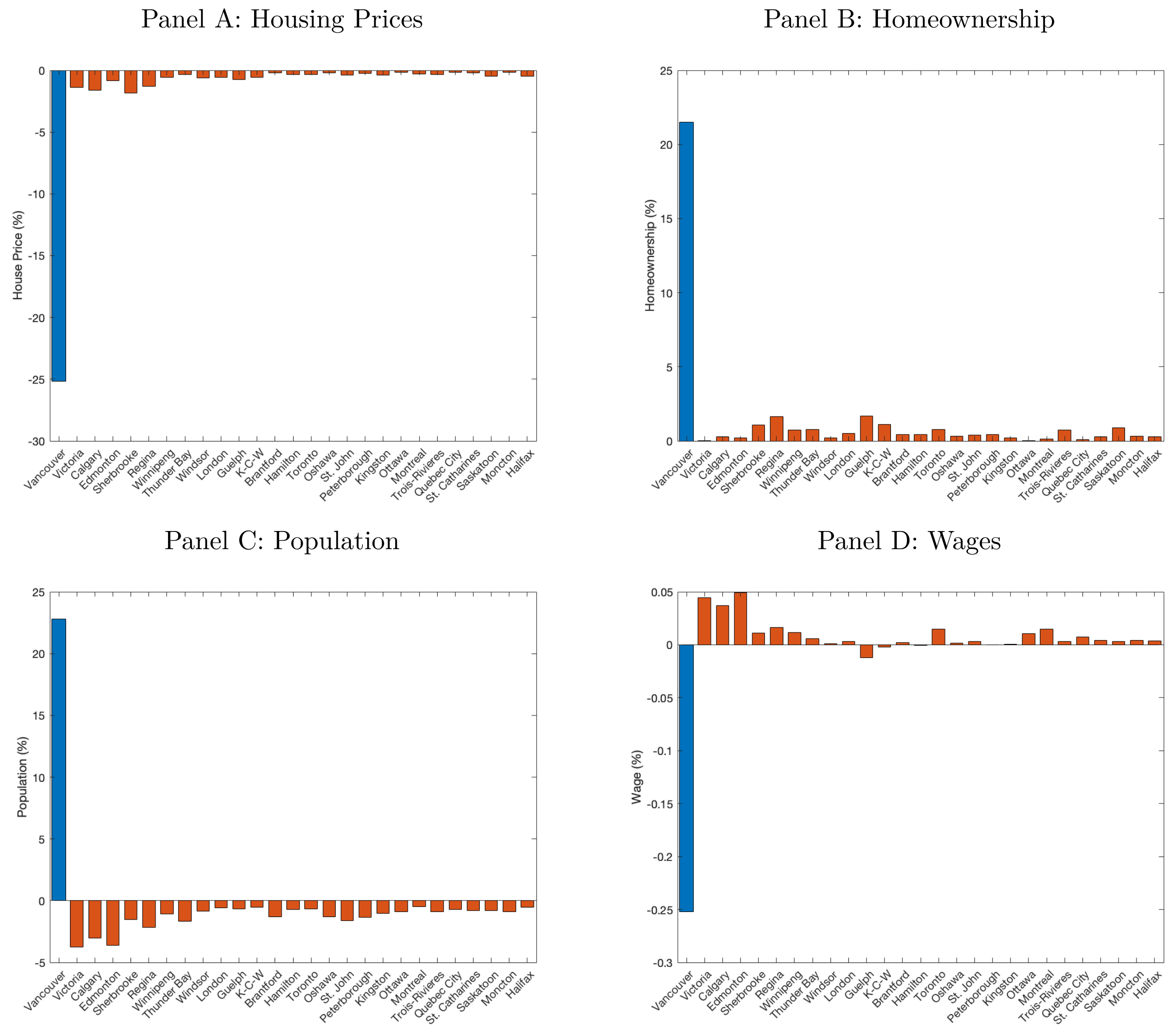



Note: This figure describes the welfare changes in each city generated in the new steady state in the model where $F_m$ is set to 0 in all the “Rust Belt" cities.

## 5.3 Releasing Housing Regulations in the Top Cities: The Vancouver Experiment

Recently, policy makers, politicians and economists have discussed changes in housing regulations in several cities with very high house prices. Zoning restrictions are a constraint to the supply of housing and have been pointed out as one of the main factors that explains the tremendous increase in house prices. Cities such as Vancouver in Canada or San Francisco in the US, are among the most expensive cities in the world. Yet, regulations to build are really tight. In Vancouver, for instance, 52% of the land can only have single family houses. What if, according to the discussion in the media, such regulations were lifted? Exploiting the rich structure of our model, we implement a plausible counterfactual experiment that decreases housing regulations in zoning in the city of Vancouver by 50%. How the welfare of different agents would be impacted? Would some individuals upgrade rather downgrade? Could more people move to Vancouver? To map the potential change of housing regulations to our model, we increase the land permits for construction, $\bar{L}$, by 50%. This is the experiment that we run through the lens of our model.

Figure 12: Impact of Higher Construction Permits in Vancouver



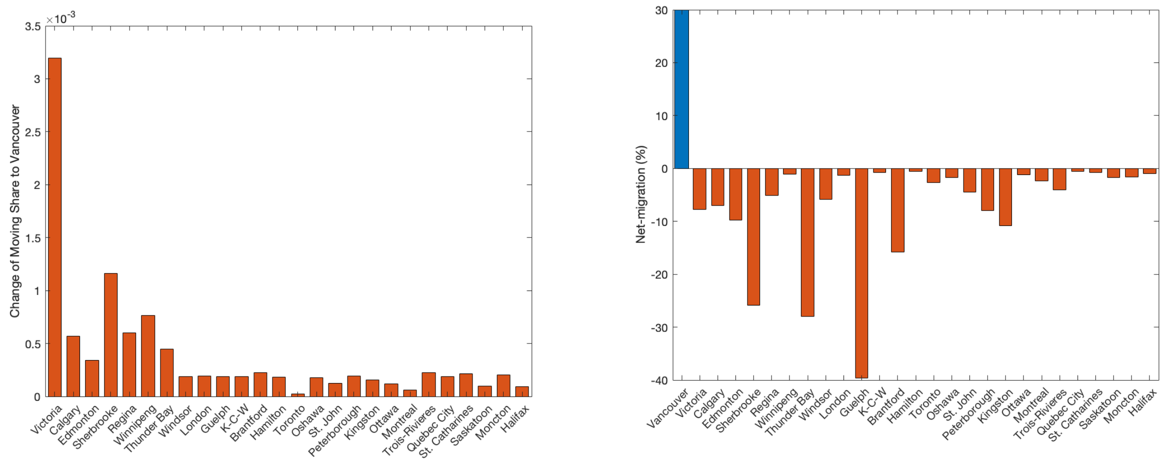

*Note:* Figure 12 plots the percentage difference between the steady state with higher $\bar{L}$ in Vancouver and the baseline economy for house prices (panel A) and homeownership rate (panel B), population (panel C) and wages (panel D).

An increase in the land permits for construction has immediate consequence an expansion of the housing supply and a decrease in house prices. As shown in panel A of figure 12 the house price in Vancouver is 35% lower in the steady state with the higher $\bar{L}$ than in the baseline economy. Such a lower price in a city like Vancouver attracts people from all over Canada. In Panel B we see that population in Vancouver is 40% higher than in the baseline economy. This higher population is driven by a higher retention of population in Vancouver and by the fact that any migrant is much more likely to move to Vancouver in the new steady state (Panel A of figure 13). Not surprisingly, the closer to Vancouver, the relative higher probability of moving to Vancouver conditional on moving. Moreover, we see in panel B that Vancouver is the only city that has a higher net-migration rate in the new steady-state when compared to the baseline economy. In all the other cities, net-migration is lower.

Figure 13: Moving Responses by City

Panel A: Change of Moving Share to Vancouver

Panel B: Change of Net-migration




Note: Panel A of this figure describes the change in moving share from each city in the sample to Vancouver between the baseline economy and the economy where $\bar{L}$ in Vancouver is set to be 1.5 times higher than in the baseline. Cities are ordered from left to right with increasing distance from Vancouver. Panel B describes the change in moving share from each city in the sample to Vancouver between the baseline economy and the economy where $\bar{L}$ in Vancouver is set to be 1.5 times higher than in the baseline. Cities are ordered from left to right with increasing distance from Vancouver.

The higher concentration in Vancouver leads to lower wages in Vancouver. However, house prices fall relatively more than wages when compared to the initial steady-state, which implies a higher "real wage", which reinforces the attractiveness of Vancouver and explains why relatively more people choose this city when decide to migrate.

Table 8: A Decrease in Housing Regulations in Vancouver

| | **Baseline** | **High Vancouver $\overline{L}$** |
|---|---|---|
| Av. Out-migration | 1.4902% | 1.4893% |
| Av. Out-migration: Homeowners | 1.3822% | 1.3679% |
| Av. Out-migration: Renters | 1.7390% | 1.7893% |
| Av. Out-migration: Net Worth ($<$ 25th) | 1.8847% | 1.8945% |
| Av. Out-migration: Net Worth (25th-50th) | 1.6196% | 1.6182% |
| Av. Out-migration: Net Worth (50th-75th) | 1.3895% | 1.3968% |
| Av. Out-migration: Net Worth ($>$ 75th) | 1.1495% | 1.1388% |
| Av. Out-migration: Age $[25-34]$ | 1.6480% | 1.6481% |
| Av. Out-migration: Age $[35-44]$ | 1.5916% | 1.5915% |
| Av. Out-migration: Age $[45-64]$ | 1.5248% | 1.5235% |
| Av. Out-migration: Age $[65-74]$ | 1.4762% | 1.4741% |
| Av. Out-migration: Age $[75-84]$ | 1.2256% | 1.2245% |
| **Moving to "Opportunity" Share** | | |
| House Price | 46.73% | 46.97% |
| House Price, Homeowners | 45.72% | 45.66% |
| House Price, Renters | 52.95% | 55.09% |
| House Price, Net Worth ($<$ 25th) | 36.48% | 37.12% |
| House Price, Net Worth (25th-50th) | 42.85% | 44.08% |
| House Price, Net Worth (50th-75th) | 48.98% | 50.73% |
| House Price, Net Worth ($>$ 75th) | 60.34% | 56.85% |
| House Price, Age $[25-34]$ | 44.13% | 43.16% |
| House Price, Age $[35-44]$ | 45.54% | 46.30% |
| House Price, Age $[45-64]$ | 47.21% | 47.88% |
| House Price, Age $[65-74]$ | 48.54% | 48.60% |
| House Price, Age $[75-84]$ | 47.59% | 47.36% |
| Wage | 54.52% | 55.72% |
| Wage, Homeowners | 51.93% | 53.16% |
| Wage, Renters | 70.51% | 71.56% |
| Wage, Net Worth ($<$ 25th) | 69.36% | 69.89% |
| Wage, Net Worth (25th-50th) | 64.55% | 65.63% |
| Wage, Net Worth (50th-75th) | 48.38% | 49.24% |
| Wage, Net Worth ($>$ 75th) | 31.71% | 33.27% |
| Wage, Age $[25-34]$ | 62.49% | 63.11% |
| Wage, Age $[35-44]$ | 59.20% | 60.60% |
| Wage, Age $[45-64]$ | 54.06% | 55.43% |
| Wage, Age $[65-74]$ | 48.19% | 49.38% |
| Wage, Age $[75-84]$ | 48.19% | 49.06% |
| In-migration to Toronto | 13.86% | 13.80% |
| In-migration to Vancouver | 4.64% | 4.93% |

Note: This table reports the results of moving rates generated in the steady state in the model as in the previous section in the baseline column (1). In column (2) reports the results for an economy where $\bar{L}$ for Vancouver is 50% permanently lower than in the baseline economy.

Despite a different distribution of people across space in the new steady-state, average out-migration remains at similar level than in the previous economy, as reported in 8. In the long-run, an economy with lower house prices in Vancouver does not induce higher migration flows, only affects the destination of those that decide to migrate. In other words, although more people move to Vancouver, migration rate remains unchanged because people that would otherwise move to other cities move now to Vancouver and the outflow from Vancouver decreases.

However, there are some differences across groups. Specifically, the out-migration rates for renters would increase by 0.05p.p. in the entire Canada. When we look at out-migration by networth, we observe that it would increase by 0.01p.p. for the ones with lowest networth. When we look at age groups, we differences are extremely tiny. In the bottom part of the table, that describes the characteristics of the places where individuals would move, we observe there would be an increase of .24p.p. in the share of individuals moving to places with higher house prices and 1.2% in the share of individuals moving to locations with higher wages. Decomposing by demographic groups, we observe that renters benefit the most in terms of moving to locations with higher house prices. In terms of networth, the model suggest that individuals with lower networth are the once moving to locations with higher house prices. Difference across age groups do not seem to be striking. Instead, regarding wages, both homeowners and non-homeowners are moving more to locations with higher wages. The same is true for individuals splitted by networth. The same is true when we divide demographic groups by age.

Table 9: Welfare Change (%): A Decrease in Housing Regulations in Vancouver

| | Whole Canada | Vancouver |
|---|---|---|
| All | 0.5499 | 5.8255 |
| Homeowners | 0.4540 | 4.6664 |
| Renters | 0.6733 | 7.2800 |
| Low Net Worth | 0.6116 | 6.7345 |
| High Net Worth | 0.4388 | 4.3780 |
| Young (<45) | 0.7632 | 6.6657 |
| Mature ($\geq$ 45) | 0.3707 | 4.6570 |

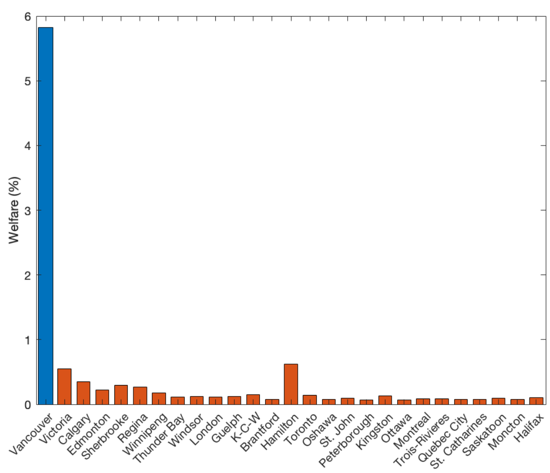
Note: This table reports the results of moving rates generated in the steady state in the model as in the previous section in the baseline column (1). In column (2) we report the welfare changes for an economy where $\bar{L}$ for Vancouver is 50% permanently lower than in the baseline economy. In column (3) we report the welfare changes for those in Vancouver.

Although in short run, a decrease in wages and house prices may affect negatively welfare in Vancouver, mainly to homeowners, in the long-run the welfare gains are very significant. This is explained by the increase in "real income" in the long-run induced by this policy. Table 9 reports the welfare calculation of the change in policy in Vancouver for Canada as a whole in column (1) and for Vancouver, specifically in column (2). This table reports that in the new steady-state, welfare in Vancouver would be approximately 5% higher. The biggest beneficiaries would be young renters with low networth. Homeowners benefit less, despite the increase in "real income" since lower house prices induce lower house wealth at the end of their lives. Housing in fact becomes less attractive as a saving mechanism as house prices drop.

The welfare in the overall Canada are also significant. Overall, welfare in Canada would 0.57% higher. The main benefit comes from the higher wages in the other locations induced by the higher concentration of people in Vancouver. House prices decrease very little, so "real income" increases across Canada. Most of the welfare gains come from homeowners, while for renters, in aggregate the effect is negative. This is due to a compositional effect. Higher wages induce a higher homeownership rate. Those that remain renters are those which have on average lower welfare. When we look at welfare by networth, we observe that high networth would benefit the most, overall, following the same reasoning. Finally, when decomposing by age group, we find that both young and mature would benefit, with youngest the most.

Figure 14 reports the welfare gain in each Canadian city. Cities are plotted with increasing distance from Vancouver. Welfare gains are similarly distributed across cities with the highest spikes in Regina and Hamilton.

Figure 14: Welfare Changes by City (%): A Decrease in Housing Regulations in Vancouver




Note: This figure describes the welfare changes in each city generated in the new steady state in the model where $\bar{L}$ in Vancouver is set to be 1.5 times than in the baseline. Cities are ordered from left to right with increasing distance from Vancouver, which welfare effect is reported in blue.

# 6 Conclusions

Location is one of the most important decisions in life. However, evidence suggests that some demographic groups have hard time moving and, also, moving to "opportunity". Several reasons have been pointed out. We developed a dynamic model with agents that differ in assets, age, endogenous housing status and where individuals sort into different locations based on these characteristics.

This is the first quantitative dynamic location model to feature sorting of agents across locations based on their assets, age and home-ownership status. We motivate the main assumptions of the model by exploiting evidence on migration patterns by demographic groups in Canada. We apply the model to the data by calibrating it to 28 Canadian cities, with a mix of reduced form and structural estimation. We validate the model by comparing key moments, such as the networth distribution and the migration decisions, with the data.

We, then, use the model to run several counterfactuals. First, we "unpack moving" by reducing the moving costs. A 10% subsidy in moving, if disbursed in utility terms, would increase the migration rates by almost 50%. At the same time, would induce a lower share of movers to move to "opportunity". Second, we, apply the model to study a decrease in housing regulation in one of the most expensive cities in the world, Vancouver. We find that removing zoning in Vancouver might increase welfare by approximately 5% in Vancouver and by .57% in Canada overall.

Understanding how individuals make their location decisions and how this affects welfare, both in the short and in the long-run, is a question that many economists and policy makers are after. Through the lens of our model several complementary analyses can be conducted. First, how can an aging population affect the overall slow down in mobility rates in the US? Second, how a temporary unemployment shock to the family can translate to permanent consequences if individuals move to a worse neighborhood characterized by less positive spillover effects. All these questions are in need for an answer. We believe that our framework provides a benchmark to shade new lights on an important decision such as location choice and can serve as a tool to continue in the quest for "unpacking moving".

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# A Tables

Table 10: Heterogeneous Migration Responses (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: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 11: Heterogeneous Migration Responses

| | (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 $\times$ Year Fixed-Effects | No | No | No | No | Yes | Yes | Yes | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 12: Heterogeneous Migration Responses (CMA)

| | (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: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 13: Moving Where? - Definition II

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| Homeowner | 0.944*** | 0.615*** | -0.964 | -2.363*** | 0.016 | -0.801 | 0.755** | 0.633 |
| | (0.285) | (0.214) | (0.908) | (0.601) | (0.547) | (0.592) | (0.320) | (0.394) |
| Age [36-45] | 0.632** | -0.375** | 0.639* | -0.905*** | -1.130*** | -1.463*** | 0.142 | 0.067 |
| | (0.307) | (0.174) | (0.338) | (0.283) | (0.210) | (0.301) | (0.327) | (0.334) |
| Age [46-65] | 3.502*** | -1.226*** | -0.443 | -4.452*** | -4.303*** | -6.356*** | 1.929*** | 0.620 |
| | (0.550) | (0.183) | (0.764) | (0.925) | (0.711) | (0.925) | (0.565) | (0.596) |
| Age [66-75] | 5.679*** | -1.932*** | -1.368 | -6.993*** | -6.535*** | -10.071*** | 3.149*** | 0.813 |
| | (0.835) | (0.381) | (1.597) | (1.409) | (1.124) | (1.438) | (0.759) | (0.758) |
| Age [76-85] | 4.832*** | -1.862*** | -1.394 | -6.244*** | -5.677*** | -8.333*** | 2.395*** | 0.639 |
| | (0.730) | (0.462) | (1.842) | (1.323) | (1.060) | (1.439) | (0.729) | (0.775) |
| Credit Score [640-759] | -2.627*** | 0.036 | 0.551 | 3.727*** | 1.877*** | 1.799*** | -2.017*** | -1.998*** |
| | (0.398) | (0.401) | (0.856) | (0.771) | (0.418) | (0.555) | (0.382) | (0.396) |
| Credit Score [760-799] | -3.392*** | 0.154 | 0.566 | 5.192*** | 2.338*** | 1.815** | -2.783*** | -2.912*** |
| | (0.536) | (0.587) | (1.149) | (1.146) | (0.639) | (0.849) | (0.573) | (0.615) |
| Credit Score [800-900] | -3.546*** | 0.647 | 0.067 | 5.278*** | 2.933*** | 1.384 | -2.787*** | -3.237*** |
| | (0.619) | (0.551) | (1.090) | (1.163) | (0.708) | (0.941) | (0.674) | (0.744) |
| Observations | 3270066 | 2410812 | 1768011 | 3242807 | 3188731 | 3188532 | 2785001 | 2784668 |
| Adjusted $R^2$ | 0.294 | 0.420 | 0.332 | 0.409 | 0.328 | 0.322 | 0.280 | 0.265 |
| City $\times$ Year Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 14: Moving Where? (CMAs)

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| Homeowner | 0.332 | 0.780* | -0.416 | -1.529** | -0.571 | -0.769 | 0.233 | 0.288 |
| | (0.362) | (0.418) | (0.556) | (0.594) | (0.725) | (0.562) | (0.361) | (0.375) |
| Age [36-45] | 0.421 | -0.329 | 0.683* | -0.242 | -0.829** | -0.879*** | 0.178 | 0.052 |
| | (0.401) | (0.250) | (0.366) | (0.299) | (0.325) | (0.286) | (0.366) | (0.362) |
| Age [46-65] | 2.478*** | -0.965 | 0.093 | -1.787** | -3.650*** | -4.043*** | 1.873*** | 1.330** |
| | (0.568) | (0.603) | (0.649) | (0.735) | (0.531) | (0.428) | (0.579) | (0.589) |
| Age [66-75] | 3.969*** | -1.505 | -0.588 | -3.591*** | -5.849*** | -7.031*** | 2.904*** | 1.824** |
| | (0.832) | (1.075) | (1.188) | (1.240) | (0.910) | (0.742) | (0.755) | (0.728) |
| Age [76-85] | 3.250*** | -1.251 | -0.566 | -3.780*** | -5.198*** | -6.175*** | 2.343*** | 1.692** |
| | (0.693) | (0.962) | (1.326) | (1.255) | (1.123) | (0.987) | (0.680) | (0.671) |
| Credit Score [640-759] | -1.498*** | -0.333 | 0.375 | 2.649*** | 1.052** | 0.985*** | -1.498*** | -1.560*** |
| | (0.290) | (0.656) | (0.722) | (0.920) | (0.390) | (0.341) | (0.382) | (0.397) |
| Credit Score [760-799] | -1.808*** | -0.168 | 0.174 | 3.299** | 1.060* | 0.878* | -1.941*** | -2.167*** |
| | (0.509) | (0.992) | (0.896) | (1.216) | (0.534) | (0.469) | (0.553) | (0.560) |
| Credit Score [800-900] | -1.702** | 0.340 | -0.390 | 2.962** | 1.568** | 0.880 | -1.733*** | -2.074*** |
| | (0.633) | (0.938) | (0.829) | (1.184) | (0.646) | (0.631) | (0.601) | (0.608) |
| Observations | 1781695 | 1781695 | 1571674 | 1781695 | 1781695 | 1781695 | 1551194 | 1551194 |
| Adjusted $R^2$ | 0.304 | 0.412 | 0.392 | 0.510 | 0.455 | 0.438 | 0.306 | 0.306 |
| City $\times$ Year Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 15

Moving Where? - Definition II ( CMAs)

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| Homeowner | 0.737* | 0.879** | -0.393 | -1.470** | 0.379 | -0.060 | 0.600 | 0.727* |
| | (0.428) | (0.417) | (0.556) | (0.586) | (0.499) | (0.416) | (0.368) | (0.400) |
| Age [36-45] | 0.497 | -0.134 | 0.717* | -0.226 | -0.686** | -0.735** | 0.207 | 0.282 |
| | (0.392) | (0.175) | (0.373) | (0.302) | (0.256) | (0.300) | (0.375) | (0.367) |
| Age [46-65] | 2.350*** | -0.683*** | 0.137 | -1.800** | -3.080*** | -3.871*** | 1.738*** | 1.403** |
| | (0.509) | (0.192) | (0.651) | (0.739) | (0.429) | (0.450) | (0.524) | (0.526) |
| Age [66-75] | 4.000*** | -0.809* | -0.490 | -3.618*** | -4.462*** | -6.178*** | 2.674*** | 2.050*** |
| | (0.824) | (0.450) | (1.191) | (1.245) | (0.563) | (0.682) | (0.744) | (0.681) |
| Age [76-85] | 3.288*** | -0.795 | -0.420 | -3.781*** | -3.826*** | -4.822*** | 2.404*** | 1.978*** |
| | (0.657) | (0.520) | (1.332) | (1.261) | (0.616) | (0.745) | (0.661) | (0.674) |
| Credit Score [640-759] | -1.806*** | -0.434 | 0.294 | 2.555*** | 0.926*** | 0.659 | -1.732*** | -1.861*** |
| | (0.348) | (0.569) | (0.726) | (0.898) | (0.307) | (0.467) | (0.449) | (0.484) |
| Credit Score [760-799] | -2.229*** | -0.455 | 0.087 | 3.164** | 1.018** | 0.271 | -2.313*** | -2.558*** |
| | (0.531) | (0.839) | (0.902) | (1.185) | (0.456) | (0.756) | (0.621) | (0.674) |
| Credit Score [800-900] | -2.212*** | 0.028 | -0.464 | 2.845** | 1.470** | -0.116 | -2.221*** | -2.680*** |
| | (0.629) | (0.778) | (0.837) | (1.163) | (0.597) | (0.955) | (0.681) | (0.749) |
| Observations | 1781695 | 1781695 | 1571674 | 1781695 | 1781695 | 1781695 | 1551194 | 1551194 |
| Adjusted $R^2$ | 0.314 | 0.445 | 0.385 | 0.522 | 0.396 | 0.384 | 0.302 | 0.293 |
| City $\times$ Year Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

Table 16: Moving Decomposition

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| All | 49.68 | 51.06 | 23.82 | 47.84 | 49.29 | 48.32 | 49.28 | 49.31 |
| Homeowners | 50.37 | 50.79 | 22.93 | 46.78 | 47.97 | 46.1 | 49.37 | 48.96 |
| Renters | 49.62 | 51.25 | 24.17 | 48.04 | 49.59 | 48.97 | 49.42 | 49.62 |
| Age [25-35] | 48.05 | 50.99 | 24.39 | 49.68 | 50.79 | 50.54 | 47.99 | 48.42 |
| Age [36-45] | 50.15 | 52.23 | 24.79 | 47.12 | 49.44 | 48.39 | 49.83 | 49.99 |
| Age [46-65] | 51.32 | 50.65 | 22.86 | 46.07 | 47.48 | 45.75 | 50.39 | 49.88 |
| Age [66-75] | 51.8 | 49.61 | 20.74 | 45.6 | 47.02 | 44.84 | 50.96 | 50.23 |
| Age [76-85] | 47.59 | 49.11 | 20.68 | 50.32 | 50.32 | 50.05 | 48.09 | 49.12 |
| Credit Score [0-639] | 48.58 | 50.99 | 24.44 | 48.46 | 49.86 | 49.58 | 49.09 | 49.45 |
| Credit Score [640-759] | 49.61 | 51.25 | 24.04 | 47.88 | 49.63 | 48.9 | 49.36 | 49.51 |
| Credit Score [760-799] | 49.66 | 50.97 | 23.87 | 48.25 | 49.43 | 48.38 | 49.01 | 48.95 |
| Credit Score [800-900] | 50.64 | 50.86 | 22.97 | 47.05 | 48.25 | 46.39 | 49.47 | 49.11 |
| Credit Usage - Qt 1 | 49.66 | 51.15 | 24.95 | 48.14 | 49.57 | 48.53 | 48.89 | 48.89 |
| Credit Usage - Qt 2 | 50.78 | 51.47 | 24.02 | 47.28 | 48.97 | 47.44 | 49.72 | 49.62 |
| Credit Usage - Qt 3 | 50.21 | 51.37 | 23.33 | 47.36 | 48.68 | 47.58 | 49.68 | 49.56 |
| Credit Usage - Qt 4 | 49.31 | 51.16 | 23.5 | 48.01 | 48.93 | 48.2 | 49.18 | 49.29 |
| Credit Usage - QtE | 50.24 | 50.74 | 22.98 | 46.83 | 48.64 | 47.25 | 49.65 | 49.46 |

Table 17: Moving Decomposition - Definition II

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| All | 57.05 | 60.55 | 24.07 | 48.58 | 62.61 | 56.38 | 53.97 | 54.24 |
| Homeowners | 57.93 | 60.41 | 23.22 | 47.5 | 61.72 | 54.35 | 54.26 | 54.07 |
| Renters | 56.87 | 60.72 | 24.41 | 48.78 | 62.77 | 57 | 54.02 | 54.45 |
| Age [25-35] | 55.11 | 60.35 | 24.61 | 50.48 | 63.68 | 58.6 | 52.62 | 53.24 |
| Age [36-45] | 57.51 | 61.81 | 25.05 | 47.91 | 62.74 | 56.57 | 54.6 | 55.01 |
| Age [46-65] | 58.94 | 60.24 | 23.16 | 46.76 | 61.14 | 53.68 | 55.15 | 54.84 |
| Age [66-75] | 59.65 | 59.18 | 21.08 | 46.18 | 61.29 | 52.94 | 55.59 | 55.26 |
| Age [76-85] | 56.22 | 58.8 | 21.06 | 50.89 | 64.44 | 58.32 | 52.81 | 54.18 |
| Credit Score [0-639] | 57.21 | 60.7 | 24.8 | 49.29 | 62.37 | 57.25 | 54.12 | 54.73 |
| Credit Score [640-759] | 56.97 | 60.83 | 24.29 | 48.6 | 62.89 | 57.05 | 54.06 | 54.44 |
| Credit Score [760-799] | 56.53 | 60.29 | 24.09 | 48.95 | 63.04 | 56.64 | 53.51 | 53.8 |
| Credit Score [800-900] | 57.36 | 60.14 | 23.21 | 47.79 | 62.1 | 54.48 | 54 | 53.8 |
| Credit Usage - Qt 1 | 55.93 | 60.62 | 25.12 | 48.81 | 62.79 | 56.27 | 53.22 | 53.43 |
| Credit Usage - Qt 2 | 56.88 | 60.74 | 24.19 | 48 | 62.7 | 55.5 | 54.05 | 54.12 |
| Credit Usage - Qt 3 | 57.39 | 60.73 | 23.57 | 48.08 | 62.36 | 55.95 | 54.29 | 54.53 |
| Credit Usage - Qt 4 | 57.53 | 60.64 | 23.81 | 48.8 | 62.12 | 56.44 | 54.14 | 54.45 |
| Credit Usage - Qt 5 | 58 | 60.45 | 23.29 | 47.55 | 62.2 | 55.49 | 54.54 | 54.59 |

Table 18: Moving Decomposition (CMAs)

| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| All | 51.07 | 51.62 | 25.67 | 47.72 | 49.22 | 48.91 | 49.48 | 49.76 |
| Homeowners | 51.91 | 51.57 | 25.04 | 46.42 | 47.25 | 46.52 | 49.82 | 49.81 |
| Renters | 51.03 | 51.83 | 25.89 | 47.89 | 49.72 | 49.56 | 49.57 | 49.95 |
| Age [25-35] | 48.91 | 51.22 | 25.97 | 50.18 | 51.08 | 51.24 | 47.65 | 48.25 |
| Age [36-45] | 52.05 | 53.12 | 26.62 | 45.99 | 49.18 | 48.62 | 50.52 | 50.78 |
| Age [46-65] | 53.27 | 51.37 | 25.04 | 45.64 | 46.9 | 46.22 | 51.2 | 51.11 |
| Age [66-75] | 53.99 | 50.5 | 22.93 | 44.8 | 45.63 | 44.51 | 51.63 | 51.24 |
| Age [76-85] | 50.78 | 49.48 | 22.96 | 48.06 | 48.69 | 48.13 | 48.83 | 49.06 |
| Credit Score [0-639] | 50.83 | 51.31 | 26.69 | 47.87 | 49.65 | 49.6 | 49.44 | 49.72 |
| Credit Score [640-759] | 50.96 | 51.81 | 25.85 | 47.79 | 49.67 | 49.53 | 49.51 | 49.93 |
| Credit Score [760-799] | 50.75 | 51.57 | 25.55 | 48.38 | 49.45 | 49.17 | 49.13 | 49.39 |
| Credit Score [800-900] | 51.61 | 51.56 | 24.74 | 47.1 | 48.07 | 47.31 | 49.67 | 49.73 |
| Credit Usage - Qt 1 | 50.39 | 51.67 | 26.69 | 48.03 | 49.8 | 49.33 | 48.97 | 49.22 |
| Credit Usage - Qt 2 | 51.44 | 52.2 | 25.76 | 47.32 | 49.12 | 48.5 | 49.7 | 49.98 |
| Credit Usage - Qt 3 | 51.71 | 52.11 | 25.03 | 46.97 | 48.37 | 48.03 | 49.97 | 50.19 |
| Credit Usage - Qt 4 | 51.32 | 51.78 | 25.32 | 47.57 | 48.5 | 48.43 | 49.56 | 49.86 |
| Credit Usage - QtE | 51.88 | 51.43 | 24.98 | 46.87 | 48.24 | 47.75 | 50.01 | 50.1 |

Table 19: Moving Decomposition - Definition II (CMAs)

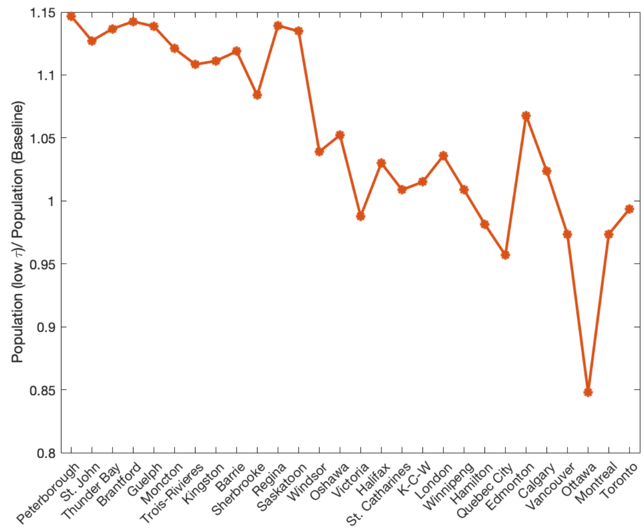
| | Lower Hp | Lower Unempl. | Higher Amenities | Higher Population | Higher Income | Higher Wages | Higher Income/Hp | Higher Wages/Hp |
|---|---|---|---|---|---|---|---|---|
| All | 55.5 | 61.34 | 25.92 | 48.79 | 63.82 | 58.31 | 53.76 | 54.52 |
| Homeowners | 56.56 | 61.52 | 25.31 | 47.5 | 62.87 | 56.57 | 54.33 | 54.88 |
| Renters | 55.33 | 61.47 | 26.12 | 48.93 | 64.06 | 58.82 | 53.76 | 54.58 |
| Age [25-35] | 53.3 | 60.68 | 26.18 | 51.3 | 64.86 | 60.24 | 51.9 | 52.88 |
| Age [36-45] | 56.65 | 62.91 | 26.88 | 47.11 | 63.98 | 58.16 | 54.9 | 55.67 |
| Age [46-65] | 57.65 | 61.36 | 25.33 | 46.67 | 62.29 | 55.87 | 55.51 | 55.97 |
| Age [66-75] | 58.27 | 60.66 | 23.26 | 45.63 | 61.92 | 54.94 | 55.7 | 56.08 |
| Age [76-85] | 55.11 | 59.53 | 23.33 | 48.87 | 64.15 | 58.67 | 53.17 | 54.05 |
| Credit Score [0-639] | 55.64 | 61.65 | 27.05 | 49.15 | 63.39 | 58.62 | 54.01 | 54.88 |
| Credit Score [640-759] | 55.4 | 61.62 | 26.08 | 48.83 | 64.22 | 58.99 | 53.82 | 54.68 |
| Credit Score [760-799] | 55.04 | 60.96 | 25.76 | 49.36 | 64.25 | 58.63 | 53.27 | 54.06 |
| Credit Score [800-900] | 55.84 | 60.92 | 24.96 | 48.15 | 63.19 | 56.83 | 53.8 | 54.3 |
| Credit Usage - Qt 1 | 54.4 | 61.26 | 26.84 | 48.94 | 63.91 | 58.05 | 52.95 | 53.51 |
| Credit Usage - Qt 2 | 55.47 | 61.49 | 25.92 | 48.32 | 63.88 | 57.77 | 53.76 | 54.31 |
| Credit Usage - Qt 3 | 56.09 | 61.63 | 25.25 | 47.99 | 63.55 | 57.89 | 54.27 | 55.03 |
| Credit Usage - Qt 4 | 56.05 | 61.5 | 25.62 | 48.73 | 63.37 | 58.34 | 54.03 | 54.91 |
| Credit Usage - QtE | 56.5 | 61.54 | 25.27 | 47.93 | 63.5 | 57.64 | 54.47 | 55.2 |

# B Figures

Figure 15: Estimates of TFP, Amenities and Housing Elasticities


Notes: This figure reports the distribution of the estimates of TFP, amenities and housing elasticities calculated with the methods described in the text, respectively in panel A, B and C. On the x-axis the cities are distributed by size.

Figure 16: Population Change induced by the Moving Subsidy in the Rust-Belt




Notes: This figure reports the ratio of the population in the steady-state with moving subsidies in the Rust-Belt to the baseline economy for different cities

# C Definitions

- *Migrants*: We define migrants all the individuals in our dataset that report living in a different CMA than the one in the previous period.
- *Homeowners*: We define homeowners all the individuals that report having an active mortgage or has a line of credit above CAD 50,000 or paid their entire mortgage.
- *Credit Usage*: We define credit usage as the total outstanding debt balance divided by the credit limit. We consider any open credit account besides mortgages. Specifically, we consider credit cards, installments, auto-loans and lines of credit.

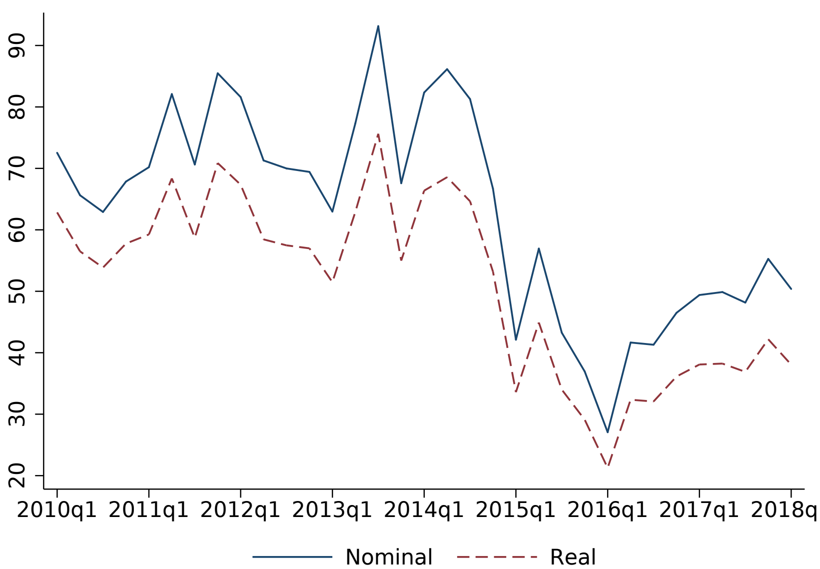
# D The Oil Shock in Canada

Canada is the fifth largest oil producer in the world and most of its crude oil production is exported. Although being one five biggest oil producers in the world, the share of the Canadian oil production relative to the worldwide production is relative small, which make oil price variations plausibly exogenous with respect to the Canadian economy. Thus, we will use changes in the oil price as a source of exogenous shocks to real income in Canada.We follow the identification strategy of Kilian and Zhou (2018) who showed that real oil price shocks in Canada constitute exogenous shocks to regional real income.

We obtain oil prices from the Canadian Association of Petroleum Producers. We follow Kilian and Zhou (2018) in focusing on the WCS crude oil price measured in Canadian dollars. WCS is the reference price for heavy crude oil (e.g. blended bitumen) delivered at Hardisty, Alberta. WCS is representative of the price of oil from the oil sands, the most common type of oil produced in Canada.[14] To construct the *Oil Price shock* used in the empirical analysis, we also obtain total employment statistics by education, industry and city in 2011 from *Statistics Canada*. We define the oil industry according to the *2111 - Oil and Gas Extraction* classification of the North American Industry Classification System (NAICS) of 2007.

Figure 17 reports the evolution of the Western Canadian Select (WCS) crude oil price measured in Canadian dollars. Between 2010 and 2014, oil price was relatively stable, but it dropped around 62 percent between 2014 and 2016 both in nominal and real terms.[15] Although it started slowly recovering, current oil prices remain almost 40 percent lower the average value before 2014.

Figure 17: Oil Price Evolution




[14]It takes more energy to produce refined products (e.g. gasoline) from heavy crudes, therefore WCS trades at a discount to lighter crudes.

[15]Real oil price is computed by deflating WCS by the national wide Canadian consumer price index (CPI). WCS is the oil price measured also used by Kilian and Zhou (2018)

Although changes in oil prices may indirectly affect the entire Canadian economy, the impact of oil price shocks on income vary substantially by region. 95% of the total oil production is located in only three Canadian provinces: Alberta, Saskatchewan, and Newfoundland and Labrador. These three provinces that concentrate almost oil production are usually denominated by the *Oil Provinces*. Thus, oil price shocks constitute sizable regional income shocks in Canada.

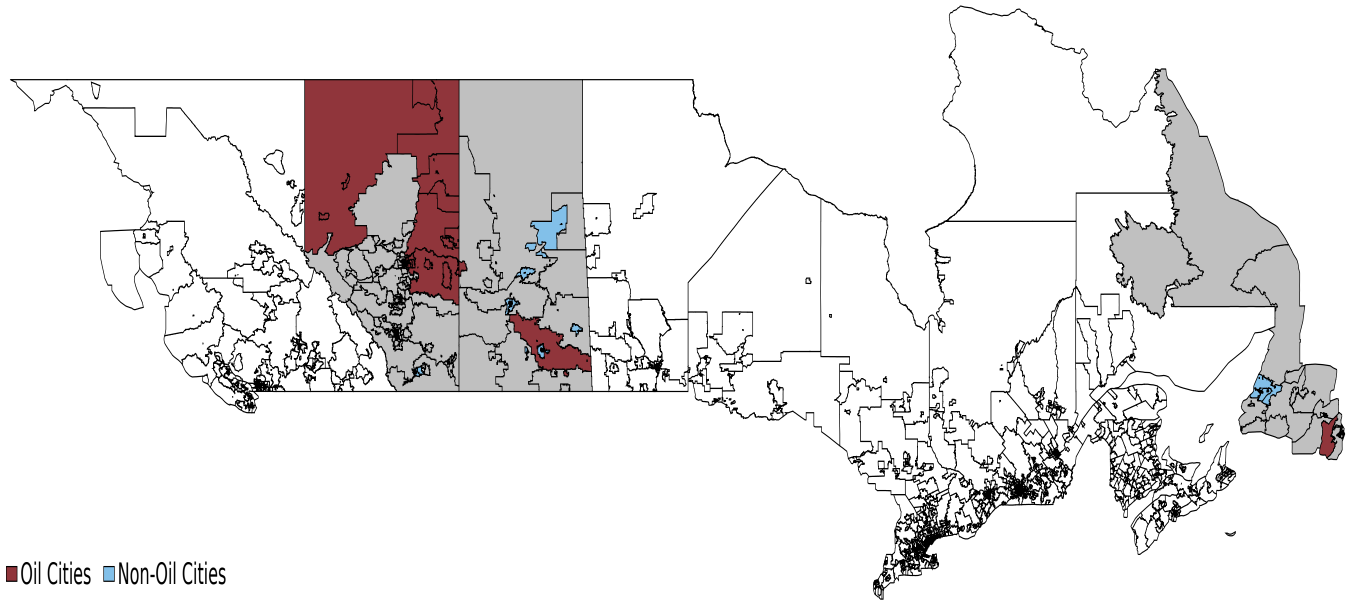
The ideal identification strategy would capture those that are directly impacted by this shock. Given that we are not able to observe who is directly affected, we identify small regions where oil industry is disproportionately relevant. These are naturally the closest FSAs to Thermal in-situ facilities of Bitumen production, Mining facilities, Upgraders of bitumen and heavy oil and Refineries. We manually collect the location of these facilities from the *Oil Sands Magazine* that offers a large set of statistics on oil and gas prices, energy statistics and oil sands operating metrics, as monthly production by facility. We therefore define as an *Oil City* all FSAs located within a 10 miles radius of each of the facilities.

Most of the facilities are located close to Oil sands that are a natural mixture of sand, water and bitumen (oil that is too heavy or thick to flow on its own). The oil sands are found in main three regions within the provinces of Alberta and Saskatchewan: Athabasca, Cold Lake and Peace River, which combined cover an area more than 142,000 square kilometres. The oil sands are located at the surface near Fort McMurray, but deeper underground in other regions. Oil sands are recovered using two main methods: drilling (in situ) and mining. The method used depends on how deep the reserves are deposited. In Newfoundland and Labrador, most of the production occurs offshore. Although some of the refineries are presented outside the *Oil Provinces*, given their small relevance to the local economy, we restrict our analyses to the three provinces that constitute the *Oil Provinces*.

Given the proximity to the oil production facilities and the relevance of the oil industry in these areas, we conjecture that the oil shock will have highest impact in the *Oil Cities*. Individuals in these cities are highly affected by an oil shock, either directly or indirectly, which minimizes concerns about the heterogeneous effect of the shock within these regions. As a control group, we select all areas of the *Oil Provinces* with an employment share in the oil industry below 1%.[16]

[16] We then exclude regions with an employment share in the oil industry above 1% but that are not close to one of the oil facilities. In these areas, we expect that the shock is less likely to affect all individuals in a similar way, which would introduce noise in our analysis. Therefore, we decide to exclude them. However, as robustness, we present in the appendix the results including such locations. Results remain unchanged.

Figure 18: Oil Cities and Non-Oil Cities within the Oil Provinces




In Figure 18 we present a map of Canada where we identify the *Oil Cities* in red and the *Non-oil Cities* in blue. Both groups of cities are not adjacent to each other which attenuates concerns about commuters across cities.

As in Kilian and Zhou (2018), we build a city specific *Oil Shock* taking into account the employment share in the oil industry in each of the *Oil Cities*. Specifically, we build a measure of regional exposure to the oil shock that resembles the standard *Bartik* shocks as follows:

$$OilShock_{z,t} = -\alpha_z log(\text{OilPrice})_t \tag{13}$$

where $\alpha_{z,t-1}$ is the share of employment in the oil sector in city $z$ in 2011. $log(\text{OilPrice})_t$ is the logarithm of the real oil price at quarter $t$. As in Kilian and Zhou (2018), we interpret the results causally under the assumption that variations in the oil price are exogenous to the Canadian economy and not correlated with other macroeconomic variables relevant for our analysis.

Since our analysis lies in a period of decline in oil prices, we measure the Oil shock as negative shock to the local economy. Therefore, a higher value of *Oil Shock* corresponds to a larger negative shock.

## D.1 Summary Statistics

We now present some summary statistics for both Movers and Stayers by *Oil Cities* and *Non-Oil Cities*. For migrants, we analyze the individual characteristics one quarter before the moving date and for stayers we consider the median quarter among those that the individual is present in the sample. We restrict the analysis to the period between 2013 and 2016, the period that registered a decline in oil prices. We restrict the sample to individuals that are present in the sample for at least 8 consecutive quarters and whose age is above 18 and below 75. We observe a total of 810,305 individuals in both *Oil Cities* and *Non-Oil Cities*. We define as Migrants everyone that moves out of a given city to other city within or outside the *Oil Provinces*. We also consider everyone that moves from a city to a rural area.[17] Individuals that move across FSAs within the same city are classified as Stayers.

Overall, as reported in Table 20, migrants are younger and have lower credit score than stayers. In the *Oil Cities*, while about 65% of the migrants are less than 45 years old, only 50% of the stayers are in the same age range. 55% of the migrants are considered Prime borrowers with an average credit score of 722, which contrast with the stayers that have on average a credit score of 750. The share of homeowners among migrants is smaller than the one among stayers and they have larger credit usage even excluding mortgages. The migrant population in the *Oil Cities* seems to be quite selected. Although *Oil Cities* and *Non-Oil Cities* seem to differ slightly in some demographic characteristics, these differences are not significant and are valid for both migrants and stayers.

## D.2 The Heterogeneous Migration Behaviour

In this section, we analyse how distinct individuals migrate and also how they respond differently to a negative oil shock. Specifically, we look at homeownership, age and ability to borrow (measured in terms of credit score). We adapt the Bartik-style panel regression model proposed by Kilian and Zhou (2018) to study the regional propagation of oil price shocks in Canada. The authors demonstrate that under empirically plausible conditions the derivative of the dependent variable with respect to the oil price shock in their regression can be given a causal interpretation. We depart from them by looking also at how such individual-level characteristics interact with a negative shock to the local economy through the following specification:

[17] Since we focus on our analysis on *Oil Cities*, we exclude from the sample those that potentially move from rural areas into cities, but not the other way around. This happens because we need to match each location to the city-level Oil shock, whose for data limitations we cannot define for rural areas. Given that we don't match the Oil shock with the destination city, we consider everyone that moves from a city to a rural area.

Table 20: Summary Statistics for *Transunion* Variables

| | Oil Cities | | Non-oil Cities | |
|---|---|---|---|---|
| | Migrants | Stayers | Migrants | Stayers |
| Age(Mean) | 40.33 | 45.81 | 38.42 | 46.82 |
| Old (share %) | 34.83 | 50.45 | 29.63 | 53.04 |
| Credit Score (Mean) | 721.96 | 750.21 | 724.94 | 753.33 |
| Prime (share %) | 54.99 | 66.76 | 57.43 | 68.68 |
| Homeowners (share %) | 35.51 | 45.85 | 30.28 | 43.28 |
| Home Equity (Mean) | 20.04 | 23.38 | 19.85 | 22.81 |
| Number Credit Accounts (Mean) | 1.91 | 1.9 | 1.81 | 1.83 |
| Credit Usage (Mean) | 55.78 | 51.07 | 54.27 | 48.67 |
| Credit Use except Mortg. (Mean) | 49.85 | 47.46 | 48.31 | 45.82 |
| Credits 90+ day (Mean) | 1.19 | 1.15 | 1.16 | 1.13 |
| Credits 90+ day (share %) | .2 | .13 | .18 | .12 |
| Mortgages 90+ day (share %) | 2.47 | 1.55 | 1.99 | 1.36 |
| Observations | 49679 | 404788 | 42370 | 313468 |

Note: This table reports the summary statistics of the variables from *TransUnion* use in the empirical specification. We divide the sample between cities with oil industry and cities without. For each of these groups, we divide the sample between migrants and stayers. We cover the years between 2013 and 2016.

$$\begin{aligned} Move_{i,z,t} =& \beta_0 + \beta_1 OilShock_{z,t-1} X_{i,z,t-1} + \beta_2 X_{i,t-1} + \beta_3 OilShock_{z,t-1} \\ &+ \beta_4 W_{i,z,t-1} + \gamma_i + \delta_z + \theta_t + \epsilon_{i,z,t} \end{aligned} \tag{14}$$

where Move$_{i,z,t}$ is a dummy variable that equals 1 if individual $i$ in location $z$ at time $t$ moves to a different city. $X_{i,t-1}$ 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.

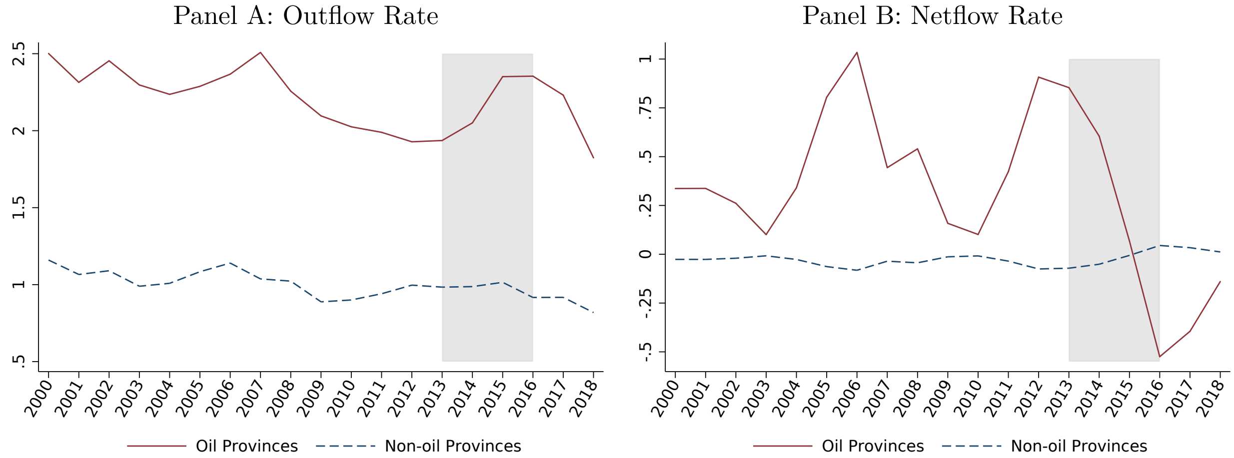
Our main specification also includes individual fixed effects, quarter fixed effects and city fixed effects. The individual fixed effects, $\gamma_i$, controls for unobservable individual heterogeneity as different preferences for moving. It also ensures that all results are estimated exploiting individual variation over time rather than across individuals. The quarter fixed effects, $\theta_t$, absorb overall trends in migration rates and any potential aggregate shock to the economy. The city fixed effects, $\delta_z$, control for city characteristics as amenities, long-run productivity levels, quality of life, among others. We also employ alternative empirical specification where we include city-by-quarter fixed effects to absorb any other potential local shock or changes in local economic conditions that occur simultaneously to the oil shock. We cluster our standard errors at city level.

The main coefficients of interest for our analysis is $\beta_1$ that measures how individuals with different characteristics respond to the same local oil shock. In other words, it identifies how different demographics, $X_{i,t-1}$, affect the probability of moving out of location $z$ given the *Oil Shock*. Specifically, we look at homeownership status, age and credit score as proxy for individual's ability to borrow. In the main specification we consider five age group categories: 26-35, 36-45, 45-55, 56-65 and 66-85. In terms of credit scores, we group the individuals in five groups: 300-640, 640-719, 720-759, 760-799 and 800-900. A borrower is considered Prime if their credit score is above 720. We interpret that higher the credit score, higher the ability to smooth shocks through borrowing.

$\beta_2$ measures the unconditional migration probability and $\beta_3$ can be interpreted as the impact of one standard deviation increase in the exposure to the oil shock in the probability of moving out of location $z$. The rest of the variables serve as controls. As explained before, we consider two set of cities. A "treated" city is a city that surrounds an oil facility and a "control" city are those cities in the *Oil Provinces* where the employment share in the oil industry is residual. We explore heterogeneity across the "treated" cities by computing the city level exposure to the oil shock given the share of oil industry employment in the city, as defined in equation 13. By construction, the *Oil Shock* in the "control" cities is zero. By restricting the treatment group to areas close to oil facilities allow us to capture at a greater extent the workers in the oil sectors, those that must be directly impacted by the decline in oil price.

Before turning to the results, we present some evidence of outflows from and to the oil regions. Figure 19 plots migration rates for Oil Regions and Non-Oil regions between 2000 and 2018 using official statistics from Statistics Canada. Outflow rate (Panel A) and Netflow Rate (Panel B) has been very stable for Non-Oil Regions throughout the entire period. The Non-Oil regions show a nearly constant Outflow rate of 1% that seems to be compensated by a constant inflow of similar magnitude. However, migration ratios for Oil-Regions are much more volatile and of higher magnitudes. The outflow was around 2.5% per year until 2005 when started to decline and reach its lowest value of 2% in 2013. After 2013, outflow rate seemed to follow the oil price pattern. While oil price declined between 2013 and 2016, the number of people leaving the Oil Regions increased. The pattern reversed when oil prices started recovering. More striking is the behavior of the netflow rate during the same period. In 2012, the netflow rate was positive around 1% and reached the negative level of -0.25% in 2016. These results are suggestive that individuals react to oil shocks by leaving at higher rate the *Oil Provinces* but above all negative oil shocks seem to reduce the incentives to migrate into these provinces. The high correlation between oil prices and migration flows both in

Figure 19: Migration Patterns in Canada




Note: Figure 1 plots the Migration patterns in Canada between 2000 and 2018 for Oil Provinces and Non-oil Provinces. Panel A plots the Outflow Rate and Panel B plots the netflow Rate. Outflow Rate is defined by the number of people leaving a certain set of provinces divided by the total Population in the same set of provinces in the year before. Netflow Rate is defined by the difference between the number of people entering and leaving a set of provinces divided by the total Population in the same set of provinces in the year before. Data is Statistics Canada.

terms of the direction and timing presented in this figure gives us confidence that oil shocks are an important driver of individuals migration decisions in the regions with higher exposure to the oil industry. This also suggest that the changes in the migration rates at national level are coming mostly from the oil regions.

Table 21: Heterogeneous Migration Responses

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | | | | Move=100 | | | | |
| Oil Shock | 0.527*** | | 0.708*** | | 0.613*** | | 0.859*** | |
| | (0.106) | | (0.051) | | (0.064) | | (0.071) | |
| Homeowner | -0.119*** | -0.126** | | | | | -0.165*** | -0.173*** |
| | (0.037) | (0.043) | | | | | (0.025) | (0.027) |
| Age [26-35] | | | 0.951*** | 0.923*** | | | 0.955*** | 0.926*** |
| | | | (0.146) | (0.151) | | | (0.146) | (0.149) |
| Age [36-45] | | | 1.022*** | 0.985*** | | | 1.028*** | 0.990*** |
| | | | (0.158) | (0.161) | | | (0.154) | (0.155) |
| Age [46-55] | | | 0.808*** | 0.777*** | | | 0.814*** | 0.781*** |
| | | | (0.155) | (0.153) | | | (0.147) | (0.141) |
| Age [56-65] | | | 0.511*** | 0.488*** | | | 0.516*** | 0.491*** |
| | | | (0.121) | (0.128) | | | (0.107) | (0.110) |
| Age [66-90] | | | 0.110 | 0.118 | | | 0.111 | 0.117 |
| | | | (0.118) | (0.148) | | | (0.101) | (0.127) |
| Credit Score [640-719] | | | | | -0.047* | -0.047** | -0.047** | -0.047** |
| | | | | | (0.024) | (0.021) | (0.021) | (0.018) |
| Credit Score [720-759] | | | | | -0.033 | -0.035 | -0.031 | -0.035* |
| | | | | | (0.031) | (0.026) | (0.025) | (0.019) |
| Credit Score [760-799] | | | | | 0.011 | 0.008 | 0.010 | 0.005 |
| | | | | | (0.051) | (0.047) | (0.046) | (0.040) |
| Credit Score [800-900] | | | | | -0.008 | -0.012 | -0.012 | -0.017 |
| | | | | | (0.057) | (0.055) | (0.048) | (0.042) |
| Oil Shock × Homeowner | -0.196*** | -0.269*** | | | | | -0.116*** | -0.177*** |
| | (0.034) | (0.031) | | | | | (0.036) | (0.029) |
| Age [26-35] × Oil Shock | | | -0.195*** | -0.325*** | | | -0.160** | -0.282*** |
| | | | (0.063) | (0.057) | | | (0.067) | (0.060) |
| Age [36-45] × Oil Shock | | | -0.330*** | -0.489*** | | | -0.279** | -0.422*** |
| | | | (0.098) | (0.088) | | | (0.102) | (0.090) |
| Age [46-55] × Oil Shock | | | -0.370** | -0.527*** | | | -0.305** | -0.446*** |
| | | | (0.132) | (0.120) | | | (0.131) | (0.118) |
| Age [56-65] × Oil Shock | | | -0.282 | -0.458** | | | -0.211 | -0.372** |
| | | | (0.184) | (0.159) | | | (0.181) | (0.156) |
| Age [66-90] × Oil Shock | | | -0.440 | -0.570** | | | -0.375 | -0.497** |
| | | | (0.278) | (0.220) | | | (0.268) | (0.211) |
| Credit Score [640-719] × Oil Shock | | | | | -0.118*** | -0.113*** | -0.098*** | -0.085*** |
| | | | | | (0.027) | (0.026) | (0.024) | (0.023) |
| Credit Score [720-759] × Oil Shock | | | | | -0.184*** | -0.183*** | -0.150*** | -0.135*** |
| | | | | | (0.039) | (0.036) | (0.034) | (0.032) |
| Credit Score [760-799] × Oil Shock | | | | | -0.238*** | -0.253*** | -0.191*** | -0.188*** |
| | | | | | (0.046) | (0.039) | (0.037) | (0.032) |
| Credit Score [800-900] × Oil Shock | | | | | -0.304*** | -0.327*** | -0.226*** | -0.220*** |
| | | | | | (0.081) | (0.068) | (0.061) | (0.051) |
| Observations | 12990210 | 12990210 | 12990210 | 12990210 | 12990210 | 12990210 | 12990210 | 12990210 |
| Adjusted $R^2$ | 0.102 | 0.104 | 0.103 | 0.104 | 0.102 | 0.104 | 0.103 | 0.104 |
| Individual Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| Quarter Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| City × Quarter Fixed-Effects | No | Yes | No | Yes | No | Yes | No | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 14. The dependent variable is the decision on whether to move or not. Standard errors are presented in parentheses and are clustered at the quarter-city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively.

## Table 22: Heterogeneous Migration Behavior

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | | | Move=1 | | | | | |
| Oil Shock | 0.428*** | | 0.707*** | | 0.517*** | | 0.845*** | |
| | (0.051) | | (0.100) | | (0.043) | | (0.119) | |
| Homeowner | -0.132*** | -0.130*** | | | | | -0.173*** | -0.173*** |
| | (0.033) | (0.038) | | | | | (0.017) | (0.020) |
| Age [26-35] | | | 0.654*** | 0.637*** | | | 0.656*** | 0.637*** |
| | | | (0.146) | (0.151) | | | (0.142) | (0.146) |
| Age [36-45] | | | 0.673*** | 0.659*** | | | 0.679*** | 0.663*** |
| | | | (0.177) | (0.183) | | | (0.169) | (0.173) |
| Age [46-55] | | | 0.499*** | 0.495** | | | 0.505*** | 0.499*** |
| | | | (0.174) | (0.182) | | | (0.164) | (0.170) |
| Age [56-65] | | | 0.322** | 0.320** | | | 0.328** | 0.326** |
| | | | (0.144) | (0.155) | | | (0.132) | (0.141) |
| Age [66-90] | | | 0.106 | 0.110 | | | 0.108 | 0.113 |
| | | | (0.106) | (0.125) | | | (0.094) | (0.112) |
| Credit Score [640-719] | | | | | -0.029* | -0.028 | -0.029** | -0.029** |
| | | | | | (0.017) | (0.017) | (0.013) | (0.012) |
| Credit Score [720-759] | | | | | -0.030 | -0.030 | -0.028 | -0.028 |
| | | | | | (0.026) | (0.026) | (0.019) | (0.017) |
| Credit Score [760-799] | | | | | -0.000 | 0.001 | -0.004 | -0.005 |
| | | | | | (0.042) | (0.042) | (0.032) | (0.031) |
| Credit Score [800-900] | | | | | -0.026 | -0.023 | -0.031 | -0.030 |
| | | | | | (0.051) | (0.054) | (0.034) | (0.034) |
| Oil Shock × Homeowner | -0.234*** | -0.278*** | | | | | -0.140*** | -0.175*** |
| | (0.056) | (0.051) | | | | | (0.032) | (0.027) |
| Age [26-35] × Oil Shock | | | -0.214*** | -0.295*** | | | -0.171*** | -0.246*** |
| | | | (0.063) | (0.052) | | | (0.057) | (0.047) |
| Age [36-45] × Oil Shock | | | -0.430*** | -0.533*** | | | -0.364*** | -0.458*** |
| | | | (0.127) | (0.116) | | | (0.114) | (0.103) |
| Age [46-55] × Oil Shock | | | -0.502*** | -0.607*** | | | -0.422*** | -0.516*** |
| | | | (0.154) | (0.144) | | | (0.137) | (0.127) |
| Age [56-65] × Oil Shock | | | -0.479*** | -0.601*** | | | -0.391** | -0.502*** |
| | | | (0.173) | (0.162) | | | (0.153) | (0.143) |
| Age [66-90] × Oil Shock | | | -0.632*** | -0.751*** | | | -0.554*** | -0.666*** |
| | | | (0.185) | (0.180) | | | (0.166) | (0.162) |
| Credit Score [640-719] × Oil Shock | | | | | -0.125*** | -0.125*** | -0.094*** | -0.088*** |
| | | | | | (0.027) | (0.028) | (0.018) | (0.019) |
| Credit Score [720-759] × Oil Shock | | | | | -0.191*** | -0.194*** | -0.138*** | -0.132*** |
| | | | | | (0.041) | (0.042) | (0.027) | (0.027) |
| Credit Score [760-799] × Oil Shock | | | | | -0.243*** | -0.258*** | -0.168*** | -0.170*** |
| | | | | | (0.051) | (0.050) | (0.028) | (0.028) |
| Credit Score [800-900] × Oil Shock | | | | | -0.346*** | -0.368*** | -0.218*** | -0.219*** |
| | | | | | (0.088) | (0.086) | (0.046) | (0.045) |
| Observations | 44079715 | 44079715 | 44079715 | 44079715 | 44079715 | 44079715 | 44079715 | 44079715 |
| Adjusted $R^2$ | 0.096 | 0.097 | 0.096 | 0.097 | 0.096 | 0.097 | 0.096 | 0.097 |
| Individual Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| Quarter Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| City × Quarter Fixed-Effects | No | Yes | No | Yes | No | Yes | No | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 1. The dependent variable is the decision on whether to move or not.

As expected, the probability of moving out of a city increases with a negative oil shock. A standard deviation increase in the exposure to the oil shock increases the moving probability between 0.5% and 0.871%.

Without the presence of the *Oil Shock*, homeowners tend to migrate less less than non-homeowners. Age also seems to matter as older individuals tend to migrate less than younger ones. The exception seems to be the individuals whose age belongs to the 36 to 45 group, as individuals in this group presents higher unconditional migration probabilities. However, credit score seems to not be a relevant margin to the migration decision when individuals do not face any negative shock. These results are robust to the inclusion of city and quarter fixed effects and city $\times$ quarter fixed effects, as they are similar both in sign and in magnitude. The unconditional probabilities are also similar if we run each of the characteristics separate or jointly.

Such characteristics seem to become even more relevant when individuals are hit by a negative and unexpected shock that can impact directly or indirectly their employment status or income.

Homeowners tend to move less than non-homeowners when exposed to the same shock. For a given *Oil Shock*, homeowners move on average between 12 and 18 bps less than renters and this difference increases as the exposure to the oil shock rises. Overall, homeowners buffer less the shock by moving than renters, even when conditional on other observables.

Older individuals also seem to react less than younger ones to the oil shock. Although we find that individuals older than 36 and younger than 45 years old migrate more unconditionally in respect to younger individuals, when we look at the interaction between age and the oil shock, they are less likely to move than the very young, for a given level of exposure to the oil shock. So, younger individuals buffer more the shock by moving than old, especially those that are expected to be out of the labor force (above 65 years old).

Although credit score seems to not be important for migration decisions in areas not exposed to a shock, it seems to play an important role when it comes to respond to the shock. Individuals with lower credit score, on average, move more than those with higher credit score. The moving response to the shock is monotonic regarding the credit score. Specifically, individuals with credit score between 640-719 move around 9 bps less than individuals with credit score less than 640. Individuals with very high credit score (800-900) moved 22 bps less than individuals with lower credit score. This result suggests that higher credit score individuals use their borrowing capacity to buffer a temporary shock without moving. Those that are less likely to access credit markets in times of distress see in moving to a new location their way to smooth shocks.

In the Appendix, we run different specifications as robustness. In Table 22, we consider a "Continuous" *Oil Shock*. Specifically, we use the definition of the oil shock in equation 13 without restricting to the Cities around the oil facilities. Although magnitudes vary depending on the specification, we find nevertheless the same relationship between moving probabilities and homeowneship, age and credit score.

## D.3 Where People Move to?

In this section, we analyze the cities' characteristics to which individuals migrate to in response to the shock. Are individuals more likely to move to places with higher income than their previous locations? Do house prices matter when individuals move due to a shock? We perform this analysis in two dimensions. First, we conduct a decomposition by destination and migrants characteristics. Second, we test formally in a regression setting which characteristics determine the type of location they choose to move to. We do so by running the following specification:

$$MoveTO_{i,z,z',t} = \alpha + \beta_1 X_{i,t-1} + \beta_2 OilShock_{z,t-1} + \beta_3 W_{i,t-1} + \gamma_i + \delta_z + \theta_t + \epsilon_{i,z,t} \tag{15}$$

where $MoveTO_{i,z,z',t}$ equals 100 if the new location $z'$ is "better" than the previous location $z$. For instance, if the new location has higher income or amenities. We control for the strength of the Bartik shock in location $z$ and for other individual characteristics as in equation (14).

Table 23: Moving Decomposition

**Panel A**

| | **Oil Provinces** | | **House Prices** | | | **Population** | | | **Unemployment Rate** | | | **Amenities** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inside | Outside | Higher | Same | Lower | Higher | Same | Lower | Higher | Same | Lower | Higher | Lower |
| All | 22.28 | 77.72 | 27.19 | 35.25 | 37.56 | 51.1 | 15.78 | 33.12 | 70.41 | .54 | 29.05 | 33.11 | 66.89 |
| Homeowners | 24.27 | 75.73 | 24.5 | 34.74 | 40.77 | 49.69 | 16.29 | 34.02 | 68.52 | .64 | 30.83 | 32.87 | 67.13 |
| Renters | 21.39 | 78.61 | 28.4 | 35.49 | 36.11 | 51.68 | 15.58 | 32.75 | 71.21 | .5 | 28.29 | 33.21 | 66.79 |
| Young | 20.78 | 79.22 | 28.4 | 35.83 | 35.77 | 51.49 | 15.97 | 32.54 | 72.13 | .53 | 27.34 | 33.69 | 66.31 |
| Old | 25.41 | 74.59 | 24.67 | 34.05 | 41.28 | 50.11 | 15.32 | 34.58 | 66.29 | .57 | 33.14 | 31.49 | 68.51 |
| Non-Prime | 19.97 | 80.03 | 26.65 | 36.05 | 37.3 | 50.15 | 14.52 | 35.33 | 69.25 | .51 | 30.25 | 32.03 | 67.97 |
| Prime | 24.08 | 75.92 | 27.61 | 34.63 | 37.76 | 51.76 | 16.68 | 31.56 | 71.25 | .57 | 28.18 | 33.78 | 66.22 |

**Panel B**

| | **Total Income (Nom)** | | | **Median Income (Nom)** | | | **Total Income (Real)** | | | **Median Income (Real)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Higher | Same | Lower | Higher | Same | Lower | Higher | Same | Lower | Higher | Same | Lower |
| All | 65.45 | 5.91 | 28.65 | 30.12 | 14.46 | 55.42 | 65.13 | 1.27 | 33.6 | 38.53 | 7.38 | 54.09 |
| Homeowners | 63.67 | 6.07 | 30.26 | 25.37 | 13.87 | 60.76 | 64.32 | 1.57 | 34.11 | 36.75 | 7.65 | 55.6 |
| Renters | 66.2 | 5.84 | 27.96 | 32.14 | 14.72 | 53.15 | 65.48 | 1.14 | 33.38 | 39.29 | 7.26 | 53.45 |
| Young | 66.81 | 6.18 | 27 | 32.32 | 14.98 | 52.7 | 66.23 | 1.2 | 32.56 | 39.03 | 7.29 | 53.68 |
| Old | 62.17 | 5.24 | 32.59 | 24.85 | 13.21 | 61.94 | 62.5 | 1.43 | 36.07 | 37.34 | 7.57 | 55.09 |
| Non-Prime | 64.78 | 5.39 | 29.83 | 30.25 | 14.29 | 55.46 | 64.47 | 1.15 | 34.38 | 39.35 | 7.32 | 53.32 |
| Prime | 65.93 | 6.28 | 27.79 | 30.03 | 14.58 | 55.39 | 65.61 | 1.36 | 33.03 | 37.94 | 7.41 | 54.64 |

Similarly, we control for individual, origin city and quarter fixed effects. The main coefficient of interest is $\beta_1$ that tell us which individuals are more likely to "move up".

### D.3.1 Results

Table 23 reports the share of individuals that move to certain locations for different individual characteristics. We only consider individuals that moved after the oil shock and identify the individual characteristics in the quarter before they move. Approximately 78% of individuals that faced an *Oil Shock* moved to a city outside the oil regions. Renters, younger and non-prime members moved outside the *Oil Provinces* more than their respective counterparts. Regarding housing prices, we see that only 27% of the movers went to areas with higher house prices while about 35% moved to regions with similar house prices.[18] Therefore, 73% of the individuals move to places where house prices are similar or lower than the median house prices in their previous location. Renters, younger and prime members tend to move more to places with higher house price.

51% of the movers tend to move to larger cities, while only 33% move to smaller cities. This trend to be very similar across all individuals. Interestingly, when we look at unemployment rates, 70% of the individuals, on average, move to cities with higher unemployment rates. Renters, younger and prime-members move more to cities with higher unemployment rates, which tend to be correlated with city size. When we look at amenities, we observe that only 33% of the movers go to locations with higher amenities. Renters, young and prime members then to go more to these locations than their counterparts.

[18] We define a similar region to the previous location when the difference between the two cities of variable of interest is less than 5% in absolute terms

Table 24: Where are Movers Going?

**Panel A**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Higher House Prices | | Outside Oil Provinces | | Higher Population | | Unemployment Rate | | Higher Amenities | |
| Oil Shock | 0.272 | | -0.749 | | -0.242 | | -22.552*** | | 30.200 | |
| | (0.626) | | (0.737) | | (0.739) | | (4.540) | | (12.458) | |
| Homeowner | -2.519*** | -2.482*** | -1.067* | -1.039 | -3.834*** | -3.854*** | -0.147 | -0.087 | -0.761 | -0.781 |
| | (0.593) | (0.612) | (0.574) | (0.585) | (0.635) | (0.629) | (0.900) | (0.997) | (1.890) | (1.835) |
| Age [26-35] | -0.458 | -0.454 | 3.735*** | 3.712*** | 1.038 | 1.031 | 2.902* | 2.494 | 4.014 | 4.059 |
| | (0.798) | (0.792) | (0.518) | (0.495) | (1.769) | (1.770) | (1.408) | (1.496) | (2.610) | (2.604) |
| Age [36-45] | -1.320 | -1.364 | 4.293*** | 4.276*** | 0.304 | 0.271 | 3.001 | 2.412 | 5.554 | 5.660 |
| | (0.904) | (0.890) | (0.900) | (0.875) | (2.375) | (2.361) | (2.186) | (2.421) | (2.295) | (2.284) |
| Age [46-55] | -2.881** | -2.879** | 4.418*** | 4.455*** | -3.045 | -3.060 | 3.490* | 2.606 | 4.714 | 4.810 |
| | (1.228) | (1.192) | (0.839) | (0.819) | (2.315) | (2.297) | (1.626) | (1.847) | (2.048) | (2.039) |
| Age [56-65] | -4.749*** | -4.742*** | 6.038*** | 5.989*** | -8.362*** | -8.391*** | 1.672 | 1.428 | 2.157 | 2.229 |
| | (1.413) | (1.366) | (0.713) | (0.712) | (2.171) | (2.117) | (1.427) | (1.603) | (1.329) | (1.349) |
| Age [66-90] | -4.470*** | -4.368*** | 6.313*** | 6.439*** | -8.786*** | -8.712*** | 2.335 | 1.262 | 3.538 | 3.433 |
| | (1.351) | (1.336) | (0.583) | (0.566) | (2.453) | (2.490) | (1.248) | (1.023) | (2.071) | (2.054) |
| Credit Score [640-719] | 0.664 | 0.660 | 2.108** | 1.988** | 2.421*** | 2.427*** | -0.131 | -0.573 | 0.452 | 0.282 |
| | (0.591) | (0.590) | (0.714) | (0.710) | (0.601) | (0.629) | (0.382) | (0.509) | (0.553) | (0.542) |
| Credit Score [720-759] | 2.069** | 2.099** | 2.033* | 1.970* | 5.563*** | 5.514*** | 0.436 | 0.354 | 0.599 | 0.506 |
| | (0.780) | (0.776) | (1.092) | (1.084) | (1.282) | (1.290) | (0.637) | (0.520) | (0.880) | (0.901) |
| Credit Score [760-799] | 4.414*** | 4.367*** | 5.470*** | 5.394*** | 6.661*** | 6.591*** | 0.020 | 0.166 | 1.010 | 0.907 |
| | (0.848) | (0.857) | (1.652) | (1.666) | (1.801) | (1.806) | (0.663) | (0.641) | (1.531) | (1.485) |
| Credit Score [800-900] | 5.103*** | 5.074*** | 5.727*** | 5.582*** | 6.882*** | 6.819*** | 0.317 | -0.264 | 0.045 | -0.135 |
| | (0.679) | (0.679) | (1.633) | (1.642) | (1.426) | (1.440) | (1.053) | (0.900) | (1.185) | (1.126) |
| Observations | 95785 | 95785 | 95795 | 95795 | 59603 | 59603 | 45574 | 45574 | 21717 | 21717 |
| Adjusted $R^2$ | 0.385 | 0.389 | 0.169 | 0.180 | 0.168 | 0.171 | 0.319 | 0.496 | 0.349 | 0.354 |
| Individual Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Quarter Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| City $\times$ Quarter Fixed-Effects | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |

Note: This table reports the OLS estimates for every year for the regressions in 15. The dependent variable is reported in the respective columns. Standard errors are presented in parentheses and are clustered at the quarter-city level. The ***, **, and * represent statistical significance at the 0.001, 0.01, and 0.05 levels respectively. Differently from table 1 we impose that if a city does not have any oil plant, the value of the Bartik is equal to 0. If a city does not have oil plants, the Bartik is set to be 0.

Table 24: Where are Movers Going? (Cont'd)

**Panel B**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Higher Total Inc (Nom) | | Higher Median Inc (Nom) | | Higher Total Inc (Real) | | Higher Median Inc (Real) | |
| Oil Shock | -1.632 | | 5.540*** | | -1.266** | | 0.026 | |
| | (1.035) | | (1.209) | | (0.581) | | (0.449) | |
| Homeowner | -3.566*** | -3.557*** | -0.316 | -0.330 | -2.317** | -2.364** | -0.548 | -0.706 |
| | (0.718) | (0.700) | (0.702) | (0.671) | (0.924) | (0.946) | (1.224) | (1.300) |
| Age [26-35] | 1.098 | 1.153 | -0.521 | -0.514 | 1.333 | 1.356 | 1.732 | 1.668 |
| | (1.774) | (1.774) | (1.257) | (1.252) | (1.857) | (1.850) | (1.243) | (1.242) |
| Age [36-45] | 0.981 | 0.947 | -2.363* | -2.228* | 1.378 | 1.360 | 2.708* | 2.557* |
| | (2.268) | (2.275) | (1.179) | (1.201) | (2.453) | (2.452) | (1.424) | (1.418) |
| Age [46-55] | -1.449 | -1.494 | -4.652*** | -4.514*** | -0.768 | -0.798 | 1.495 | 1.361 |
| | (1.848) | (1.847) | (1.312) | (1.378) | (1.896) | (1.881) | (1.182) | (1.180) |
| Age [56-65] | -6.247*** | -6.477*** | -6.896** | -6.709** | -4.852** | -4.964** | 2.612 | 2.835 |
| | (1.669) | (1.640) | (2.505) | (2.417) | (1.835) | (1.805) | (1.636) | (1.657) |
| Age [66-90] | -6.564** | -6.565** | -8.436*** | -8.449*** | -5.903** | -5.955** | 2.250 | 2.283 |
| | (2.457) | (2.419) | (2.666) | (2.636) | (2.239) | (2.200) | (1.721) | (1.692) |
| Credit Score [640-719] | 2.334*** | 2.296*** | 0.282 | 0.437 | 2.142** | 2.113** | -1.023 | -1.190 |
| | (0.526) | (0.558) | (0.619) | (0.610) | (0.730) | (0.755) | (1.400) | (1.500) |
| Credit Score [720-759] | 4.443*** | 4.570*** | 2.284** | 2.336*** | 4.138** | 4.131** | -1.603 | -1.857 |
| | (1.234) | (1.244) | (0.748) | (0.687) | (1.439) | (1.442) | (1.449) | (1.539) |
| Credit Score [760-799] | 5.695*** | 5.843*** | 0.660 | 0.612 | 4.904** | 4.895** | -2.846 | -2.958 |
| | (1.575) | (1.594) | (1.146) | (1.090) | (1.885) | (1.883) | (1.664) | (1.681) |
| Credit Score [800-900] | 5.274*** | 5.316*** | 1.266 | 1.371 | 4.845** | 4.841** | -3.457 | -3.789 |
| | (1.350) | (1.394) | (0.976) | (0.891) | (1.874) | (1.897) | (2.411) | (2.599) |
| Observations | 59648 | 59648 | 59648 | 59648 | 59648 | 59648 | 59648 | 59648 |
| Adjusted $R^2$ | 0.326 | 0.335 | 0.398 | 0.413 | 0.370 | 0.373 | 0.272 | 0.296 |
| Individual Fixed-Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| Quarter Fixed-Effects | Yes | No | Yes | No | Yes | No | Yes | No |
| City × Quarter Fixed-Effects | No | Yes | No | Yes | No | Yes | No | Yes |

We know analyze income in terms of their income statistics. In panel B of Table 23, we start by analyzing cities total nominal income. This variable is positively correlated with city size, and we find that 65% of individuals move to areas with similar or higher total nominal income, a similar value of those that move to cities with similar or bigger size. However, we find that renters and younger individuals move more to these cities, while no significant differences in terms of credit score.

Larger cities tend to have higher total income, but not necessarily higher median income. In fact, 55% of the individuals choose to move to a city with lower median income in nominal terms. Once again we find differences between across age and homeownership status. We find similar results if we look at real income statistics. We compute real income statistics by dividing city level income by median house prices. All these variables are strongly correlated with city size, so these results suggest that most of the individuals tend above all to choose big cities. Moreover, renters, young and prime seem to move *up* more than their counterparts.

We now look deeper into this decomposition exercise by analyzing in a regression setting which individuals characteristics are associated with moving to certain locations. In table 24, we report the estimates of specification 15 where the dependent variables are Higher house prices, larger population, higher unemployment rate and higher amenities, higher total income (nominal and real) and higher median income (nominal and real). Overall, we find that homeowners tend to move more to lower house prices and to lower population cities. Older people tend to move more to lower house prices areas, outside the oil Provinces and smaller cities. Finally, we observe that individuals with higher credit scores tend to move relatively more to areas with more expensive housing, outside the Oil Provinces and to larger cities. We find that demographic characteristics do not determine the sorting based on unemployment rate and amenities. Regarding income, homeowners and older older individuals move relatively less to larger places although, both in nominal and real terms. Individuals with higher credit score move monotonically more to larger places and to places with higher median income, although the income effect is lower than the size effect.

# E Algorithm

## E.1 Stationary Equilibrium

To solve the stationary general equilibrium of the economy, we first set up a discrete grid space for asset and housing. We start with guessing a vector of wages $\mathbf{w}^0$ and a vector of house prices $\mathbf{p}^0$ where each element of the vector corresponds to a location, and from the non-arbitrage condition in Equation (7), we calculate a vector of house rents $\mathbf{p}_r^0$. In each period, new age 25 group is born. They start their lives as renters. The distribution of the age 25 group over asset is read directly from the 2012 Survey of Financial Security and is assumed to be the same across locations. At each asset level, the share of unemployed in each location is set to be equal to the location-specific average unemployment rate from 2000 to 2011. The mass of the age 25 group in each location equates the total population in that location divided by 30 (total number of age groups).

**Step 1.** Given $\mathbf{w}^0, \mathbf{p}^0$, value functions and policy functions can be solved using backward induction, starting from the problem of last age group. The consumption and saving problem for age $q$ group is solved given the value functions over asset and housing for age $q+1$ group across locations. Given the value functions, the migration probabilities can be constructed using (6). Then using the migration probabilities and policy functions, based on the distribution of initial young (age 25 group), we can solve forward to obtain the distribution for all the age groups $L^R(l, a, \epsilon, q), L^H(l, a, \epsilon, q, h)$. The distribution is computed following the transition of endogenous states (housing, saving, homeownership status policies, and location choice) and exogenous states (employment status shock, age).

**Step 2.** Given the distribution $L^R(l, a, \epsilon, q), L^H(l, a, \epsilon, q, h)$, we update wages $\mathbf{w}^1$ and house prices $\mathbf{p}^1$ using labor market clearing condition in Equation (6) and housing market clearing condition implied by Equations (8) − (10).

**Step 3.** Now given updated wages and prices, we return to Step 1. We follow Step 1 and then Step 2 until wages and prices in all the locations converge.

## E.2 Transition Path

To compute the transitional path after some shock, we first use the algorithm listed in Section E.1 to compute the pre-shock stationary equilibrium, and the new stationary equilibrium after the shock. The economy starts with the population distribution in the pre-shock stationary equilibrium, then shock occurs in period 1. We assume after some period $T$, the economy reaches the new stationary equilibrium. Given $T$, we guess a wage path $\{\mathbf{w}_t^0\}_{t=1}^T$ and a house price path $\{\mathbf{p}_t^0\}_{t=1}^T$. After period $T$, wages and house prices are equal to those in the post-shock stationary equilibrium. We use Equation (7) to obtain a path of house rent.

**Step 1.** Given guessed paths of wages, house prices and rents, we solve the value functions and policy functions along the path backward starting from period $T$, since in period $T+1$, value functions and policy functions are known, given by those in the new stationary equilibrium. Then migration probabilities can be constructed as well using Equation (5).

Next, given the initial population (old stationary equilibrium distribution), we can compute a path of population $\{L_t^R(a,\epsilon,q,l), L_t^H(a,\epsilon,q,l,h)\}_{t=1}^T$ following the transition of endogenous states (housing, saving, homeownership status policies, and location choice) and exogenous states (employment status shock, age).

**Step 2.** Given the path of distribution $\{L_t^R(a,\epsilon,q,l), L_t^H(a,\epsilon,q,l,h)\}_{t=1}^T$, we can update wage path $\{\mathbf{w}_t^1\}_{t=1}^T$ and house price path $\{\mathbf{p}_t^1\}_{t=1}^T$ using the using labor market clearing condition in Equation (6) and house stock evolution conditions implied by Equations $(8)-(10)$.

**Step 3.** Given updated wage and house price path, we return to Step 1. We follow Step 1 and then Step 2 until wage and price paths in all the locations converge.

**Step 4.** Then we check whether in period $T$, wages and prices reach the corresponding levels in the after-shock stationary equilibrium. If not, we increase $T$.