UNPACKING MOVING*

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Abstract

We develop a dynamic life-cycle model of location choice with incomplete markets. The model captures the role of monetary and utility mobility frictions, amenities, credit constraints, city-specific housing supply elasticities and aging. The features of the model are motivated by empirical evidence on the heterogeneous mobility patterns of different demographic groups. Individuals with higher ability to borrow, young and non-homeowners move, on average, more and are more likely to move to "opportunity" than their respective counterparts. However, individuals with higher ability to borrow tended to migrate relatively less in reaction to an oil price shock in Canada. We calibrate the model to the 28 largest Canadian labor markets and perform counterfactual analysis in three dimensions. First, we replicate the oil shock in the model as a productivity shock and we find similar heterogeneous responses as in the data. Second, we compare sources of mobility restrictions: utility and monetary costs. We find that utility moving costs matter more than the monetary ones. When utility moving costs decrease by 10%, mobility rates almost double, but the share of individuals that move to "opportunity" decreases. Last but not the least, if in Vancouver, housing regulations, such as zoning, were less stringent, welfare would increase by 9% in Vancouver and by 1.12% overall in Canada in the long-run.

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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 situation but also affects family prospects. Therefore, understanding individuals' location choices and the main mobility barriers that impact their decision has been a central issue in recent research. One would expect individuals to move to "opportunity" or to use migration as a way to buffer income shocks. However, evidence suggests that some demographic groups do not move to "opportunity" and that the use of migration to attenuate the negative impact of shocks is limited.[1] Several explanations have been proposed to rationalize such empirical findings. The most predominant ones are large migration costs, indivisibility of housing and aging of population. More recently, Bilal and Rossi-Hansberg (2018) have put forward the notion of location as an asset in which individuals in response to a shock may move but to worse locations.

A large body of empirical and quantitative research has studied each of these channels separately. However, there are no quantitative studies of location decisions within a comprehensive dynamic structural model of household behavior, where households vary by their *key* demographic characteristics. This gap in the literature is troubling since migration as a short-term response to income shocks is paramount for macroeconomists and policy makers to alleviate inequality and spur growth. Identifying the determinants of different individuals moving decisions is crucial in shaping local economic policies, such as *housing regulations* or *moving subsidies*, and in assessing whether income shocks can have vastly different welfare effect under different local macroeconomic conditions. Hence, we aim at "unpacking" the migration decisions in response to income shocks and quantifying how much each of these channels, in isolation and in interaction, affects their migration responses. First, we exploit a rich individual credit bureau dataset for Canada to give motivational evidence of heterogeneous migration patterns by different demographic groups in steady state and in response to an oil shock. Second, we develop a life-cycle model with incomplete markets and location, consumption-saving and housing choices. We discipline the assumptions and the calibration of the model by the empirical evidence.The calibrated model allows us to evaluate the oil shock as validation exercise. But, more importantly, it allows us to run counterfactuals for moving costs as well as change in housing regulations.

The paper consists of three parts. In the first part, using individual-level credit history data for Canada, we study the characteristics of those that move. We also exploit an unanticipated drop in

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

international oil prices to study the characteristics of those that responded to such income shock. In particular, we look at home-ownership, age and ability to borrow. We find that homeowners move less than renters, younger individuals move more and those that are more able to borrow move more. 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. On average, lower credit score, older and homeowners are more likely to *downgrade* by moving to location with lower house prices, lower wages and lower amenities.

In the second part of the paper, we develop a dynamic life-cycle model with incomplete markets, location, consumption-saving and housing choices 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 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. Such framework can also answer how migration response would look like if population age distribution was as projected in the next 30 years. Last but not the least, it allows us to look at the welfare implications of a policy that relaxes housing regulations in expensive and large cities such as Vancouver or Toronto.

In the third part of the paper, we 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 et al. (2016), Acemoglu and Restrepo (2017) and Jones et al. (2011)). In our setting, the main ingredients and mechanisms present in the model are strongly informed by the empirical evidence on heterogeneous migration behaviour and from the international oil price shock. We estimate the production function using regional variation to obtain a series of city-level productitivities 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. To validate the model, we 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. Then, to understand how the model's mechanisms work, we reduce migration frictions' elements such as monetary migration costs and bilateral moving utility losses. Finally, we analyze two main counterfactuals: (i) what would be the impact of migration subsidies on the overall mobility patterns and the moving to "opportunity"? We find that a monetary migration subsidy to liquidate the house has very little impact on the moving decisions but a utility subsidy does substantially. (ii) how would the welfare effects be if *housing regulations* were less stringent in Vancouver? We find evidence that if housing supply in Vancouver was 20% more elastic, welfare for the generation right after the change in regulation would increase by 9% in Vancouver and by 1.23% in Canada. These number increase slightly for the following generations.

Literature Review This paper relates to several branches of the 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 et al. (2018), Giannone (2017), Lagakos et al. (2018), Lyon and Waugh (2018), Bilal and Rossi-Hansberg (2018) and Caliendo et al. (2019) and Eckert and Kleineberg (2019). We complement this class by modeling explicitly location choices by heterogeneous agents with borrowing constraint that sort into locations, life-cycle and housing. Our framework is the first to include all these margins that are first-order to run realistic local policy evaluations. Specifically, it allows us to evaluate how agents with different levels of assets, age and home status sort across different locations and how they respond to shock differently. An agent with lower level of asset might move as a response to the oil shock by downgrading her location to one with cheaper house prices, but also lower wages and lower amenities. The agent would have more incentive to do so if she was older and if she did not own a house. This frameworks sets the ground for a variety of counterfactuals and policy evaluations such as aging population and housing.

This paper also relates to empirical analyses that aim at quantifying what is the migration response to negative demand shocks such as Topalova (2010), McCaig (2011), Autor et al. (2014), Dix-Carneiro and Kovak (2017) and Greenland et al. (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 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 general equilibrium mechanisms such as housing choice, life-cycle, amenities and sorting by assets. The resulting framework allows us to study a wider range of policy experiments compared to previous work thanks to a efficient computational code, which is key in order 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.

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 strategy and results. Section 3 develops the theoretical framework. Section 4 reports the estimation and the calibration strategy. Section 5 reports counterfactual analysis by reducing the moving frictions and describing the overall migration response if population aging happens as projected. Finally, section 6 concludes.

2 Empirical Motivation

In this section, we propose motivational evidence of migration heterogeneity along age, homeownership and ability to borrow. First, we describe the data used in the empirical analysis that aims at capturing the heterogeneous migration patterns by different demographic groups and their response to an oil shock. Second, we discuss our main empirical specification and the results. Thirs, we analyze where people move both in steady state and in response to the shock by performing a decomposition analysis. In specific, we sort cities in several dimensions, as house prices, income, amenities, among others, and identify which demographic groups move more to different locations based on cities' characteristics.

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. The dataset is updated at a monthly frequency and 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. In specific, we observe credit limits, balances, payments, and delinquency status for each of the 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[2] 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.

We obtain oil prices from the Canadian Association of Petroleum Producers. We use the Western Canadian Select (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.[3] 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.

2.2 The Oil Shock in Canada

Canada is the fifth largest oil producer in the world. Most Canadian crude oil is exported, with almost all oil exports going to the United States. As the oil sold in global markets generates

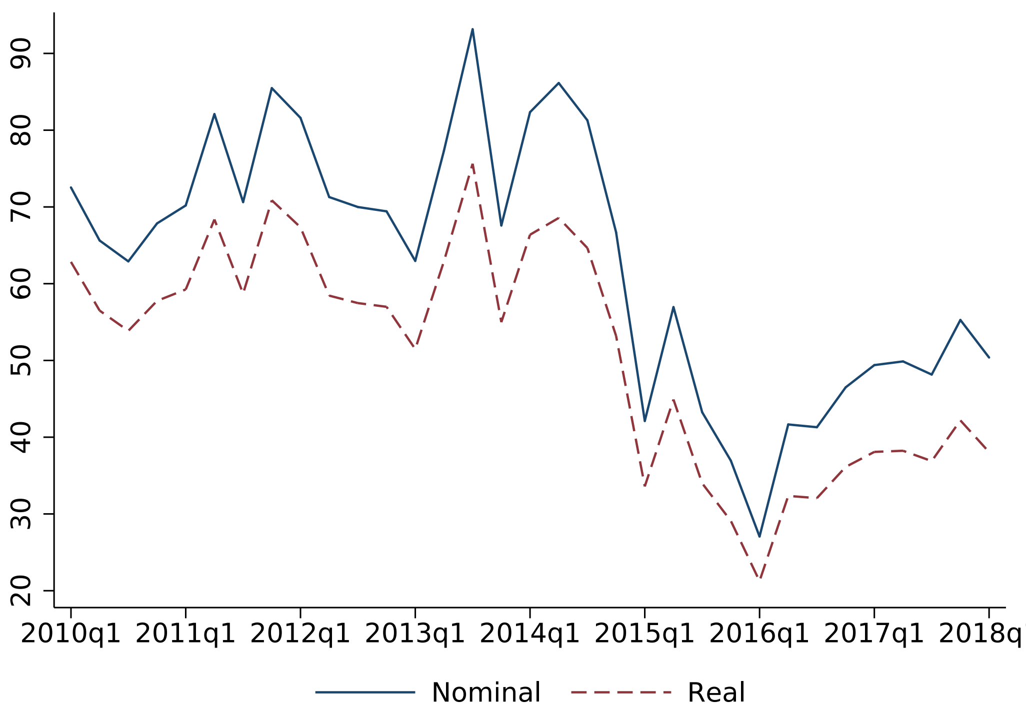
[2] A city is defined as a census metropolitan area (CMA) or a census agglomeration (CA) that are formed by one or more adjacent municipalities centered on a population core. A CMA must have a total population of at least 100,000 of which 50,000 or more must live in the core. A CA must have a core population 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.

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

higher revenue, real incomes in the Canadian oil industry increase when international oil prices rise. 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.

Figure 1 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.[4] Although it started slowly recovering, current oil prices remain almost 40 percent lower the average value before 2014.

Figure 1: Oil Price Evolution



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.

[4] Real oil price is computed by deflating WCS by the national wide Canadian consumer price index (CPI).

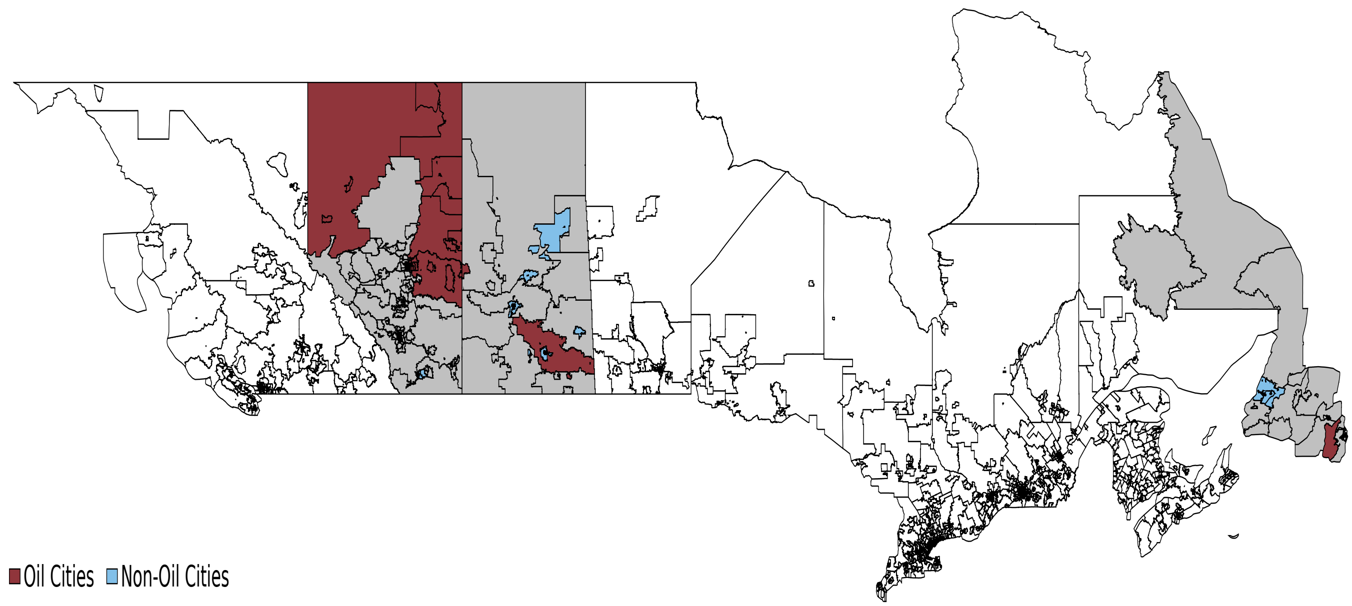
In our empirical analysis, we would like to identify individuals that are directed impact by this shock. Given that we are not able to observe who is directly affected, we identify small regions where oil industry is disproportionally relevant. These are naturally the closest FSAs to Thermal in-situ 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%.[5]

[5] 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 2: Oil Cities and Non-Oil Cities within the Oil Provinces



In Figure 2 we present a map of Canada where 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.

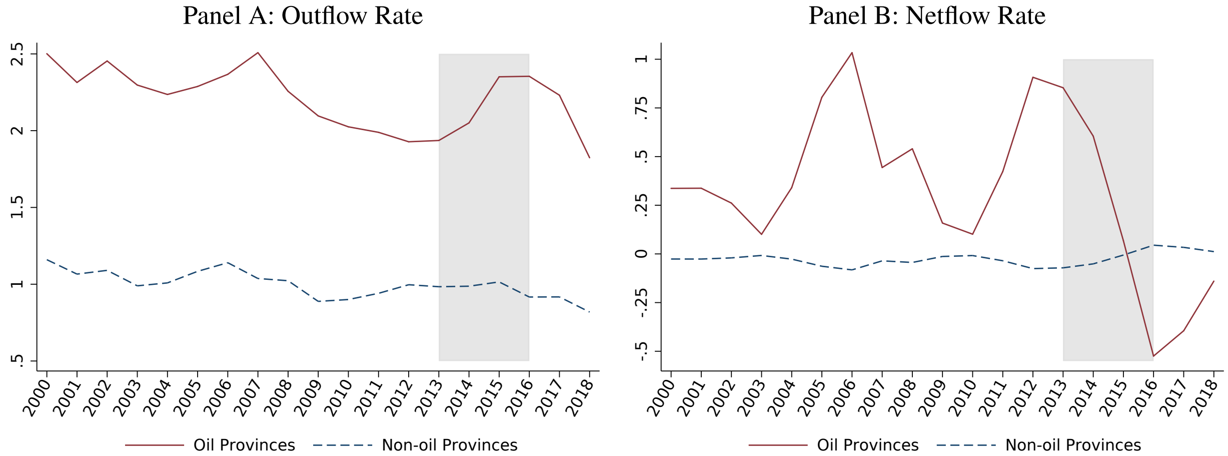
Similarly to Kilian and Zhou (2018), we build a city specific *Oil Shock* taking into account the employment share in the oil industry in each of the *Oil Cities*. In specific, we build a measure of regional exposure to the oil shock that resembles the standard *Bartik* shocks as follows:

$$OilShock_{z,t} = -\alpha_z log(\text{OilPrice})_t \tag{1}$$

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. The causal interpretation rests on the assumption that changes in the real price of oil are exogenous with respect to the Canadian economy, that they are unpredictable, and that they are not correlated with exogenous changes in other variables that affect the Canadian economy.

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.

Figure 3: Migration Patterns in Canada



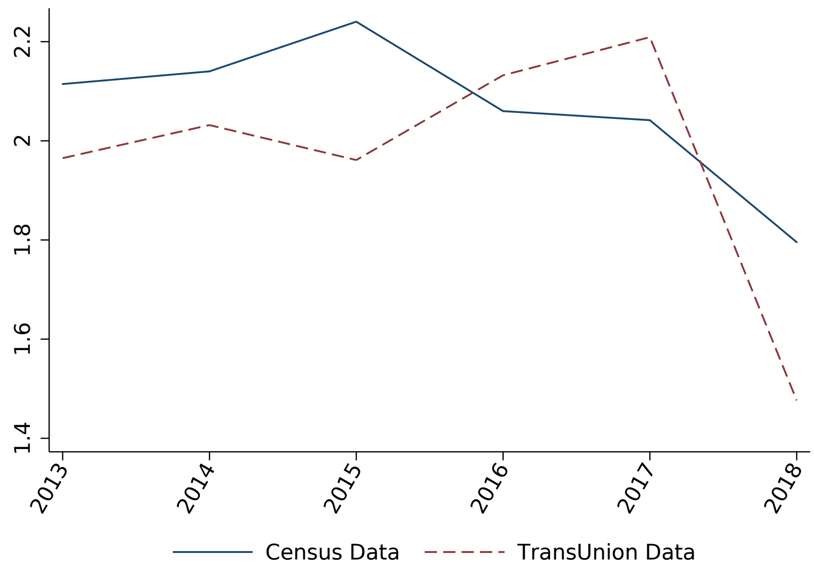
Note: Figure 4 plots the Migration patterns in Canada between 2000 and 2018 for Oil Provinces and Non-oil Provinces. Panel A plots the Outflow Rate and Panel B plots the Netflow Rate. Outflow Rate is defined by the number of people leaving a certain set of provinces divided by the total Population in 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.

2.3 Migration Patters in Canada

Below we describe the migration patterns in Canada in the recent years and compare official statistics from Statistics Canada with the migration flows inferred from *Transunion*.

Figure 3 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 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.

Figure 4: Migration Patters in the Canada (Grossflows): Census vs TransUnion Data

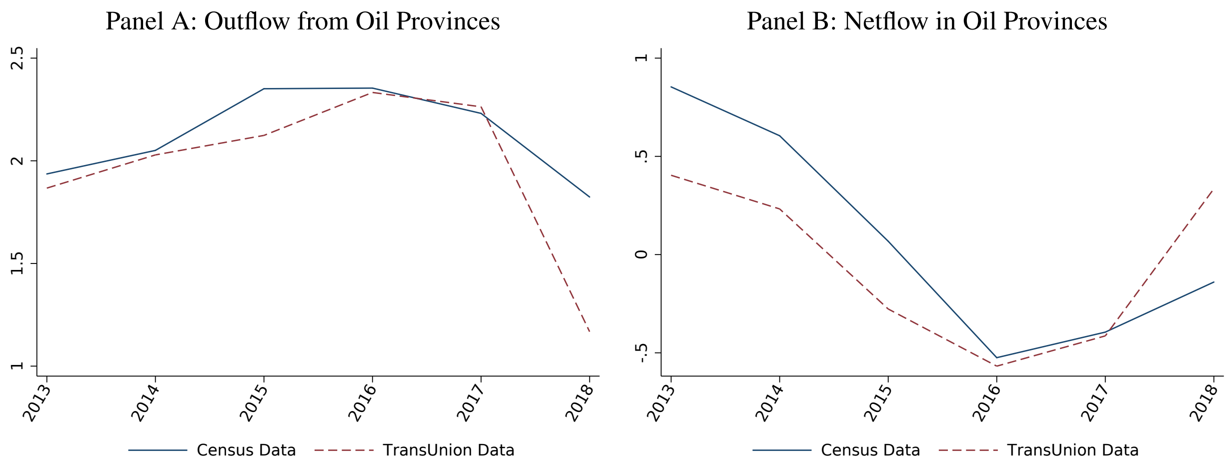


We now evaluate how *Transunion* dataset is able to track the movement of people across space in Canada. Overall, as shown in figure 4, the migration rates obtained using individual data from *Transunion* matches pretty close the official migration rates from Statistics Canada both in terms of magnitudes and timewise. *Transunion* does particularly well in matching the Outflow rate from *Oil-Provinces* between 2013 and 2016, the time period used to perform the empirical analysis of this paper (Panel A of Figure 5). Although *Transunion* tends to underestimate the netflow of the Oil regions, it presents very similar trends (Panel B of Figure 5). Overall, *Transunion* seems to be a reliable source to track migration rates within Canada.

2.4 Summary Statistics

We know 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

Figure 5: Migration Patters in the Oil Provinces: Census vs TransUnion Data



Note: Figure ?? plots the Migration patterns in the Oil Provinces between 2013 and 2018. Panel A plots the Outflow Rate and Panel B plots the Netflow Rate. Outflow and Netflow Rates are computed as described in 4. Rates are computed using official migration rates from Statistics Canada and TransUnion.

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.[6] Individuals that move across FSAs within the same city are classified as Stayers.

Overall, as reported in Table 1, 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.

[6]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 1: 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.

2.5 The Heterogeneous Migration Behaviour

In this section, we analyse how distinct individuals migrate and also how they respond differently to a negative oil shock. In specific, we look at homeownership, age and ability to borrow (measured in terms of credit score). We departure from most of the current literature that usually looks at the correlation between migration and demographic characteristics by looking also at how such characteristics interact with a negative shock to the local economy by implementing the following specification:

$$\begin{aligned} Move_{i,z,t} =& \beta_0 + \beta_1 OilShock_{z,t-1} X_{i,z,t-1} + \beta_2 X_{i,t-1} + \beta_3 OilShock_{z,t-1} \\ &+ \beta_4 W_{i,z,t-1} + \gamma_i + \delta_z + \theta_t + \epsilon_{i,z,t} \end{aligned} \tag{2}$$

where $\text{Move}_{i,z,t}$ 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, γ_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, θ_t, absorb overall trends in migration rates and any potential aggregate shock to the economy. The city fixed effects, δ_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 β_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*. In specific, 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.

β_2 measures the unconditional migration probability and β_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 1. 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.

2.5.1 Results

Table 2 reports the results of the main specification described in equation 2. Columns (1)-(2) include only homeownership as explanatory variable, columns (3)-(4) include only age groups and columns (5)-(6) include only credit score groups. Columns (7)-(8) include all the previous explanatory variable jointly.

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

Table 2: 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 2. 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.

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 9, we consider a "Continuous" *Oil Shock*. In specific, we use the definition of the oil shock in equation 1 without restricting to the Cities around the oil facilities. In Table **??**, we restrict the sample to cities where the share of low skill workers in the Oil Industry is not larger than the national average. Although magnitudes vary depending on the specification, we find nevertheless the same relationship between moving probabilities and homeowneship, age and credit score.

2.6 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:

$$MoveTO_{i,z,z',t} = \alpha + \beta_1 X_{i,t-1} + \beta_2 OilShock_{z,t-1} + \beta_3 W_{i,t-1} + \gamma_i + \delta_z + \theta_t + \epsilon_{i,z,t} \quad (3)$$

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 (2).

Table 3: 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 β_1 that tell us which individuals are more likely to "move up".

2.6.1 Results

Table 3 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.[7] 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.

We know analyze income in terms of their income statistics. In panel B of Table 3, 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 homeownship 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,

[7] 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 4: 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 3. 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 2 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 4: 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 $\times$ Quarter Fixed-Effects	No	Yes	No	Yes	No	Yes	No	Yes

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 4, we report the estimates of specification 3 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.

3 Model

We now analyze migration through the lens of a dynamic life cycle model with incomplete markets, consumption-saving decisions and housing choice. The first subsection presents the household's optimization problem. The second subsection describes production. The third defines the general equilibrium.

3.1 Consumption-Saving and Directed Migration

We consider an life cycle model with consumption, saving, housing and migration decisions. Each cohort of agents lives deterministically for $\bar{Q}$ periods. In each period, a measure of $1/\bar{Q}$ agents are born, so that the economy has a stationary population of 1 and a flat age structure. The agent works in the initial Q periods and retires after that. During her working period, she receives age and location specific labor income, subject to an idiosyncratic employment shock, $w^l(q)\epsilon$. Specifically, $\epsilon \in \{\epsilon_h, \epsilon_l\}$ represents an unemployment and full-time employment status, respectively. In case of unemployment, the agents received an unemployment subsidy that is common across locations. The employment shock is associated with the Markov transition matrix M. Upon retired, an agent simply receives a fixed income $\bar{w}$ regardless of her location, which is reminiscent of a pension or social security benefit. Agents can save through a risk-free asset, a, subject to a borrowing constraint b. Moreover, a fraction Π_h of agents are homeowners ($I_h = 1$) and the fraction $1 - \Pi_h$

are renters. Although the homeownership status is fixed across their lifetime, agents can choose the amount of housing services consumed every period.

Agents in our model can move across locations in any period of their life. Locations in the model are indexed by $l \in \{1, 2, ..., N\}$. Below, location subscripts are omitted unless necessary. Locations differ in four dimensions: productivity (z), labor market risk (M), housing supply elasticity (κ) and amenities (A). Agents can direct their migration towards specific locations subject to idiosyncratic location preference shocks and mobility frictions. Specifically, we assume that every period agents draws a vector of N independent Type 1 extreme value shocks with scale parameter ν. To move, all agents incur an utility moving cost, $\tau^{l,l'}$, that is a function of both origin and destination locations. Homeowners incurs an extra monetary moving cost δ^l. This monetary moving cost captures the transaction costs associated with buying and selling properties (taxes, commissions, etc).

The timeline of the decision-making is as follows:

(i) The agent enters the period knowing her current location l and all her individual states (a, ϵ, q, I_h);

(ii) A vector of idiosyncratic preference shocks realizes;

(iii) Migration decision is made;

(iv) Consumption, savings, housing services decisions are made and moving costs are paid if moving occurs;

(v) State variables evolve according to the exogenous shock processes and individual decisions.

We know formalize the individual's problem. An agent in location l, with individual state (a, ϵ, q, I_h), where a is her current asset holding, ϵ is her unemployment status, q is age, and I_h is her home-ownership status solves the following Bellman equation:

$$V^l(a, \epsilon, q, I_h) = \max_{c \geq 0, h \geq 0} U(c, h) + \nu \log(\sum_{l'=0}^{N} \exp(\beta E^{l'}_{\epsilon'|\epsilon} V^{l'}(\widetilde{a}^{l'}, \epsilon', q+1, I_h) - \tau^{l,l'})^{\frac{1}{\nu}})],$$

$$\text{s.t.} \qquad \widetilde{a}^l = (1+r)a + w^l(q)\epsilon - p^l h - c,$$

$$\widetilde{a}^{l'} = \widetilde{a}^l - \delta^l I_h,$$

$$\widetilde{a}^{l'} \geq b$$

Following McFadden (1973), due to the Type 1 Extreme value assumption on location preference shock, the moving probability from l to l' is defined as follows:

$$\mu^{l,l'}(a, \epsilon, q, I_h) = \frac{\exp(\beta E^{l'}_{\epsilon'|\epsilon} V^{l'}(\widetilde{a}^{l'}, \epsilon', q+1, I_h) - \tau^{l,l'})^{\frac{1}{\nu}}}{\sum_{l'=0}^{N} \exp(\beta E^{l'}_{\epsilon'|\epsilon} V^{l'}(\widetilde{a}^{l'}, \epsilon', q+1, I_h) - \tau^{l,l'})^{\frac{1}{\nu}}}.$$

We assume that the utility function $U(c, h)$ is CRRA as follows:

$$U(c, h) = \frac{(c^{\alpha}(h)^{1-\alpha}A^{\gamma})^{1-\sigma}}{1-\sigma} \tag{4}$$

To be consistent with observed savings after retirement, we assume a bequest function a la De Nardi (2004):

$$\varphi(a) = \theta \frac{(a+\phi)^{1-\sigma}}{1-\sigma} \tag{5}$$

where $\varphi(a)$ represents the terminal value that an individual obtains from leaving assets, a, to his or her heirs. θ captures the intensity of the bequest motive and ϕ determines the curvature of the bequest function and hence the extent to which bequests are a luxury good.

3.2 Production and Housing Supply

The production side of the economy is standard. The production function of a unique consumption good is assumed to be $\exp(z^l)(L^l)^{\eta}$, where L^l is total employment in location l. The equilibrium city-level wage in location l is then given by

$$w^l = \eta \exp(z^l)(L^l)^{\eta-1} \tag{6}$$

Housing supply is assumed to have constant elasticity κ^l that varies across locations.[8] Housing market clearing in each location l implies that housing prices satisfy

$$p^l = (H^l)^{\kappa^l},$$

where H^l is the total demand for housing services defined by

$$H^l = \sum_a \sum_{\epsilon} \sum_q \sum_{I_h} h^l(a, \epsilon, q, I_h).$$

[8] We are currently working on a version of the model where housing is a stock that accumulates over time.

3.3 Equilibrium

Given the group age 1 distribution across states, $L^l(a,\epsilon,q,I_h)$, the stationary equilibrium of the economy consists of: price vectors **w**, **p**; a set of value functions $V^l(a,\epsilon,q,I_h)$, and policy functions $\widetilde{a}^{l,l'}(a,\epsilon,q,I_h), h^l(a,\epsilon,q,I_h)$; population distribution $L^l(a,\epsilon,q,I_h)$ such that:

1. Given **w**, **p**, $V^l(a,\epsilon,q,I_h), \widetilde{a}^l(a,\epsilon,q,I_h), h^l(a,\epsilon,q,I_h)$ solve the agent's problems

2. Given **w**, **p**, the value functions and policy functions, migration probabilities are given by

$$\mu^{l,l'}(a,\epsilon,q,I_h) = \frac{\exp(\beta E^{l'}_{\epsilon'|\epsilon} V^{l'}(\widetilde{a}^{l'},\epsilon',q+1,I_h) - \tau^{l,l'})^{\frac{1}{\nu}}}{\sum_{l'=0}^{N} \exp(\beta E^{l'}_{\epsilon'|\epsilon} V^{l'}(\widetilde{a}^{l'},\epsilon',q+1,I_h) - \tau^{l,l'})^{\frac{1}{\nu}}}$$

   and population distribution satisfies:

$$L^{l'}(\widetilde{a},\epsilon',q{+}1,I_h) = \sum_l \sum_a \sum_\epsilon L^l(a,\epsilon,q,I_h) 1\{\widetilde{a} = \widetilde{a}^{l'}(a,\epsilon,q,I_h)\} \mu^{l,l'}(a,\epsilon,q,I_h;\epsilon',q{+}1)\pi(\epsilon'|\epsilon)$$

3. Markets clear.

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 Appendix. Then, we report the mix of reduced-form analysis and simulated method of moments that we pursued to calibrate some of the parameters of the model. In specific, we obtain estimates for location specific productivities, z^l, amenities, A^l and housing supply elasticities, κ^l . We also internally calibrate the labor demand elasticity, η, and several household utility parameters, $\{\eta,\beta,\sigma,\gamma\}$, besides moving costs and borrowing limit, $\{\tau^{l,l'},\delta^l,b\}$.

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.

4.1 Data, Space, Age Groups and Measurement

We calibrate the model to the Canadian economy pre-oil shock. The geographic units of analysis are the 28 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

28 CMAs. We assume that individuals enter the model when they are 25 years of age and they die when they 85 years old, living, therefore, for 60 periods.

Productivities and Elasticity of Labor Demand In order to estimate the elasticity of labor demand η and local productivities, $z^l, \forall l$, we estimate the wage equation 6 by using an instrumental variable approach. Specifically, we use measures of housing regulations interacted with shocks *a la Bartik*. The intuition is that housing regulations move the labor supply without moving the labor demand for a given shock of housing. This pins down η. Once we estimate η, we predict wages and back out from the residuals z^l for all CMAs.

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.

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 increases 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$\times$time fixed effects. The housing supply elasticity corresponds then to the inverse of the estimated city-level sensitivity parameter.[9]

4.2 Simulated Method of Moments

In order to obtain estimates on the set of parameters $\{b, \beta, \tau_0, \tau_1, \eta\}$, we use simulated method of moments and target five moments: share of individuals with negative assets, the average net worth-to-income ratio, the correlation between in-migration and distance and the correlation between out-migration and distance. Table 5 reports the estimates of the parameters and the target moments both in the data and the ones generated by the model.

The estimates are in accordance with the existing literature for the parameters we can compare.

[9] 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.

Specifically, the estimate of ν is the same as in Caliendo et al. (2019) and β is similar to the one used in the life-cycle model of Kaplan et al. (2017).

Table 5: Results of Simulated Method of Moments

				Value	
Parameter	**Value**	**Description**	**Moment**	Data	Model
τ_0	35	moving costs	av.out-migration	0.0187	0.0163
τ_1	0.006	moving costs	corr.(distance,out-migration)	-0.2828	-0.2348
ν	5	variance Type 1E.V.	corr.(prod,in-migration)	0.9108	0.7368
b	-0.0936	borrowing ability	sh. pop. negative assets	0.0977	0.2358
β	.95	discount factor	av. net worth/income ratio	4.3316	0.5488

4.3 Externally Calibrated Parameters

The rest of the parameters is calibrated externally following the literature. The results are reported in Table 6. We set the interest rate to be 2% and α to 0.85, standard values in the literarure and used, among others, in Kaplan et al. (2017). α is calculated by matching the ratio of expenditures on housing services to total consumption expenditures in the US National Income and Product Account, which is around 15 percent on average over the period 1960-2009. The risk aversion coefficient, σ from the CRRA is taken from Kaplan et al. (2017) and set to be equal to 2, which gives an elasticity of intertemporal substitution equal to 0.5. The elasticity on the amenity, γ, is taken from Diamond (2016) that estimates it in a spatial equilibrium model using variation in housing supply interacted with local Bartik productivity shocks. The bequests' parameters are taken from De Nardi (2004) that looks at the wealth inequality across generations. The probability of the employment shock ϵ is calculated directly from the unemployment statistics in Canada.

Table 6: Externally Calibrated Parameters

Parameter	Description	Source	Value
α	consumption share	Kaplan et al. (2014)	.85
σ	risk aversion	Kaplan and Violante (2014)	2
γ	amenities el.	Diamond (2016)	1
θ	bequest		100
r	interest rate	IMF	.02
ϵ	unemployment shock	Statistics Canada	.5
δ^l	Housing	Authors Calc.	$.07 * \frac{p^l * H^l}{N^l}$

4.4 Model Matching Data

In this section, we report the results of the calibrated model. Among others, we are interested in understanding the migration outcomes by individual characteristics. Overall, the model matches quite well the population and income by city as shown in Figure 6. Panel A shows that with respect to population, the fit is nearly perfect.

Figure 6: Data Matching Model

Panel A: Population

Panel B: Income

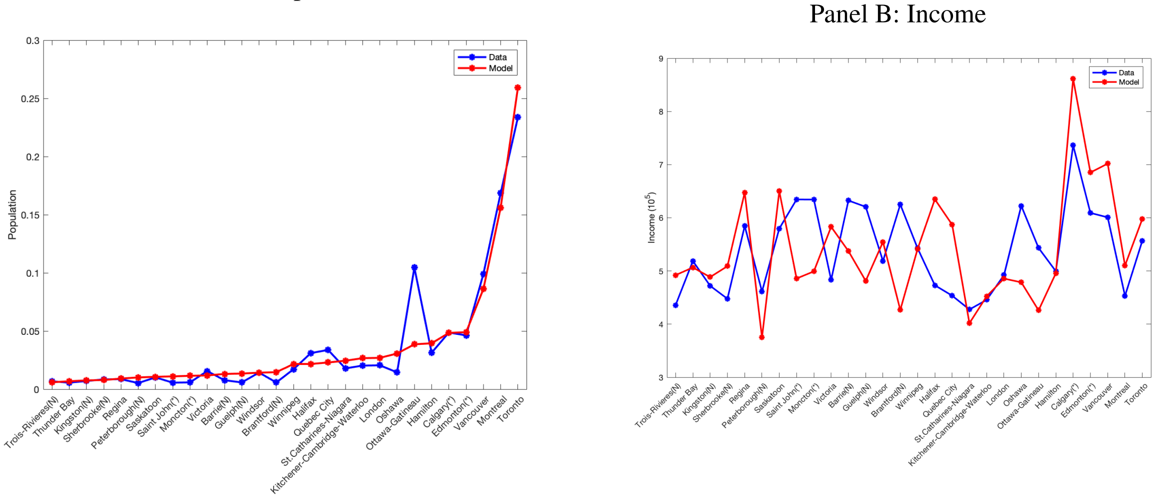
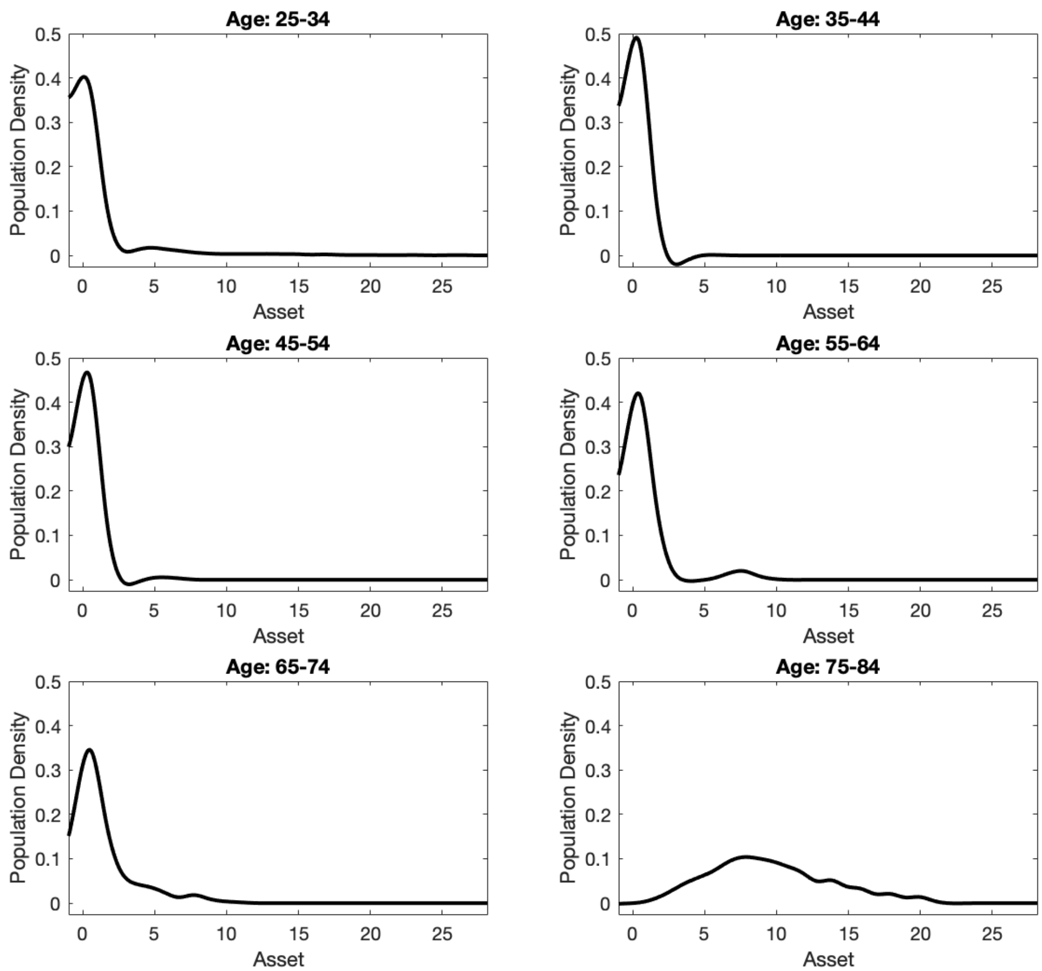


Figure 6 plots the population and income by CMA both in the data and in the model. Panel A plots population and Panel B plots income. Population and income in the data are computed using official migration rates from Statistics Canada and TransUnion.

We, then, look at the overall distribution of asset and the distributions of asset by age from the calibrated model. This is shown in Figure 7. In the current version of the model, middle-aged agents save too little when compared to the data.[10]

Figure 7: Population Distribution by Asset Level and Age



Note: This figure reports the population density for each level of asset and each age group. In our sample, individuals between 65-85 are retired.

Figure 8 shows the migration rates for different assets level in Panel A and for different age groups in the Panel B. Overall, the model matches the data. In a stationary environment, the model delivers a decreasing migration rate with age while migration tends to increase with the asset level. Although we do not observe assets in the data, we assume that the credit score and the level of assets are positively correlated and one can proximate the latter with the former.

[10]We are currently working on a new version of the model to match better the saving function by age groups.

Figure 8: Data Matching Model: Migration

Panel A: By Assets

Panel B: By Age

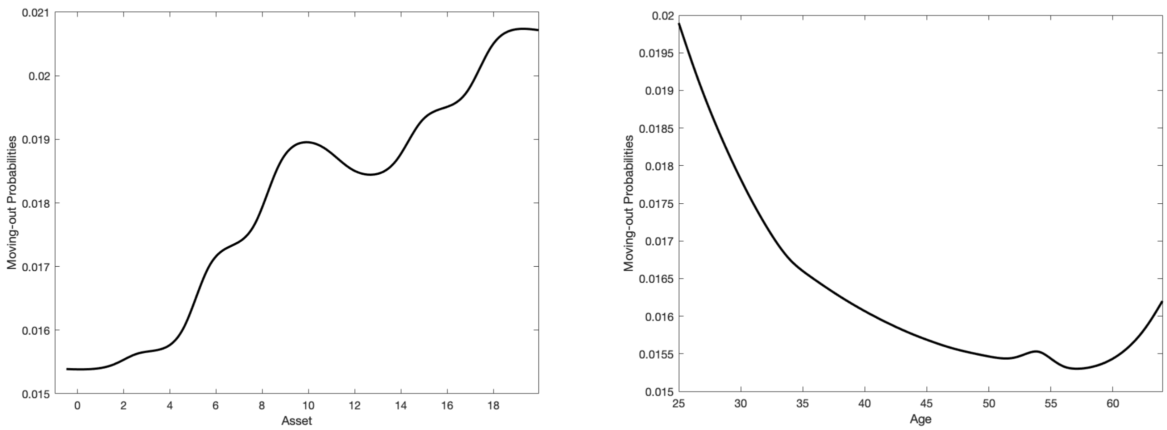


Figure 8 plots the migration rates in the model. Panel A plots it by assets and Panel B plots by age.

We now look at where agents move to and whether the destinations depend on individual state. The attraction of cities, measured in terms of in-migration rates, is very heterogeneous. Overall, as shown in Figure 9, we observe that Toronto is the city that receives most migrants. Montreal, Oshawa and Hamilton follow. The red horizontal line indicates the average of in-migration rates.

Figure 9: In-Migration bu cities

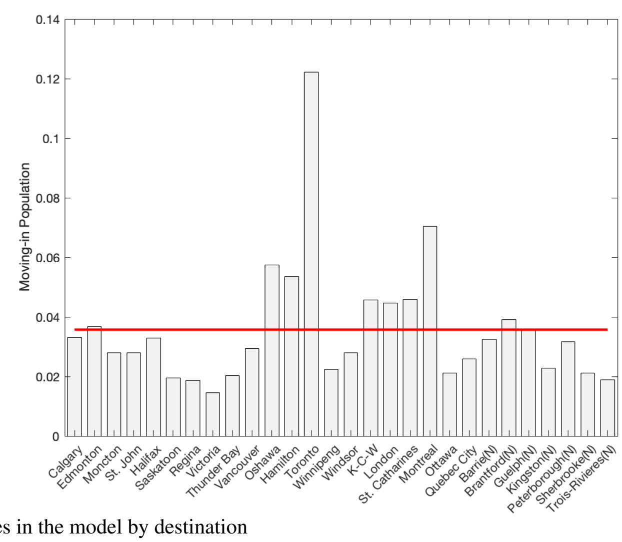


Figure 9 plots the in-migration rates in the model by destination

Where are the movers going? We analyze now in a more systematic way the city characteristics that attract more agents in the model. In panel A, we correlate in-migration rates by house rents in the city. We observe that the correlation is negative. Individuals, on average, move less to expensive places. In panel B, we plot the relationship with wages, and we observe that there is a slightly negative relationship, especially when we remove Toronto from the sample. In panel C and D, we look at city-level productivity and amenities, respectively. Both measures are positively correlated with in-migration rates.

Figure 10: Correlation between In-Migration and City's Characteristics

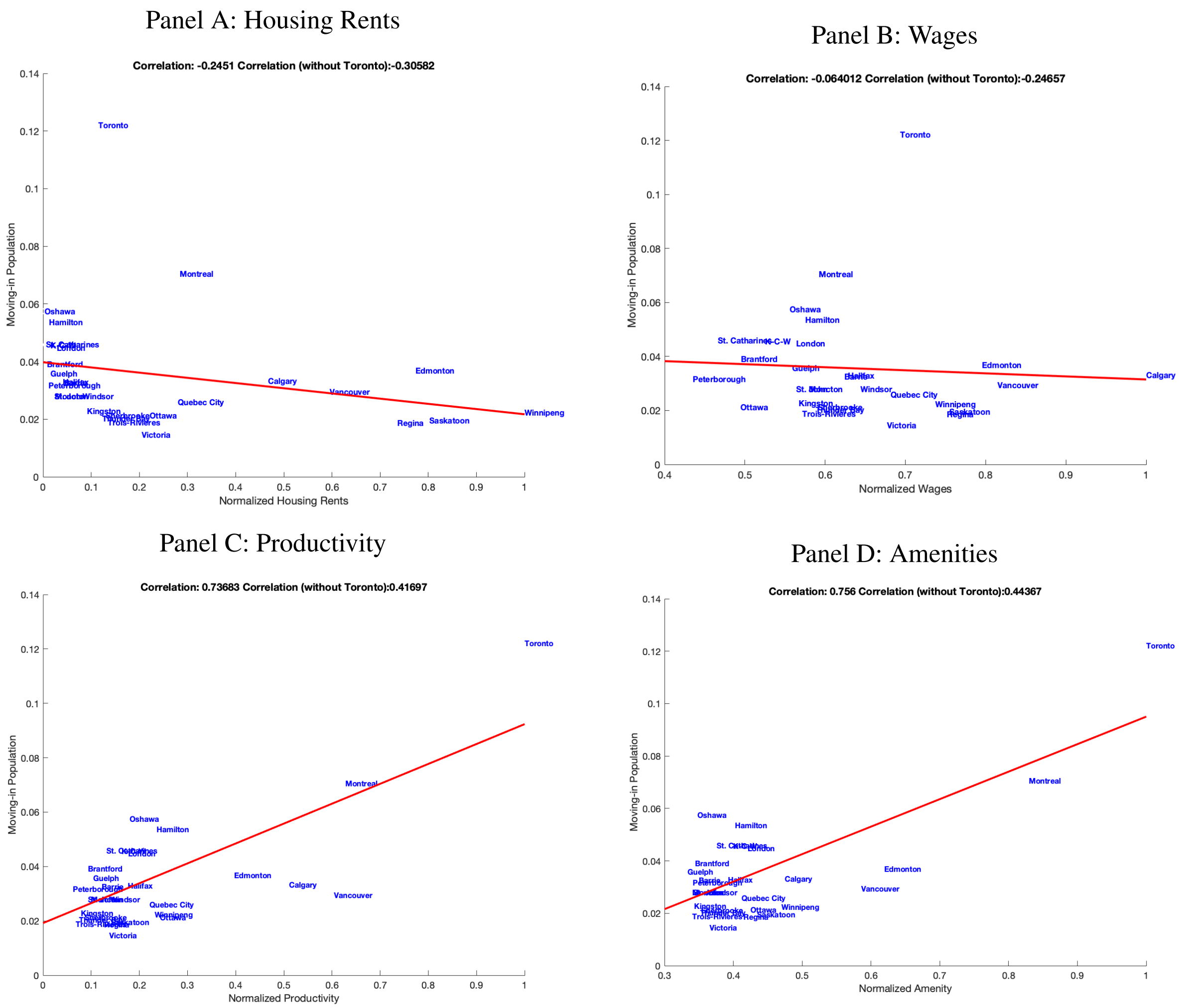


Figure 10 plots the correlation between in-migration rates and city characteristics. Panel A and Panel B plot the correlation between in-migration rates and housing rents and wages, respectively. Panel C and D, instead, plot the correlation between in-migration rates and productivity and amenities, respectively. In each of the last four panels, the correlation with and without Toronto are reported.

Are Movers Upgrading? An important part of our analysis is related to the *upgrading* or *downgrading* behaviour of agents. 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 11 we look at 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 look at wages, younger upgrade consistently more than older and the relationship is monotonic. In panel C and D, we look at 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.

Figure 11: Correlation between In-Migration and City's Characteristics by age and asset level

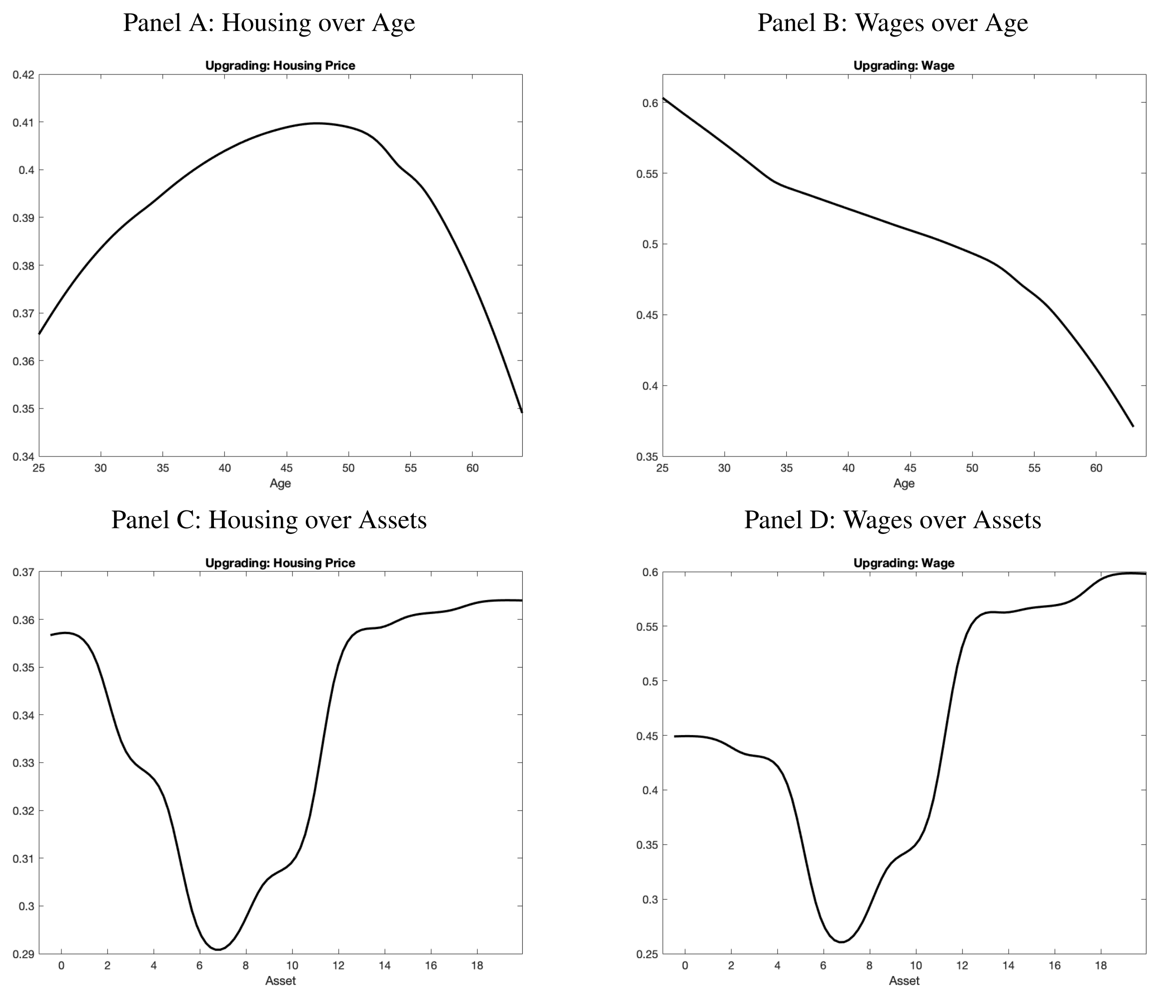


Figure 11 plots the in-migration rates in the model by destination in the top panel. Panel A and Panel B plot the correlation between in-migration rates and housing rents and wages, respectively. Panel C and D, instead, plot the correlation between in-migration rates and productivity and amenities, respectively. In each of the last four panels, the correlation with and without Toronto are reported.

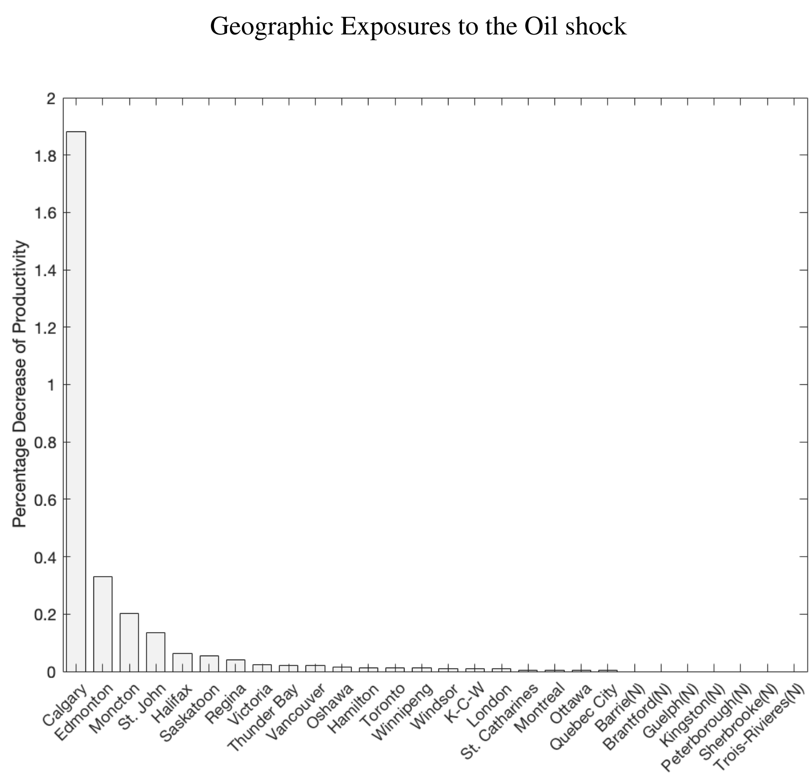
5 Counterfactual Analysis

In this section, we conduct counterfactual analysis in several dimensions. First, we replicate the oil shock in the model as we did in the data. Second, we decrease migration costs, either monetary or non-monetary, by the same dollar amount. This could be interpreted as a moving subsidy. Third, we decrease housing regulations in Vancouver, replicating a potential decrease in zoning regulations.

5.1 Can the Model Replicate the Oil Shock?

In this subsection, we replicate the oil shock that hit Canada starting in 2014, and we look at the effects of the shock on prices and location choices. Figure 12 plots how different regions are affected by the oil shock. For each city, we compute a percentage loss of productivity measured as 40% times the share of employment in the oil extraction within that city. We see that Calgary, Edmonton, Moncton, and Saint John, all cities in the *Oil Provinces*, are are the most affected cities by the oil shock. In Calgary, the city hit the most, see a decline in productivity of about 2%.

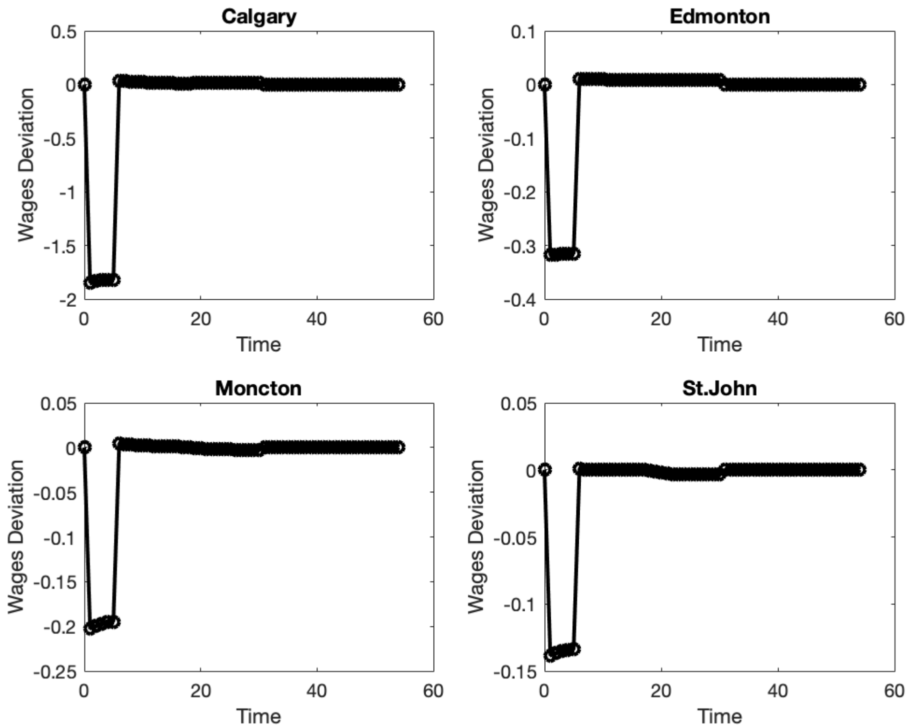
Figure 12: The Oil Shock in the Short and Long-Run



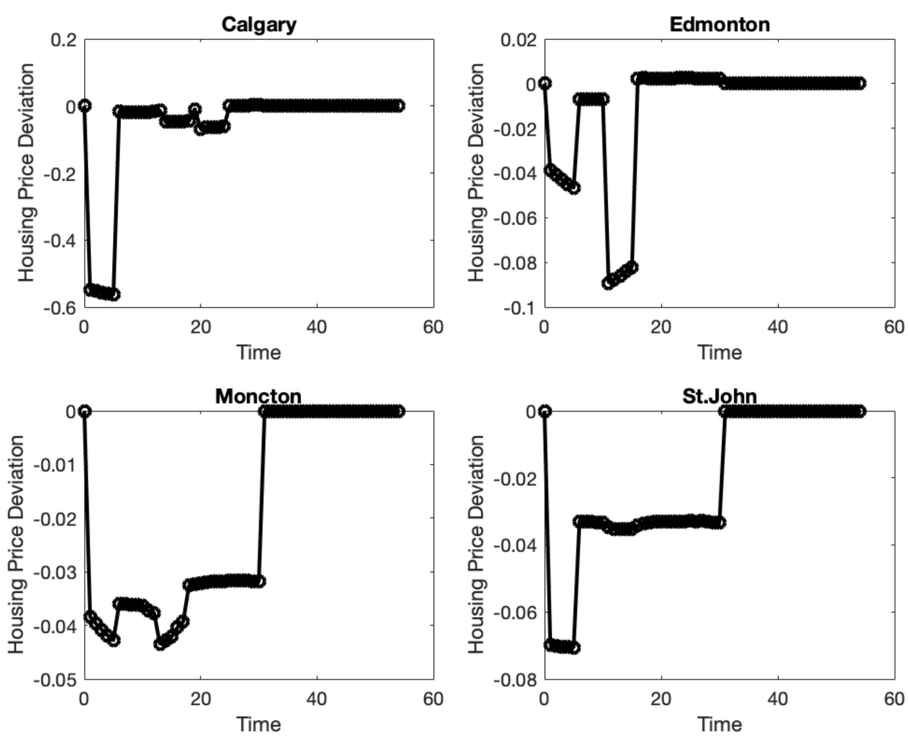
We assume that the oil shock induced a temporary regional productivity decline that last for 5

Figure 13: Transitional Dynamics after the Oil Shock

Panel A: Evolution of Wages in the Oil Regions



Panel B: Evolution of Rents in the Oil Regions



Note: Panel A of this figure reports the transitional dynamics of the wages for the cities with higher exposure to oil after a 5-year reduction in oil price. Panel B of this figure reports the transitional dynamics of the rents for the cities with higher exposure to oil after a 5-year reduction in oil price.

periods and computed the transition dynamics implied by the model. Panel A of Figure 13 plots the evolution of wages in Calgary, Edmonton, Moncton, and Saint John. We can see that the wage in Calgary decreases by approximately 2% for 5 years and immediately recovers after the negative productivity shock is eliminated. Similar patterns emerges for other oil producing cities. Regional productivity shocks also affect housing markets. In panel A of figure 13 plots the evolution of rents in oil regions. We can see that although wages recovery very fast as productivity goes back to its steady-state level, the effects in the housing market are much more persistent. This is mostly explained by the movement of people out of these cities.

But what locations are agents going after the shock? Figure 14 illustrates the effects of the oil shock on out-migration rates across regions. Out-migration rates in oil regions visibly increase after the oil shock. For example, the moving-out probability in Calgary increases by about 6%.

Panel B and C of Figure 14 focus on the changes in in-migration rates across regions. Oil regions experience significant reductions in the in-migration rates. On the other hand, Toronto, Montreal and Vancouver are receiving more migrants due to the oil shock. Figure 15 looks at the correlation of in-migration rates and various city characteristics. Here we focus on locations other than those 4 most-affected regions. Wages and prices are those of the period after the shock. Productivity is the steady state productivity without shocks. We can see that after the oil shock people are more likely to move to places with higher productivity and better amenity, while they are slightly less likely to move to high-wage or high-rent places.

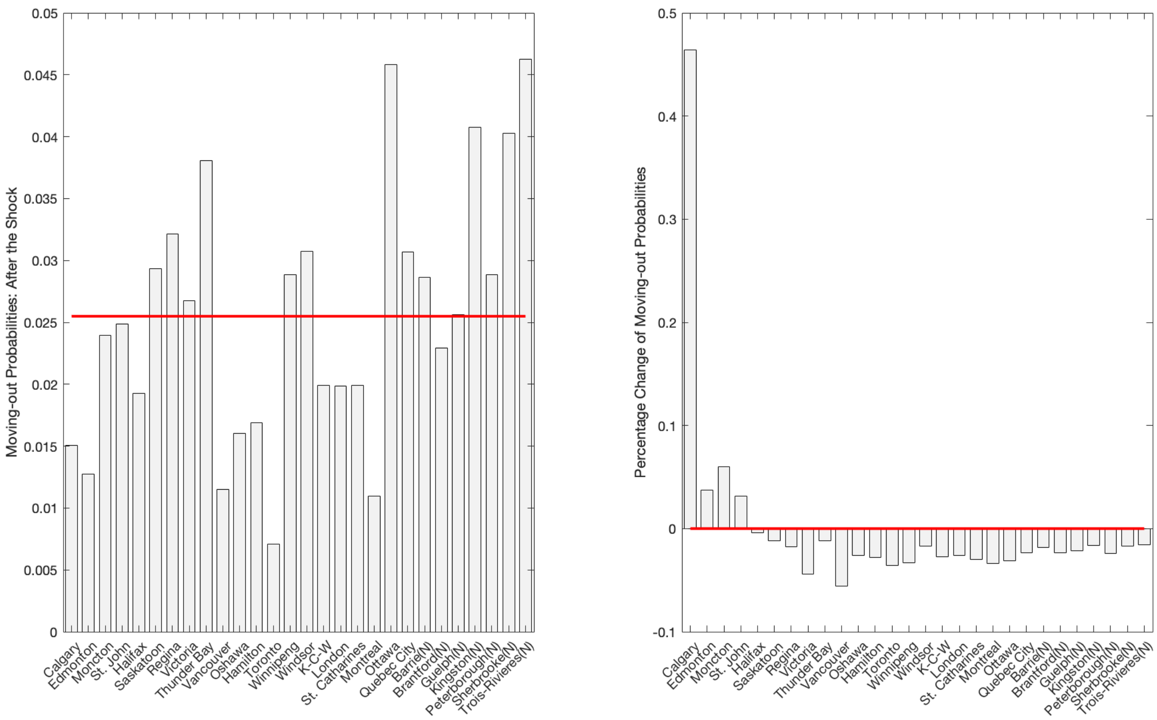
5.2 Decomposing the Moving Choice

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. Table 7 reports the results of both experiments and how they compare to the steady state. The upper panel shows the migration probabilities, both aggregate and by demographic groups. We observe that when the utility moving cost decreases by 10%, out-moving probabilities increase for all demographic groups, almost doubling. Overall, when moving costs are smaller, individuals move much more often.

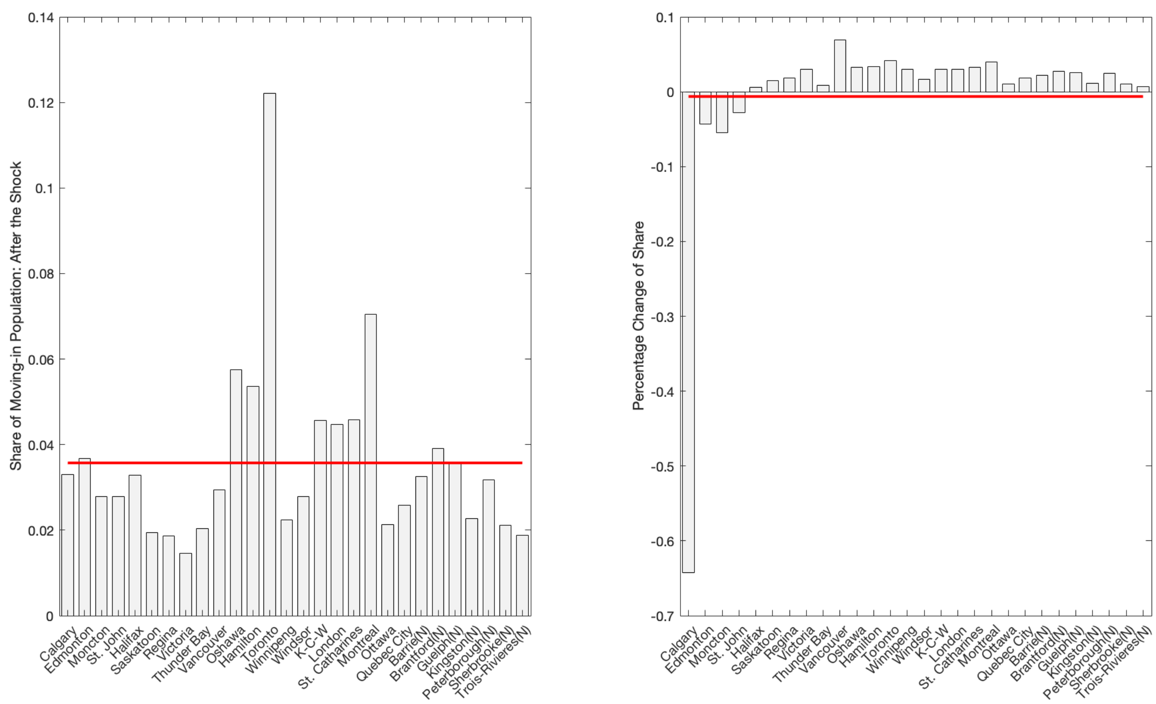
In the bottom part of the panel, when we look at those moving to locations that might have higher house prices or higher wages, locations that we define as the ones with more “opportunities”. We observe that individuals with low assets are more likely to move to locations with higher house prices, contrary to agents with more assets. When decomposed by age group, there is a 3 p.p. increase in the share of individuals upgrading to higher house prices’ locations. When we look at wages of the destination place, a smaller ratio of agents of any demographic group moves to a

Figure 14: Migration Rates by City

Panel A: Out-migration Rates by City

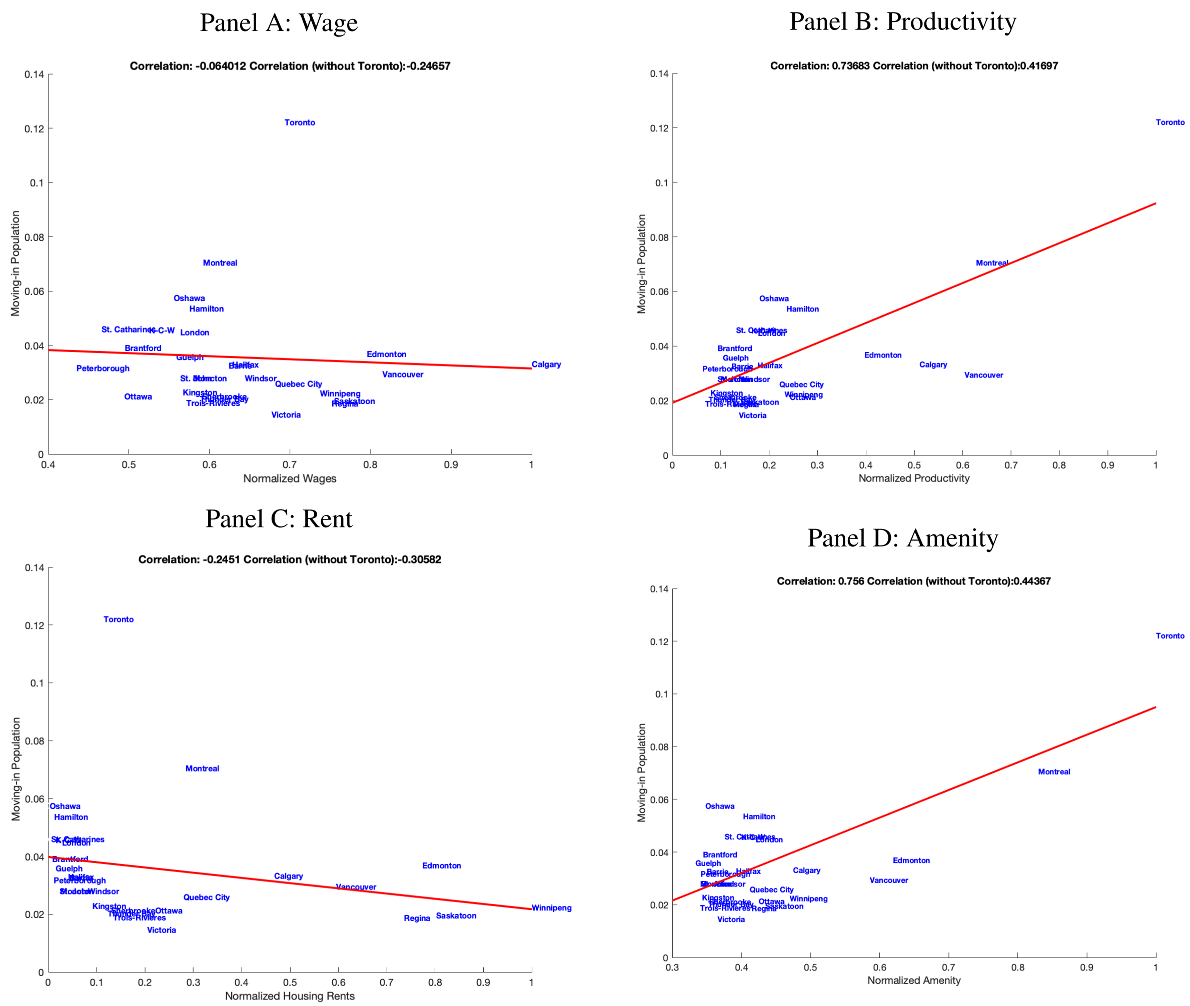


Panel B: In-migration Rates by City



Note: Panel A reports the out-migration rates by city as a response to the shock while panel B reports the in-migration rates by city.

Figure 15: Correlation between In-Migration and City's Characteristics



Note: Panel A reports the correlation between city-level wages and in-migration rates. Panel B reports the correlation between city-level productivities and in-migration rates. Panel C reports the correlation between city-level rents and in-migration rates. Panel D reports the correlation between city-level amenities and in-migration rates.

Table 7: Decomposing Migration Costs

	Baseline	**Monetary** Low δ	**Utility** Low τ
Av. Out-migration	1.64%	1.64%	3.13%
Av. Out-migration: Low Asset	1.63%	1.63%	3.12%
Av. Out-migration: High Asset	1.77%	1.77%	3.35%
Av. Out-migration: Young	1.71%	1.71%	3.14%
Av. Out-migration: Mature	1.55%	1.55%	3.11%
Moving to "Opportunity" Share			
Housing Rent, Low Asset	39.04%	39.04%	41.90%
Housing Rent, High Asset	36.18%	36.18%	36.03%
Housing Rent, Young	39.17%	39.17%	42.43%
Housing Rent, Mature	39.24%	39.24%	42.67%
Wage, Low Asset	49.89%	50.70%	45.68%
Wage, High Asset	53.93%	53.93%	45.29%
Wage, Young	55.00%	55.00%	49.28%
Wage, Mature	45.93%	45.93%	44.79%
In-migration to Toronto	12.21%	12.21%	10.92%

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 δ is lower and close to 0. Column (3) reports the results for an economy in which $\tau^{l,l'}$ for any pair of l and l' shrink for a corresponding monetary value of δ.

location that might give them a higher wage than the location where they are coming from. The reason is that now individuals move more frequently because of lower mobility cost, therefore, on average, they will be less likely to move to a location that gives them higher level of income prospects. The last raw also shows that less agents would move to Toronto. This is because there is less selection, so they can move more often and will choose Toronto less often.

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 explain the tremendous increase in house prices in several cities. 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 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 did some back of the envelope calculations using the causal relationship identified in Saiz (2010) between housing regulations and housing supply elasticity, which is about 30%. Considering that zoning regulations are approximately 50% of the regulations in the Saiz (2010) index, then, in the counterfactual experiment, we consider a 20% reduction of the housing supply elasticity in Vancouver.

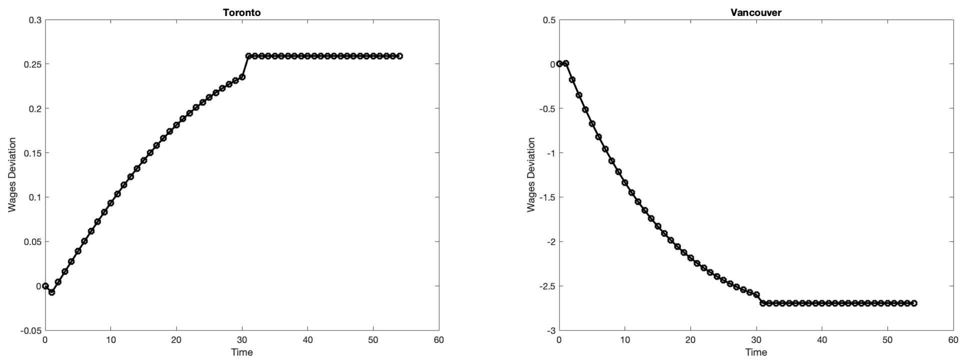
Table 8 shows how a decrease in housing regulations affects the moving probabilities and the share of movers to higher "opportunities" by demographic groups. Overall, we observe that increasing housing supply in Vancouver by 20% does not increase moving-out probabilities for any group of agents. But it changes the share of individuals that would move to "opportunity". Specifically, we observe that both low and high-assets agents would move more to more expensive locations. This result holds for both young and old agents. They would also move more to locations with higher wages. In particular, there would be an increase of 1.54p.p. in the share of low-asset agents moving to higher wages locations. Simultaneously, there would be a decrease in the in-migration to Toronto.

Then, we look at the transitional dynamics of the adjustment of wages and house prices to the new steady state after the increase in housing elasticity in Vancouver. We observe that the adjustment takes several periods, especially in house prices. The main reason is that agents will move slowly from other cities to Vancouver. This will depress wages in Vancouver and increase wages in other locations such as Toronto. In figure 16, on the top-left panel, we plot the evolution of wages in Toronto and on the top-right the evolution of wages in Vancouver. Wages increase in Toronto by more than .25% in 30 years and they decrease by 2.5% in Vancouver in 30 years. This suggests a very sluggish adjustment. When we look at housing prices in the bottom part of figure 16 we observe that they decrease both in Toronto and in Vancouver. In Vancouver they decrease right away by approximately 50%. Instead, in Toronto, they would decrease only by .1% and the adjustment is very sluggish.

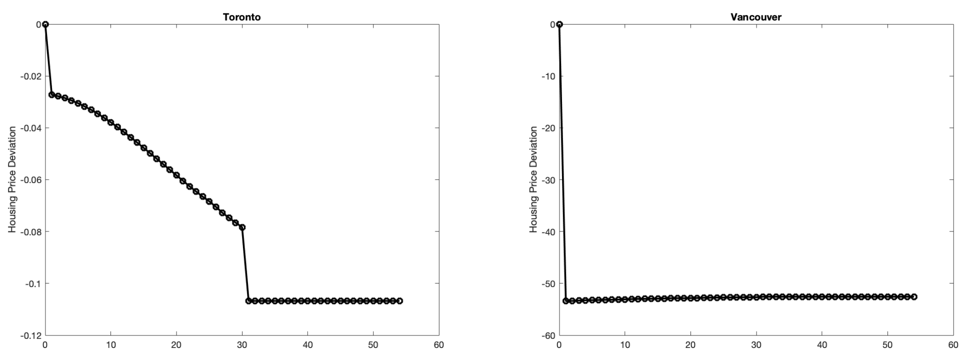
All of these results seem to point out to the fact that housing regulations might impact welfare of the generations born after the change in regulation, and that these changes in welfare might be heterogeneous for different groups. To assess this, we calculate welfare in our model as the future stream of utility for agents in the year that they enter the model. In specific, the year they turn 25 years old. In panel A of figure 17 suggests that for those born in Vancouver one year after the

Figure 16: Transitional Dynamics

Panel A: Wages



Panel B: Rents



Note: Panel A of this figure reports the transitional dynamics for Toronto and Vancouver of the wages after a permanent increase in the housing elasticity in Vancouver. Panel B reports the transitional dynamics for Toronto and Vancouver of the rents after a permanent increase in the housing elasticity in Vancouver.

Table 8: A Decrease in Housing Regulations in Vancouver

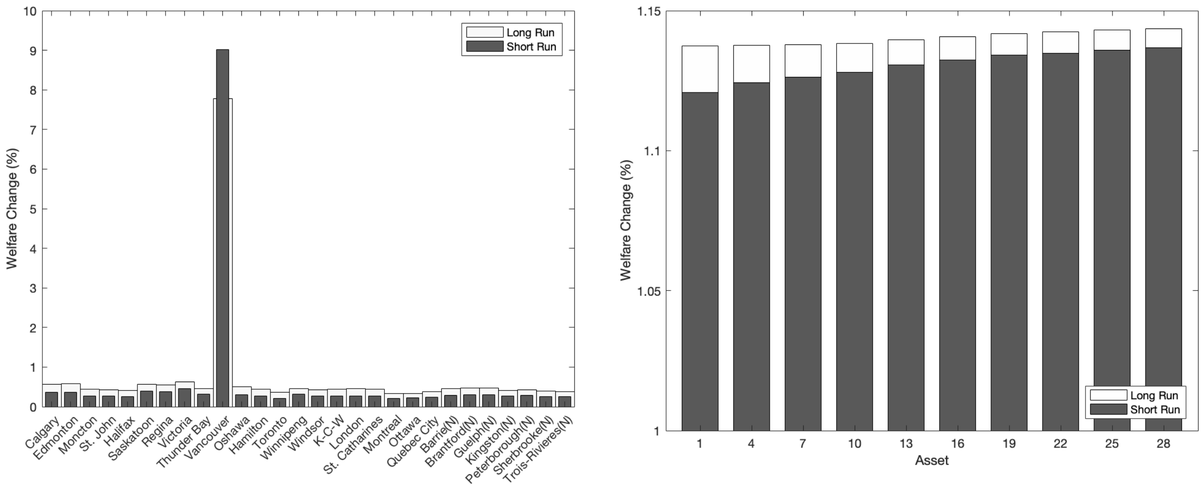
	Baseline	**Low Vancouver κ**
Av. Out-migration	1.64%	1.64%
Av. Out-migration: *Low Asset*	1.63%	1.62%
Av. Out-migration: *High Asset*	1.77%	1.76%
Av. Out-migration: *Young*	1.71%	171%
Av. Out-migration: *Mature*	1.55%	1.54%
Upgrading Share:		
Housing Rent, *Low Asset*	39.04%	+.54p.p.
Housing Rent, *High Asset*	36.18%	+.52p.p.
Housing Rent, *Young*	39.17%	+.49p.p.
Housing Rent, *Mature*	39.24%	+.5p.p.
Wage, *Low Asset*	49.89%	+1.54p.p.
Wage, *High Asset*	53.93%	+.62p.p.
Wage, *Young*	55%	+.65p.p.
Wage, *Mature*	45.93%	+.64p.p.
In-migration to *Toronto*	12.21%	-.13p.p.

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 κ for Vancouver is 20% lower permanently than in the baseline economy.

Figure 17: Welfare Effects for Short and Long-Run

Panel A: Welfare Effects by City

Panel B: Welfare Effects By Assets



Note: Panel A reports the welfare change between the baseline economy and the economy with larger housing supply by city, both in the short and long-run. Panel B reports the welfare change between the baseline economy and the economy with larger housing supply by asset level, both in the short and long-run.

change in regulation welfare increases by approximately 9% while it increases between .5%-.7% in the rest of the cities. In panel B of figure 17 we look at the welfare effects by asset. We observe that for the generation born right after the regulation change the welfare increases more for the high-assets' agents but for the following generations, the low-assets agents catch up.

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 location model of heterogeneous agents that differ in assets, housing status and age 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 response to an oil shock. We apply the model to the data calibrating it to 28 Canadian cities, with a mix of reduced form and structural estimation.

We, then, use the model to run several counterfactuals. First, to validate the model, we replicate the oil shock as a city specific decline in productivity. We observe similar sorting patterns both in the model and in the data. Second, 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”. We, then, 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 for the generation born right after the change in regulation by 9% in Vancouver and by 1.2% 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 an aging population can 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 will provide a guideline to shade new lights on an important decision such as location choice and serve as a tool to continue in the quest for “unpacking moving”.

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A Tables

Table 9: 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 2. The dependent variable is the

B 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.

C Algorithm

C.1 Stationary Equilibrium

To solve the stationary general equilibrium of the economy, we first set up a discrete grid space for asset. We start with guessing a vector of wages $\mathbf{w}^0$ and a vector of housing rents $\mathbf{p}^0$ where each element of the vector corresponds to a location. The distribution for age 25 group over asset is taken directly from the 2012 Survey of Financial Security and 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 40 (total number of age groups), among which two-thirds are home owners. For groups of age 26 and beyond, the mass is the same as the age 25 group, and two-thirds of them are always homeowners, while the distribution across asset and employment status is guessed to be uniform. This forms our initial guess of the population distribution $L^0(a, \epsilon, q, I_h; l)$.

Step 1. Given $L^0(a, \epsilon, q, I_h; l), \mathbf{w}^0, \mathbf{p}^0$, value functions $V^l(a, \epsilon, q, I_h)$ and policy functions $\widetilde{a}^l(a, \epsilon, q, I_h)$ can be solved using backward induction, starting from the problem of age 84 group. Then the consumption and saving problem for age q group can be solved, given the value functions over asset for age $q + 1$ group across locations. Then based on the value function solved $V^l(a, \epsilon, q, I_h)$, the migration probabilities can be constructed as in Section 3.3. Then using the migration probabilities and policy functions solved, based on guessed distribution $L^0(a, \epsilon, q, I_h; l)$, new distribution $L^1(a, \epsilon, q, I_h; l)$ can be computed.

Step 2. Given the new distribution $L^1(a, \epsilon, q, I_h; l)$, we update wages $\mathbf{w}^1$ and housing rents $\mathbf{p}^1$ using labor market and housing market clearing conditions.

Step 3. Given updated distribution and prices, we return to Step 1, until wages and prices converge.

C.2 Transitional Path

To compute the transitional path after some shock, we first use the algorithm listed in Section D.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, and 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 housing price path $\{\mathbf{p}_t^0\}_{t=1}^T$, and notice after T, wages and rents are equal to those in the post-shock stationary equilibrium. And we guess a path of population distribution $\{L_t^0(a, \epsilon, q, I_h; l)\}_{t=1}^T$[11].

Step 1. Given guessed paths of wages, rents and distributions, value functions and policy functions of different cohorts born in different time can be solved using backward as before in Section D.1. Then migration probabilities can be constructed, based on which we can compute a new path of population $\{L_t^1(a, \epsilon, q, I_h; l)\}_{t=1}^T$.

Step 2. Given the new path of distribution $\{L_t^1(a, \epsilon, q, I_h; l)\}_{t=1}^T$, we can update wage $\{\mathbf{w}_t^1\}_{t=1}^T$ and rent $\{\mathbf{p}_t^1\}_{t=1}^T$ path using the using labor market and housing market clearing conditions.

Step 3. Given updated distribution and prices, we return to Step 1, until wage path and rent path converge.

Step 4. Then we check whether the converged wage and rent paths reaches the corresponding levels in the after-shock stationary equilibrium. If not, we increase T.

[11] In practice, we make the initial guess that wages, rents and distributions are equal to those in the pre-shock stationary equilibrium along the path.