Migration Controls, Fiscal Externalities, and Access to Educational Opportunities in China*

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April 2, 2021

*We would like to thank Hanming Fang, Shihe Fu, Xintong Han, Bo Li, Shengzhi Mao, Jiawei Mo, Andy Postlewaite, Xuezhu Shi, Ruichao Si, Hong Song, Wei You, Zhi Wang, Junfu Zhang, Qinghua Zhang, as well as seminar participants at numerous universities and conferences for comments and suggestions.

Abstract

There have been large differences in economic development among regions and cities in China since the country embraced market-based reforms in the late 1970s. This inequality in spatial development has caused large internal migration flows as households from rural areas have sought economic opportunities for themselves and their children in urban areas. We document that internal migrants, who did not obtain full residency rights, have not enjoyed the same access to local public goods and services as city residents. In particular, unequal access to educational opportunities implies that children of migrants have lower levels of human capital accumulation than children of residents. The internal migration controls, therefore, create barriers to mobility across the income and wealth distributions within China. We develop a spatial overlapping generations model with heterogeneous households to study the feasibility of alternative internal migration policies that offer the potential of decreasing the inequality within China while at the same time increasing the level of human capital accumulation in the economy. We show that these reforms are feasible, but require significant tax increases to offset the reduction of the positive fiscal externalities provided by migrants.

Keywords: Migration Controls, Spatial Equilibrium, Overlapping Generations Model, Human Capital Accumulation, Inequality, Educational Attainment, Local Public Finance, Fiscal Decentralization, Social Mobility, and Fiscal Externalities.

1 Introduction

The economic development of China has been uneven since the country embraced its new economic policy in the late 1970s. Some large urban areas which are often located in coastal regions have experienced astonishing economic growth, while other cities and rural areas have lagged in development. These differential growth patterns have created much inequality among cities and caused large internal migration flows as households from disadvantaged areas have sought economic opportunities for themselves and their children in coastal cities. The Chinese government has managed these internal migration flows using a sophisticated system of residency rights known as the Hukou system.

While many migrants have undoubtedly benefited from this internal migration, it has also led to much inequality within major cities. This inequality is primarily the result of the Hukou system, which imposes restrictions on residency rights of migrant households. Using newly available data, we document that internal migrants that did not obtain full urban residency rights have not enjoyed the same access to local public goods and services as city residents. In particular, unequal access to educational opportunities implies that children of these migrants have lower levels of human capital than children of residents, which suppresses aggregate human capital accumulation and economic growth.[1] The Hukou system, therefore, creates barriers to mobility across the income and wealth distributions within China. Given these drawbacks associated with the current system of migration controls, it is natural to search for alternative internal migration policies that have the potential to reduce inequality and to increase the overall level of human capital in the economy.

Granting full residency rights to a larger fraction of migrants is likely to require significant changes in fiscal policies since migrants provide large fiscal externalities in all major cities in China, i.e. tax revenues generated by migrants exceed expenditures on migrants. An easing

[1] Huang (2020) also documents that students without local Hukou face restricted access to local public schools and studies children of migrants that are left behind.

of the migration controls then implies that many cities will no longer benefit from these positive fiscal externalities. The objective of this paper is, therefore, to develop a quantitative spatial overlapping generations model with heterogeneous households to study the feasibility of alternative internal migration policies in China. Given that these are non-marginal policy changes, the analysis needs to account for general equilibrium effects.

Our model builds on the pioneering research on overlapping generations models with endogenous local fiscal policies developed by Bénabou (1996, 2002) and Fernandez and Rogerson (1996, 1998, 2003).[2] These models have been used to study the impact of inequality in local public good provision on the intergenerational transmission of human capital and economic growth. Our model has multiple urban areas that differ by local labor and housing market conditions as well as local tax and expenditure policies.[3] Given the large inequality across cities, households have strong incentives to migrate to higher productivity cities that pay higher wages and have a higher quality of local public good provision. However, they face mobility costs and must pay higher housing prices in more attractive urban areas. Moreover, migrants may not enjoy full residency rights. We use wedges for public good provision to capture important distortions faced by migrants in the local economies as suggested by Chari, Kehoe, and McGrattan (2007). These wedges make migration less attractive and, thus, lead to an inefficient allocation of labor among cities. Moreover, migrant households must decide whether or not to leave their children behind with relatives in less developed areas. As a consequence, the endogenous spatial sorting of households and the heterogeneity of educational quality among cities significantly affect the human capital accumulation.

The quantitative model captures the observed migration patterns within China since the

[2] These models are dynamic extensions of static models with systems of local jurisdictions discussed in Epple and Romer (1991) and estimated in Epple and Sieg (1999). See Epple, Romano, and Sieg (2012) for a literature review.

[3] Our model thus builds on modern versions of Rosen (1979) and Roback (1982) models which capture household mobility patterns among a set of urban areas. For a survey of the literature see Moretti (2011). The most recent research is discussed by Diamond (2016) and Coen-Pirani and Sieg (2019).

era of housing market reforms in the late 1990s. Our quantitative model focuses on migration between tier 1, tier 2, and tier 3 cities, as well as less developed cities and rural places in China.[4] One period in our quantitative model corresponds to the length of the working life of a household. We, therefore, focus on the long-run transmission of human capital. We find that our model captures the heterogeneity in fiscal policies across cities, the differences in housing market conditions, and the broad migration patterns observed in the data.

Our analysis suggests that the current Hukou system increases inequality, suppresses human capital accumulation, and reduces economic growth. The Chinese central government has taken steps to address these problems. Since 2016 it has urged local governments to grant full residency rights to 100 million temporary migrants that currently live in small and medium-sized cities. In the spirit of this policy directive, we study the feasibility and effectiveness of alternative reforms of the current Hukou system. Since tier 1 cities are already large and may have limited scope for population growth under the current government regulation, we fix the Hukou policy of tier 1 cities at the current level. However, there is a large potential for population growth in tier 2 and tier 3 cities.

We find that granting full residency rights to migrants in tier 3 cities is likely to achieve the target of 100 million migrants that has been proposed by China's State Council in 2016. This policy change significantly increases the college attainment of children born in rural and less developed areas, but it requires equivalently an increase in the national consumption tax by approximately 1.3 percentage points. Even larger achievement gains can be obtained by including tier 2 cities in the set of cities that grant full residency rights to migrants. A policy that includes all tier 2 and tier 3 cities requires an equivalent consumption tax increase of approximately 3.3 percentage points. Our counterfactual analysis predicts that more than 200 million migrants will receive residency rights under this policy. In conclusion, there exist feasible reforms of the Hukou system that could significantly increase the college attainment

[4] Tier 1 cities are Beijing, Shanghai, Guangzhou, and Shenzhen. Tier 2 consists of the provincial capital cities and a few vice-provincial cities. Tier 3 consists of all other major cities in China.

of migrant children and reduce inequality by closing the educational gap between migrants and residents. By enlarging the pool of high-skill labor, these policies also promise to increase overall economic growth in the future. To offset the reductions of fiscal externalities provided by migrants, these policy reforms require significant tax increases.

Our paper is related to numerous strands of the literature. First, several papers in urban economics have studied rural-urban migration and city size in China. Au and Henderson (2006), Bosker, Brakman, and Garretsen (2012), and Desmet and Rossi-Hansberg (2013) find that most major Chinese cities are too small. We do not study the optimal size of cities. Instead, we focus on feasible reforms of internal migration and urban fiscal policies that promise to reduce inequality and increase aggregate human capital accumulation.

Second, our paper is related to the literature on the impact of the Hukou system on spatial allocation of labor and inequality. It is well understood that Hukou residency restrictions lead to an inefficient allocation of labor among cities as well as higher inequality as documented by Whalley and Zhang (2013), Ngai, Pissarides, and Wang (2018), and Piketty, Yang, and Zucman (2019). Similarly, Hao, Sun, Tombe and Zhu (2020) have studied the effect of internal migration policies on growth, structural change, and regional inequality using a trade model. They find that migration cost changes account for the majority of the reallocation of workers out of agriculture and the drop in regional inequality. Wu and You (2020) focus on the welfare implications of the Hukou system. Huang (2020) uses a quasi-experimental design to estimate the peer effects of migrant children and left-behind children on their classmates using classroom random assignment. The paper finds that there are negative spillovers from migrant and left-behind students. Despite these negative peer effects, counterfactuals presented in this paper suggest that the average human capital in the society will increase if migration controls are relaxed. There has been much less research that has studied the impact of internal migration controls on urban fiscal policies and fiscal spillovers, which is the main focus of this paper.

Third, there is a literature that has studied the economic growth of the Chinese economy.

Several previous studies found severe misallocation of production factors in China and large economic gains from eliminating the underlying distortions. Hsieh and Klenow (2009) have studied manufacturing, Song, Storesletten and Zilibotti (2011) the allocation of inputs among private and state-owned enterprises, Brandt et al. (2017) the allocation of input factors across regions. In contrast, we focus on the relationship between human capital accumulation and economic growth. Hence, our paper is also related to Fang and Herrendorf (2020) who highlight the importance of high-skill workers for the development of a high value-added service sector in the economy. Our paper complements these studies and evaluates policy reforms that can be used to increase the fraction of high-skill workers in the economy.

Finally, our paper is related to previous empirical studies on the access to local public schools by migrant children (Chen and Feng, 2013), the cognitive achievement of left-behind children (Zhang et al., 2014), the human capital accumulation of migrants (Heckman, 2005), and the intergenerational mobility (Fan, Yi, and Zhang, 2019). None of these papers have provided a comprehensive analysis of these issues within the context of an estimated spatial overlapping generations equilibrium model with heterogeneous households.

The rest of the paper is organized as follows. Section 2 provides some institutional background information about fiscal decentralization and the Hukou system in China and introduces our main data sources. Section 3 documents key stylized facts that characterize inequality across and within cities in China under the current Hukou system. Most importantly, we provide new estimates that characterize the college attainment gap between children of residents and children of migrants. Section 4 develops our overlapping generations model that we use to assess potential reform options. Section 5 introduces our quantitative model, discusses our parameter estimates, and reports the goodness of fit of our model. We turn to counterfactual policy analysis in Section 6 and study alternatives to the current Hukou policy. Section 7 offers some conclusions drawn from the analysis.

2 Institutional Background and Data

2.1 The Hukou System

China's current Hukou system was formally established in 1958 as a means of population registration to control internal migration. Individuals who stay in a location that is not their registered residence, need to acquire a temporary residence permit to get limited access to local public goods and services. By design, the Hukou registration system had a profound impact on the economic development of the People's Republic of China. It restricted labor mobility and, therefore, affected the spatial allocation of labor, capital, and other mobile production factors in the economy.

Before the start of China's transition to a market economy in 1978, the central government formulated and implemented the Hukou policy. Local governments played a limited role during that time. Since the 1990s local governments have gradually been given the power to decide the registration rules under the guideline from the central and provincial governments. As a consequence, Hukou has become a critical policy tool for local governments to manage local public finance and city growth, and to attract investment and high-skilled workers.

Currently, the Hukou status of a person is primarily defined by two characteristics: the location and the type. Location refers to the legal address of the registration. There are two types of residential status, which are commonly referred to as rural (agricultural) and urban (non-agricultural) Hukou. Each citizen is registered at birth. The location and the type of a new-born child are determined by either the mother's or the father's Hukou status.

The Hukou system is managed by the local police department at the township level. It is possible to change the Hukou status from rural to urban in most prefectures. However, the change of residency status is tightly controlled by local governments, especially in tier 1 and tier 2 cities of the country. To accomplish a change in residency status a person must apply to the local police department. A change is only granted if the person meets certain require-

ments, which are linked to the following categories: investments, tax payments, real estate purchases, employment status, college status, joining relatives, and special contributions. All tier 1 and most tier 2 cities set high criteria for migrants to obtain local urban Hukou. The requirements of these cities have become more stringent over time. In contrast, lower-tier cities tend to have weaker requirements (Zhang, Wang, and Lu, 2019).

Based on the institution of Hukou, one can define the concepts of permanent and temporary migration in China. Temporary migrants are individuals whose place of residence differs from their place of registration. Most rural-urban migrants are temporary migrants. Permanent migrants are those who have changed their registration and obtained an urban Hukou in the new city of residence. It is where an individual is registered, rather than the intended duration of stay, that defines an individual as a permanent or temporary migrant. Previous studies mostly focused on temporary migrants. Taking advantage of the data on Hukou changes of individuals, we can account for permanent and transitory migrants to evaluate the impact of Hukou policy changes on migration decisions and educational achievement.

2.2 Data Sources

Our empirical analysis is based on a combination of newly available data sets including the China Household Finance Survey (CHFS) and the Migrants Dynamic Monitoring Survey (MDMS). The CHFS provides detailed information on residency status, household income, consumption, housing, and locational choices. Moreover, the structure of this data set allows us to follow migrant households over time and study the change of a household's Hukou status. In contrast to the MDMS, the CHFS allows us to study the transition of Hukou status as well as the lifetime behavior of migrants with and without Hukou. Besides, the MDMS provides additional important information about the behavior of temporary migrant households and the constraints that they face.[5]

[5] The micro-sample of the 2000 Census is used to characterize the initial distribution of population and housing endowment. We also use data from the 2018 fiscal year central and local public finance data and the

The quantitative version of our model considers four locations with three tiers of cities and one rural, less-developed area. Hence, a migrant in our analysis is a household that moves across these four location types.[6] Hukou registration may have slowed but has not prevented the migration of hundreds of millions of households from rural areas to the cities in China during the past two decades. When households move from a rural region to a city, or from a lower-tier city to a higher-tier city they often cannot obtain a local urban Hukou registration. As a consequence, there exists a large group of migrants in most cities who work and live in a location without local urban Hukou.

Table 1: Migration by City Tier

Share of Migrants and Residents (%)			
	Tier 1	Tier 2	Tier 3
Permanent Migrants	13.5	15.8	20.3
Temporary Migrants	25.7	30.7	32.2
Residents	60.8	53.5	47.5
Share of Migrants that Changed Hukou Status (%)			
	Tier 1	Tier 2	Tier 3
Low-skill Migrant	26.0	27.5	31.5
High-skill Migrant	47.0	52.5	67.1

Table 1 shows the status of residents and migrants by city tier using data from the China City Statistics Yearbook to measure heterogeneity in local fiscal policies across city tiers.

[6] Our analysis abstracts from mobility within tier 1, tier 2, or tier 3 cities. Thus, we deviate from the previous literature that defines a migrant as somebody who moves across townships or counties and focus on only the moves across the four locations in our model. Importantly, all moves from rural to urban including those within a prefecture are counted as migrants in our quantitative analysis. Thus, our model highlights the migration flows across city tiers, but still accounts for the large scale of rural-urban migration during China's rapid urbanization since the 1990s.

CHFS in 2017, which has more than 40,000 households. We use detailed information on migration histories in the CHFS to document the pattern of migration dynamics. Comparing with commonly used Census and migrants survey data, the CHFS contains detailed Hukou information, especially the record of Hukou changes from rural to urban and from one location to another. Migrants with a change in Hukou status (permanent migrants) account for 13 to 20 percent of the city population. The share of temporary migrants ranges between 26 and 32 percent. Hence, migrants constitute 39 to 52 percent of the city population. Residents are those households that live in the city in which they obtained urban Hukou at birth or change their Hukou status from rural to urban due to the expansion of cities (without having to relocate). The share of residents ranges between 48 and 61 percent across city tiers.

One key criterion that affects the likelihood of obtaining the local urban Hukou for migrants is the level of education or skill. We divide the population into two types. Low-skill households have a head who has, at most, a high school degree. High-skill household heads attended, at least, a two-year college. Table 1 also reports the fraction of low- and high-skill permanent migrants, i.e. households that migrated to a major city and obtained local urban status in the destination city. Table 1 shows that the fraction of migrants that changed Hukou status is lowest in tier 1 cities and highest in tier 3 cities. Not surprisingly, the fraction of households that became permanent migrants is significantly larger for high-skill than low-skill households.

3 Stylized Facts

3.1 Fiscal Capacities Across Cities

There are large differences in fiscal capacities among Chinese cities, which draw revenues from a variety of sources. First, cities receive transfers from the central government. Second, revenues from tax sharing agreements are quite important since value-added, personal and

corporate income tax revenues are shared between local and central governments. Third, cities levy a variety of local taxes, charges, and fees that contribute to own-source revenues. Finally, cities generate a substantial amount of revenues from land development and housing construction. China's City Statistical Yearbook provides statistics that allow us to estimate the relevant revenue shares by city tier. As shown in Table 2, own-revenues account for 34% of total local revenues in tier 1 cities. Note that these revenues include shared personal and corporate income taxes. Land and housing-related revenues account for 35% of total revenues. The remaining revenues come from VAT sharing and other central government transfers accounting for 31% of the total local revenues in tier 1 cities. Revenue shares of tier 2 cities are similar to those of tier 1 cities. The main difference is that tier 2 cities generate fewer revenues from own-source revenues but obtain higher revenues from land sales than tier 1 cities. Tier 3 cities received 56% of their revenues from central government transfers and, therefore, rely more heavily on the central government than tier 1 and tier 2 cities.

Table 2: Revenue Shares and Expenditures by City Tiers

	Tier 1	Tier 2	Tier 3
Own-source Revenues excluding VAT	34%	24%	16%
Land and Housing Revenues	35%	45%	28%
VAT Revenues & Governmental Transfers	31%	31%	56%
Educational Expenditures per Capita	5,995	2,183	1,553
Other Expenditures per Capita	40,447	13,080	8,653

Since there are large differences in total fiscal capacity and total revenues, it is not surprising that there are also large differences in expenditures among cities. We can measure the quality of local education using public education expenditures per capita. The data is again provided by China's City Statistical Yearbook for 2017, which reports expenditures for

both the urban core and the whole prefecture.[7]

Table 2 shows the median educational expenditures and expenditures on other public goods per capita by city tier. Not surprisingly, tier 1 cities have much higher expenditures per capita than tier 2 and tier 3 cities. Note that educational expenditures and expenditures on other public goods in rural areas were, on average, 791 and 3,485 Chinese Yuan per capita respectively. In summary, there are pronounced differences in both educational and other public expenditures among cities in China.

3.2 Access to Educational Opportunities within Cities

An important feature of the Hukou system is that it regulates access to a variety of local public goods and services.[8] Here we focus on access to educational opportunities which affects investment decisions in human capital, inequality, and social development.

We have seen that there are important differences in educational spending across jurisdictions in China. Hence, there are also significant and persistent differences in educational attainment. We can measure educational achievement using college attainment. Local governments are required to provide free primary and middle school education for migrant children. However, local governments often impose strict rules that prevent migrant children from attending better local schools. These restrictions are even more severe in high school. Students without local Hukou are not allowed to participate in college entrance exams unless strict requirements are met, even if they can manage to attend a local high school.

Table 3 shows that a significant share of children of temporary migrants is not enrolled

[7] A prefecture is an administrative unit below a province and consists of a city proper (an urban core, similar to a metropolitan area) and a mostly rural area (typically called counties). We proxy rural expenditures using the total expenditures of the whole prefecture minus the expenditures for city proper in a prefecture.

[8] For example, the Hukou status restricts access to local schools, health insurance, pension, unemployment insurance, maternity benefits, and housing providence funds. See Appendix A a discussion of the impact of the Hukou system on these other public goods and services.

Table 3: Access to Educational Opportunities

Share of Temporary Migrant Children in Local Public Schools		
Parental Skills	Low-skill	High-skill
Tier 1	71.8	84.3
Tier 2	83.9	87.0
Tier 3	89.1	87.2
Share of Temporary Migrant Children Left Behind		
Parental Skills	Low-skill	High-skill
Tier 1	47.9	19.3
Tier 2	38.7	30.5
Tier 3	42.1	45.0

in local public schools. Children of low-skill households are less likely to attend local schools than children of high-skill households. These statistics are based on the Migrants Dynamic Monitoring Survey (MDMS) conducted in 2011, for which there are detailed information on the coverage of public services.[9] Table 3 also reports the proportion of children who are not living with their parents. The fraction of left-behind children of low-skill households ranges between 47.9 percent in tier 1 cities to 38.7 percent in tier 2 cities. For high-skill households, the fraction ranges from 19.3 percent to 45 percent. We conclude that a significant number of temporary migrants leave their children behind with relatives.

In summary, the Hukou system implies that migrants tend to have lower access to educational opportunities than residents. Next, we document how these inequalities affect the

[9] This is a large-scale representative survey on temporary migrants who moved out of Hukou registration county for more than 6 months. The sample has around 126,000 household observations. To match the migration definition in our model, we use only the households who moved across prefectures. Similarly, we impose the same age restrictions (20-65) for parents and keep only the households with children at schools.

intergenerational transmission of human capital. In particular, we document that children of temporary and permanent migrants tend to have much lower college attainment than comparable children of residents. As such, the Hukou system creates barriers to income mobility.

3.3 The Intergenerational Transmission of Human Capital

To estimate the magnitude of the impact of the Hukou system on the intergenerational transmission of human capital, we turn again to the 2017 Survey of the CHFS. We observe the college attainment of the household head and the child, where college attainment is measured as having, at least, two years of college education. The sample consists of "children" that were between 20 and 40 years old at the time of the survey. Hence, we can accurately measure the outcome variable for all individuals in this sample. Our final sample has 6256 observations. We estimate logit models that express the college attainment of the child as a function of migration status and parental attainment differentiating between permanent and temporary migrants. In addition, we control for a variety of demographics such as the age of the household head, household size as well as city-tier and age-group fixed effects. Table 4 summarizes our main empirical findings.

Table 4 documents that migrant children have significantly lower college attainments than children of residents. Column (1) summarizes the results for the basic specification using the full sample, while Column (2) also controls for a variety of demographics and fixed effects. We find that the estimated college attainment gap between children of permanent migrants and children of residents is approximately 5 or 6 percentage points. The gap between children of temporary migrants and children of residents ranges between 26 and 33 percentage points. Not surprisingly, attainment also decreases by city tier. The gap between children educated in tier 1 cities and children in tier 2 (3) cities is approximately 10 (15) percentage points.

Next, we conduct a variety of sensitivity checks to document that these findings are quite robust. First, we exclude short-term migrants that have lived in the destination city for less

Table 4: The Intergenerational Transmission of Human Capital: College Attainment

	Full Sample		Excluding Short-term Migrants		Control for Hukou Origin	
	(1)	(2)	(3)	(4)	(5)	(6)
Permanent migrants	-0.0614	-0.0487	-0.0583	-0.0488	0.1260	0.0553
	(0.0184)	(0.0197)	(0.0203)	(0.0216)	(0.0400)	(0.0457)
Temporary migrants	-0.3273	-0.2557	-0.3511	-0.27995	-0.1421	-0.1582
	(0.0138)	(0.0160)	(0.0150)	(0.0177)	(0.0490)	(0.0530)
Household head	0.3286	0.2977		0.2913		0.2883
with college degree	(0.0133)	(0.0149)		(0.0164)		(0.0166)
Tier 2 residence		-0.1074		-0.1072		-0.0551
		(0.0223)		(0.0236)		(0.0363)
Tier 3 residence		-0.1541		-0.1644		-0.0906
		(0.0223)		(0.0240)		(0.0361)
Tier 1 origin					0.2858	0.1865
					(0.0305)	(0.0492)
Tier 2 origin					0.2077	0.1250
					(0.0410)	(0.0502)
Tier 3 origin					0.1406	0.0872
					(0.0409)	(0.0446)
Household characteristics		Y		Y		Y
Age-group fixed effects		Y		Y		Y
Observations	6256	6256	5249	5249	5249	5249
Pseudo R^2	0.0644	0.1496	0.0721	0.1524	0.0816	0.1540

Notes: All columns report estimated marginal effects from logit models.

than 5 years. The results for that subsample are summarized in Columns (3) and (4). Overall, we find that our estimates of the attainment gaps are quite similar to the ones reported in Columns (1) and (2).

Finally, we also control for Hukou origin which is defined at the province level. The results are shown in Columns (5) and (6). Controlling for Hukou origin implies that there are not significant differences between permanent migrants and residents. However, the gap between children of residents and temporary migrants is still 16 percentage points which is quite large.

We, therefore, conclude that the college attainment gap between children of permanent migrants and children residents is small. The college attainment gap between children of temporary migrants and children of residents is rather large and economically significant. In our model, we, therefore, assume that permanent migrants and residents have the same access to public goods and services, while temporary migrants face some serious restrictions.

4 A Spatial OLG Model

We develop an overlapping generations model with a system of cities to study the impact of internal migration controls on access to educational opportunities, inequality, and the accumulation of human capital. The model captures the key institutional arrangements of fiscal decentralization and local Hukou policies discussed in the previous sections.

The economy consists of J cities and one rural, less developed area, denoted by location 0. Each location has an exogenous amenity ω_j. Each city has a local government that provides two public goods, educational quality (g_j) and other local public goods (o_j). We model public goods as expenditures per household accounting for congestion which is common in cities.[10] Local public goods are financed by a combination of local revenues: a proportional

[10] We abstract from non-fiscal congestion externalities in this paper. See, for example, Au and Henderson (2006) and Desmet and Rossi-Hansberg (2013) for models that include non-fiscal congestion externalities into

local income tax with rate t_j^w, revenues from land sales and new housing construction, and transfers from the central government. Let p_j denote the price of a unit of housing in the local housing market of city j. Cities differ in their Hukou policies as described below.

There is a continuum of individuals each of whom lives for two periods, one period as a child and one period as an adult. A household consists of an adult and a child. At each point in time the economy, therefore, consists of two overlapping generations. As in Bénabou (1996) and Fernandez and Rogerson (1996, 1998) adults make all decisions in our model, i.e. children are passive and do not make any decisions. Hence, we can characterize the dynamic equilibrium as a sequence of one-period equilibria. We, therefore, suppress time subscripts in our notation.

There are K discrete skill types. Each adult is characterized by a measure of skills, denoted by s_k, $k = 1, ..., K$. The fraction of adults with skill k living in city j at the beginning of the period is given by q_{jk}. Each adult with skill k living in city j has an endowment of housing denoted by e_{jk}.[11]

Each child attends a public school within a city. Expenditures per child are denoted by g_j. The achievement of a child is a function of school quality g_j and parental skills s_k. In our quantitative model, we use the following specification:

$$a(g_j, s_k) \;\; = \;\; \gamma_0 \; g_j^{\gamma_1} \; s_k^{1-\gamma_1} \tag{1}$$

The transition probability that a child with educational achievement a will have skills s' as an adult in the next period is given by $Pr\{s' |\; a\}$. Hence, the skill distribution in the next period is a function of household sorting by skill and local expenditures. In our quantitative model, we have two skill types: low- and high-high skill households. High-skill households

the analysis. We discuss these issues in more details in the conclusions.

[11] The housing endowment is in the location in which the adult grew up as a child. In the quantitative model, we assume that each type k has the same endowment conditional on j when the economy starts, which is broadly consistent with the initial privatization of the housing stock in China (Zhang, Fan and Mo, 2017).

have attended, at least, two years of college. We use a Logit distribution for the transition probability in the quantitative model.

Household utility is defined over child achievement a, numeraire consumption b, the quantity of housing services h, noneducational public goods o, and city amenities ω. Preferences also depend on the child arrangement. Let $c = 1$ denote the event that the child lives with the parent, and $c = 0$ characterizes the event when the child is left behind. The utility function is denoted by $U(a, b, c, h, o, \omega)$. The household utility is increasing, twice differentiable, and concave in (a, b, h, o) for $c = 0, 1$. In our quantitative model we use the following specification:

$$U(a, b, c, h, o, \omega) \;=\; \omega \;+\omega_a\, a \;+\; \omega_o\, o \;+\; (h - \underline{h^c})^{\beta^c}\; b^{1-\beta^c} \tag{2}$$

where $\underline{h^1} > \underline{h^0}$, since minimum housing demand is higher when the child lives with the parent.

Adults can relocate to a city that is different from the city in which they were born as a child. Adults decide whether to stay or move, and if move, whether to bring the child along or leave the child behind.

Residents, denoted by r, are households that are born in city j and decide to stay in city j. Migrants, denoted by m, are households that are born in location j and decide to move to a different city $l \neq j$. We first solve the decision problem of each household conditional on having chosen a city as an adult. We then solve the optimal location problem. The timing of decisions is as follows:

1. Adult household members make migration decisions given correct expectations of prices, wages, taxes, public goods, and amenities in each city.

2. After households move, they learn whether or not they obtain Hukou status in the destination city.

3. Wages are determined, consumption is realized, housing markets clear, government budgets are balanced, and the achievement of children is realized in each city.

4. Children become adults, inherit housing from their parents, and obtain a skill realization conditional on achievement. Adults die and new children are born.

A resident with skills k who decides to stay in city j receives labor income equal to w_{jk}. Labor income is taxed by the city. Let t_j^w denote the income tax rate. The value of the housing endowment is given by $p_j e_{jk}$. The household allocates resources among owner-occupied housing (h) and consumption goods (b). Let t^b denote the consumption tax rate imposed by the central government. Residents are eligible for housing subsidies, denote by s_j^h. The budget constraint is, therefore, given by:

$$(1 - s_j^h)\, p_j h \;+\; (1 + t^b)\, b \;\;=\;\; (1 - t_j^w)\, w_{jk} \;+\; p_j e_{jk} \tag{3}$$

The right-hand side of equation (3) is the total after-tax household income including asset income from the initial endowment of housing. Note that all households own their houses.[12] The left-hand side of equation (3) is the sum of after-tax consumption expenditures.

A household maximizes utility subject to the budget constraint and the achievement constraint. In our quantitative model, we use the Stone-Geary utility function in equation (2). Hence, the demand functions for housing and consumption are given by:

$$\begin{aligned} h_{jk}^r &= \frac{\beta^1}{(1 - s_j^h)\, p_j}[(1 - t_j^w)\, w_{jk} \;+ p_j e_{jk}] + (1 - \beta^1)\underline{h^1} \\ b_{jk}^r &= \frac{1 - \beta^1}{1 + t^b}[(1 - t_j^w)\, w_{jk} \;+ p_j e_{jk} - (1 - s_j^h)\, p_j \underline{h^1}] \end{aligned} \tag{4}$$

Substituting the demand and achievement functions into the utility function, we obtain the indirect utility of a household that was born in j and stays in j. It is given by:

$$V_{jjk} \;\;=\;\; U(a_{jk}^r, b_{jk}^r, c = 1, h_{jk}^r, o_j, \omega_j) \tag{5}$$

where the achievement of a resident child is given by: $a_{jk}^r = a(g_j, s_k)$.

[12] Children inherit the houses purchased by the parents which then fully endogenizes the law of motion for the initial conditions of the economy.

Next, consider the decision problem of a household that has decided to migrate from city j to city k. The decision problem of a migrant differs from the problem above in four ways. First, some migrants move with their children while others leave their children behind.[13] Children that are left behind have a different achievement than children that accompany their parents. Second, some migrants receive the urban Hukou in their destination city, while others do not. Migrants that do not receive Hukou do not have the same access to public goods. We use fiscal wedges to capture the distortions faced by migrants in the economy as suggested by Chari, Kehoe, and McGrattan (2007). In particular, we assume that there exists a wedge for educational public goods, denoted by $\Delta^g_{jk} \leq 1$, and a wedge for other public goods, denoted by $\Delta^o_{jk} \leq 1$. Third, migrants that do not obtain local urban Hukou are not eligible for the housing market subsidies. Finally, migrants do not have housing endowments in the destination city but can sell their housing endowments in their birth location.

Hence, there are four types of migrants in our model: i) with Hukou (y) and with children ($c = 1$); ii) with Hukou (y) and without children ($c = 0$); iii) without Hukou (n) and with children ($c = 1$); iv) without Hukou (n) and without children ($c = 0$). We can derive the housing demand and achievement functions for each type of migrant. Substituting these demand and achievement functions into the utility function yields the indirect utility functions (net of migration costs):

$$\begin{aligned} V^{y,c}_{ijk} &= U(a^{y,c}_{ijk}, b^{y,c}_{ijk}, c, h^{y,c}_{ijk}, o_j, \omega_j) - mc^c_{jk} \quad i \neq j, \quad c = 0, 1 \\ V^{n,c}_{ijk} &= U(a^{n,c}_{ijk}, b^{n,c}_{ijk}, c, h^{n,c}_{ijk}, \Delta^o_{jk}\, o_j, \omega_j) - mc^c_{jk} \quad i \neq j, \quad c = 0, 1 \end{aligned} \tag{6}$$

Note that we assume that mobility costs depend on the destination city, skill types, and the mobility status of the children. In our quantitative model, we adopt the following functional form specification:

$$mc^c_{jk} = mc_j + mc_k\, 1\{k = 2\} + mc^c\, 1\{c = 1\} \tag{7}$$

[13] We assume that children always live with parents ($c = 1$) if parents are residents.

where $1\{\cdot\}$ is an indicator function. The timing assumption implies that migrants find out whether or not they obtain local Hukou or not after they move. City j gives Hukou status to a fraction of migrants, denoted by r_{jk}. The migrant's expected conditional value function is given by

$$V_{ijk}^{c} = r_{jk}\, V_{ijk}^{y,c} \;+\; (1 - r_{jk})\, V_{ijk}^{n,c} \tag{8}$$

Now that we have characterized all conditional value functions, we can characterize optimal location decisions. Note that each household must decide where to live and whether to bring the child along when moving. In our model there are $J+1$ locations and two child care arrangements for migrants. As a consequence the choice set has $J \times 2 + 1$ elements. Let ϵ_{ijk}^{c} and ϵ_{jjk} denote additively separable random utility shocks which are type 1 extreme value distributed. Hence, the probability that a household of type k moves from city i to city j with child arrangement c is given by:

$$P_{ijk}^{c} \;=\; \frac{\exp(V_{ijk}^{c}/\sigma_{\epsilon})}{\sum_{d=0}^{1}\sum_{l\neq i, l\neq 0}\exp(V_{ilk}^{d}/\sigma_{\epsilon}) + \exp(V_{iik}/\sigma_{\epsilon})} \tag{9}$$

where σ_{ϵ} is the scale parameter of the random utility shocks. The probability of staying is:

$$P_{jjk} \;=\; 1 - \sum_{c=0}^{1}\sum_{l\neq j} P_{jlk}^{c}. \tag{10}$$

Given that we have characterized the households' decision problems, we can now close the model and define the equilibrium for our model. Let us denote the number of resident households living in city j for each skill type k by n_{jk}^{r} and note that:

$$n_{jk}^{r} \;=\; q_{jk}\, P_{jjk}. \tag{11}$$

Recall that q_{jk} is the initial share of type k households in city j. The total number of migrants moving to city j for each skill type k with child arrangement c is given by:

$$n_{jk}^{m,c} \;=\; \sum_{l\neq j} q_{lk}\, P_{ljk}^{c} \;=\; \sum_{l\neq j} n_{ljk}^{m,c}. \tag{12}$$

Define the fraction of migrants of skill k in city j as $n_{jk}^m = n_{jk}^{m,1} + n_{jk}^{m,0}$. Summing across residents and migrants, we can define the number of households of type k living in city j, denoted by $n_{jk} = n_{jk}^r + n_{jk}^m$.

The aggregate demand for housing in city j is defined as the sum of the demand by the residents, the migrant households with Hukou, and the migrants without Hukou:

$$H_j^d = H_j^{dr} \ + \ H_j^{dy} \ + \ H_j^{dn} \tag{13}$$

It is straightforward to derive each of these terms. The aggregate supply of housing in city j is defined as the sum of the supply of the existing housing stock and new construction:

$$H_j^s = H_j^{es} \ + \ H_j^{ns} \tag{14}$$

The existing housing stock in city j is given by:

$$H_j^{es} \ = \ \sum_{k=1}^{K} q_{jk} \ e_{jk} \tag{15}$$

New housing is supplied by the local government in cooperation with some housing developers. We assume that there is an upward sloping housing supply function which captures land supply constraints and building technology. In our quantitative model, we assume that new housing supply in city j is given by:

$$H_j^{ns}(p_j) \ = \ l_j \ p_j^{\eta_j} \tag{16}$$

where l_j is a constant and η_j is the housing supply elasticity in city j. Housing market equilibrium requires that:

$$H_j^d \ = \ H_j^s \tag{17}$$

for all cities.

Local governments receive revenues from three sources. First, local governments generate own revenues from local taxes, shared taxes, fees, and charges. We model these revenues as

proportional to income and denote these revenues by T_j^w:

$$T_j^w \;=\; t_j^w \left(\sum_{k=1}^{K} n_{jk}\, w_{jk} \right) \tag{18}$$

Second, cities generate revenues from land sales and new housing construction. We denote these revenues by T_j^h. These revenues are proportional to the value of new housing supply:

$$T_j^h \;=\; t_j^h\, p_j\, H_j^{ns} \tag{19}$$

Notice that migrants tend to bear a larger burden of this tax than residents, since they do not benefit from local housing endowments. Finally, cities received additional transfers from the central government, denoted by T_j^{tr}. These transfers are financed by a consumption tax. Transfers are given by:

$$T_j^{tr} \;=\; \delta_j\, t^b \sum_{j=1}^{J} \sum_{k=1}^{K} \left(n_{jk}^r\, b_{jk}^r + n_{jk}^m \left(r_{jk}\, b_{jk}^y + (1 - r_{jk})\, b_{jk}^n \right) \right. \tag{20}$$

where δ_j is the share of the city j. This specification allows us to account for the fact that the central government provides larger transfers to rural areas and lower tier cities. Hence, total city revenues are given by:

$$T_j = T_j^w \;+\; T_j^h + T_j^{tr} \tag{21}$$

Local governments subsidize new housing purchases of residents and migrants with Hukou. Total government housing subsidies are given by

$$S_j \;=\; s_j^h\, p_j\, (H_j^{dr} + H_j^{dy}) \tag{22}$$

Hence, the net fiscal revenues of cities are given by $T_j - S_j$.

Local governments provide education and other public goods and services. Expenditures on education are given by:

$$E_j^g \;=\; \left(n_j^r + \sum_k n_{jk}^{m,1} r_{jk} \right)\; g_j \;+\; \left(\sum_k n_{jk}^{m,1} (1 - r_{jk})\, \Delta_{jk}^g \right) g_j \tag{23}$$

The first term captures expenditures for children with Hukou. The second term captures expenditures for children without Hukou. The Hukou policy affects the fraction of migrants that receive Hukou (r_{jk}) and the fiscal wedges (Δ^g_{jk}, Δ^o_{jk}). Equilibrium requires that education expenditures are equal to the fraction of tax revenues earmarked for that purpose:

$$\zeta_j \left(T_j - S_j\right) \;=\; E^g_j \tag{24}$$

where ζ_j is the share of net tax revenue that is devoted to education. Similarly, expenditures on other public goods are given by:

$$E^o_j \;=\; \left(n^r_j + \sum_k n^m_{jk} r_{jk}\right)\; o_j \;+\; \left(\sum_k n^m_{jk}(1 - r_{jk})\; \Delta^o_{jk}\right) o_j \tag{25}$$

Note that the only difference between equation (23) and equation (25) is that migrants without children also consume other public goods and services. A balanced budget requires that that expenditures for other public goods and services equals net revenue that are earmarked for these purposes:

$$(1 - \zeta_j)\left(T_j - S_j\right) \;=\; E^o_j \tag{26}$$

Migrants also provide a positive fiscal externality to the city since they require lower expenditures, especially on education. One of the key contributions of the quantitative analysis below is that we determine the magnitude of these fiscal externalities.

To close the model we need to specify an aggregate production function which depends on the fraction of each skill type in the city. In our quantitative model we assume that production function in city j is given by:

$$Y_j \;=\; A_j \,\Pi_{k=1}^K \, n_{jk}^{\alpha_k} \tag{27}$$

where A_j denotes total factor productivity.

We can also include agglomeration effects into our model. When households and firms operate in close proximity in cities, efficiency gains primarily arise due to "sharing," "matching," and "learning" as discussed in detail in Duranton and Puga (2004). In our setting, we

assume that the productive amenity A_j increases in density. Formally, productive amenities take the following form:

$$A_j \;=\; A_{0j} \left(\frac{n_j}{l_j}\right)^{A_{1j}} \tag{28}$$

where l_j is a measure of the fixed land area of the city.[14] As we explain in detail below, our estimation approach only allows us to identify A_j. As a consequence, our estimated model is consistent with the notion that externalities may be important at the city level. To capture these externalities in our counterfactual analysis we need to make an additional assumption that allows us to decompose A_j into an exogenous and an endogenous component (Coen-Pirani and Sieg, 2019).[15]

Earnings of skill k in city j are equal to the marginal product of labor:

$$w_{jk} \;=\; A_j \; \alpha_k \; n_{jk}^{\alpha_k - 1} \; \Pi_{i \neq k} \; n_{ji}^{\alpha_i} \tag{29}$$

Note that migration to the city affects the earnings of local residents because of the concavity of the production function. Agglomeration externalities act as multipliers since migration increases density of major cities and hence overall productivity.[16]

We are now in a position to define a one-period equilibrium of the model:

[14] Alternatively, we could assume that the externality depends only on the density of high-skill households as suggested by Moretti (2011).

[15] Similarly, we could model congestion effects in amenities assuming that $\omega_j = \omega_{0j} \left(\frac{n_j}{l_j}\right)^{\omega_1}$

[16] Labor market wedges can also be incorporated into the analysis. For example, firms mays pay migrants lower wages than residents holding skills constant. Labor market discrimination lowers the attractiveness of cities for migrants and reduces the overall migration flows. Define a wage wedge $\Delta_{jk}^{w} < 1$ and assume that lifetime earnings of migrants satisfies:

$$w_{jk}^{m} \;=\; \Delta_{jk}^{w} \; w_{jk}$$

Since there is no consensus in the literature about the magnitude of these labor market wedges, we do not account for them in our quantitative analysis. Some research that has documented the existence of labor market discrimination for migrants are Meng and Zhang (2001) and Demurger et al. (2009).

Definition 1 *Given a transfer policy for the central government (t^b, δ_j), as well as an initial distribution of types and endowments, (q_{jk}, e_{jk}), local tax policies, (t_j^w, t_j^h, s_j^h), local expenditure rules (ζ_j), local Hukou policies $(r_{jk}, \Delta_{jk}^g, \Delta_{jk}^o,)$, and total factor productivity (A_j) for each city j, an equilibrium consists of expenditure policies (g_j, o_j) and housing prices (p_j) in each city, an allocation of households across cities $(n_{jk}^r, n_{jk}^{m,c})$, for $c = 0, 1$, $j = 0, .., J$ and $k = 1, ..K$, and earnings (w_{jk}) for $j = 0, .., J$ and $k = 1, ..K$, such that:*

1. *resident and migrants maximize utility subject to the relevant constraints;*
2. *housing markets clear in all communities;*
3. *local budgets are balanced in all communities; and*
4. *earnings are determined by marginal products of labor for each type in all communities.*

Note that the structure of the model allows us to define an equilibrium period by period since we assume that parents make all decisions on behalf of their children. As a consequence, we can also compute equilibria period by period using a forward iteration algorithm. The equilibria are linked by the law of motion for the initial distribution of types and their endowments. This structure has the advantage that we can study the long-term transitions of the economy without having to assume stationary or that the economy is on a balanced growth path. Both assumptions may be problematic for China.

5 The Quantitative Model

Given a specification of all relevant functions of interest, parameter values, and initial conditions, we can compute the expenditure policies (g_j, o_j), housing prices (p_j), and earnings (w_{jk}) that satisfy the housing market equilibrium conditions (17), local budget constraints (24), (26), and first-order conditions of local labor markets (29). There are $(K + 3)(J + 1)$ unknowns and $(K + 3)(J + 1)$ equations. Thus, the solution can be found using standard

numerical methods. To obtain a useful quantitative version of our model, we need to specify the initial conditions and estimate the structural parameters of the model. We discuss these steps in detail below and provide some goodness of fit analysis.

5.1 Initial Conditions and Policy Parameters

The first step of the quantitative analysis is to determine the initial conditions of the model. After the founding of the People's Republic of China, all land was nationalized, and all new housing units were owned by the state. Since 1978 China has undergone successive market reforms. Major urban reforms were initiated in the early 1990s, including the privatization of public housing. A milestone in the housing reform was the 23rd Decree issued by the State Council in 1998, which stated that work units, mostly state-owned enterprises, were no longer allowed to develop residential housing for their employees (Wu, Gyourko, and Deng, 2010). By the end of the 1990s, a private housing market has gradually developed. Hence, we use the state of the economy in 2000 to determine the initial conditions for our model.

One of the nice features of the CHFS is that it contains a variety of retrospective questions that allow us to characterize the initial distribution of household types. We use this retrospective information together with the observed college achievement of the household head to estimate the initial distribution of skill types in each city. Similarly, we use the 2000 Census to estimate the initial distribution of housing endowments by skill type. Table 5 summarizes the estimated initial distribution of skills and endowments.

Note that tier 1 cities comprised 5.6 percent of the population in 2000. Tier 2 cities accounted for 15 percent of the population. Tier 3 cities had a 13.2 percent share of the total population. The remaining 66.2 percent of the population lived in less developed, rural areas. Not surprisingly, the average skill level is declining by city tier, with tier 1 cities accounting for the largest share of high-skill households. Average housing endowments that resulted from the initial privatization of the housing stock were fairly uniformly distributed among

Table 5: Initial Conditions

	Share of Skill Type (q_{jk})		Endowments (e_{jk})	
	Low-skill	High-skill	Low-skill	High-skill
Tier 1	3.52	2.11	62	72
Tier 2	9.70	5.31	62	72
Tier 3	8.87	4.29	67	78
Rural	59.90	6.30	80	84
Housing endowments are measured in square meters.				

households in major cities with high-skill households receiving slightly larger housing units than low-skill households. Average initial housing endowments were larger in rural parts of the country than in major cities. However, housing in major cities was much more valuable than housing in rural areas in 2000.

We treat revenue policies as predetermined in our model and measure the average income tax rate in each city as the ratio of own-source revenues to local GDP. Table 6 shows that the estimated income tax rate ranges between 2 percent and 9.7 percent. The most developed tier 1 cities have the highest capacity to generate own-source revenues.[17]

Tax revenues from land sales and new housing construction are proportional to the value of the new housing stock. Using the share of land revenues reported in Table 2, a reasonable estimate of the housing tax rate, denoted by t_j^h, is 40 percent for all cities. The value-added tax was 16 percent in 2018. Since the central and local governments equally share this tax, we set the consumption tax rate of the central government that funds intergovernmental transfers at 8 percent in our model.

[17] Tier 1 and tier 2 cities attract more firms than tier 3 cities and rural areas in generating corporate income tax revenues. The progressive nature of the income tax system and tax sharing agreement also imply that cities with a larger share of high-income households can generate more income tax revenues.

Table 6: Local Government Policy Parameters

	Income Tax Rate	Share of Education Expenditures	Housing Subsidy Rate	Education Expenditure Wedge		Other Expenditure Wedge	
				Low-skill	High-skill	Low-skill	High-skill
Tier 1	0.098	0.156	0.024	0.717	0.843	0.325	0.705
Tier 2	0.058	0.156	0.029	0.839	0.869	0.188	0.505
Tier 3	0.028	0.167	0.038	0.891	0.872	0.143	0.481
Rural	0.020	0.208					

The share of expenditures that are allocated to education, denoted by ζ_j, can be estimated by the average ratio of educational expenditures and total expenditures reported in Table 2. Different public good wedges play an important role in our analysis. We measure the educational wedge Δ^g_{jk} based on the share of migrant children in local public schools as reported in Table 3. We measure the wedge for other public goods Δ^o_{jk} based on the fraction of migrants who have access to social security or medical insurance as reported in Table 11.

5.2 Estimation

First, consider the estimation of the parameters of the production function. There are two types of labor in our model: high-skill and low-skill. We allow the share of low-skill labor to be city-specific. Using local wages for each type w_{jk} and the share of labor inputs n_{jk} observed in the CHFS, the parameters of the production function can be estimated using the first-order conditions in equation (29) that characterize competitive wages in each city. In total, we can estimate eight parameters of the production function – namely the TFP parameters (A_j) and

the share of unskilled labor (α_{j1}) – using a minimum distance estimator.[18] Table 7 reports our production function parameter estimates and estimated standard errors. We find that tier 1 cities have higher TFP estimates than tier 2 and 3 cities. In contrast, the labor share of unskilled labor is increasing in city tier, with tier 1 cities having the lowest share of unskilled labor.

Second, consider the housing demand function for residents given by equation (4). The demands for migrants can be derived in a similar way. We can measure the permanent income and housing consumption of migrants and residents households using the CHFS. Hence, we can estimate the parameters of the housing demand function using a method of moments estimator. Table 7 summarizes our parameter estimates and the standard errors. We find that households with children have a higher level of minimum housing consumption ($\underline{h}$), but are less responsive to changes in income (β). High-skill households have stronger preferences for housing than low-skill households. Overall, our estimates imply that the housing shares are highest in tier 1 cities typically ranging between 34 and 46 percent of permanent income. Migrants with children have shares exceeding 50 percent, which shows that homeownership in tier 1 cities has become excessively expensive for migrants. Housing shares in tier 2 (3) cities range between 13 (6) and 22 (12) percent. Housing shares are even lower in rural areas and small cities.[19]

Finally, we estimate the remaining parameters of the model using a nested fixed-point algorithm. We compute the equilibrium for the model in the inner loop and search over the parameters in the outer loop. Since we condition on observed housing prices, local tax rates, and fiscal wedges in the estimation, the implied equilibrium appears to be unique. Moments are based on the net migration flows, college attainment rates of children, the share of children left behind, the relative levels of housing consumption, and the lifetime expenditures on education and other goods per capita. Table 7 reports the parameter estimates and estimated

[18] Assuming constant returns to scale we have $\alpha_{j2} = 1 - \alpha_{j1}$.

[19] We follow Wang and Zhang (2014) and set the housing supply elasticity $\eta_j = 2.1$ for all three city tiers.

Table 7: Structural Parameters

Parameter	Estimate	Std Error	Parameter	Estimate	Std Error
Utility Function			Housing Demand		
ω_1	4.27	(0.27)	β_0^1	0.087	(0.014)
ω_2	2.40	(0.14)	β_2^0	0.037	(0.009)
ω_3	-0.10	(0.83)	β_1^1	0.045	(0.003)
ω_0	0.00	—	β_2^1	0.011	(0.001)
ω_g	0.29	(0.03)	$\underline{h}_1^0$	19.63	(6.61)
ω_o	0.98	(0.30)	$\underline{h}_2^0$	62.43	(8.23)
σ_a	1.55	(0.04)	$\underline{h}_1^1$	57.93	(1.08)
			$\underline{h}_2^1$	83.41	(1.26)
Production Function			Mobility Cost		
A_1	10.45	(0.35)	mc_1	11.42	(0.21)
A_2	6.93	(0.14)	mc_2	7.38	(0.08)
A_3	5.49	(0.16)	mc_3	4.43	(0.07)
A_0	2.02	(0.06)	mc_k	-1.95	(0.12)
α_{11}	0.43	(0.02)	mc^c	-0.05	(0.13)
α_{21}	0.53	(0.01)	Achievement Function		
α_{31}	0.62	(0.02)	γ_0	5.25	(0.04)
α_{01}	0.92	(0.01)	γ_1	0.23	(0.01)
			σ_ϵ	3.73	(0.15)

standard errors for our preferred specification of the model.[20]

Table 7 shows that all parameters of the utility function have the expected sign and are estimated relatively precisely. There are significant differences in amenities across city tiers. Tier 1 cities are twice as attractive as tier 2 cities, while tier 3 cities are similar to the rest of the country. Households also value education and other expenditures. The parameters of the achievement function are positive. Not surprisingly, better schools translate into a higher probability of obtaining a college degree. As expected, there are significant moving costs. Note that the moving costs capture all other reasons why migrants may not want to move to major cities, that we do not explicitly model. The estimates show that it is more costly to move to tier 1 and tier 2 cities than tier 3 cities. High-skill households face lower mobility costs than low-skill households.

5.3 Goodness of Fit

Table 8 evaluates the goodness of fit of our model. We find that our model matches closely the observed and predicted net-migration flows. The predicted share of households who leave their children behind is precisely matched. Table 8 also reports college attendance rates observed in the data and predicted by our model by skill type and city tier. Overall, our model captures these spatial patterns of human capital accumulation nicely. Human capital accumulation increases as households move to more attractive cities. Moreover, residents tend to have higher college attainment than migrants. Finally, we can also show that our model also fits the observed revenue and expenditure policies in each city. We, therefore, conclude that our model fits the key dimensions of the data very well.

[20] We explored models with different tax structures and skill types to arrive at this specification.

Table 8: Model Fit

	Net Migration Rates				Migrant Children Left Behind			
	Low-skill		High-skill		Low-skill		High-skill	
	Data	Model	Data	Model	Data	Model	Data	Model
Tier 1	0.055	0.055	0.034	0.033	0.478	0.439	0.193	0.213
Tier 2	0.187	0.186	0.080	0.082	0.387	0.389	0.305	0.309
Tier 3	0.172	0.175	0.053	0.051	0.421	0.429	0.450	0.376
Rural	0.404	0.403	0.012	0.014				
	College Attendance: Residents				College Attendance: Migrants			
	Low-skill		High-skill		Low-skill		High-skill	
	Data	Model	Data	Model	Data	Model	Data	Model
Tier 1	0.774	0.791	0.927	0.987	0.519	0.570	0.842	0.956
Tier 2	0.656	0.623	0.890	0.955	0.447	0.498	0.905	0.915
Tier 3	0.591	0.523	0.927	0.917	0.389	0.431	0.901	0.872
Rural	0.321	0.320	0.735	0.742				
	Housing Demand: Residents				Housing Demand: Migrants			
	Low-skill		High-skill		Low-skill		High-skill	
	Data	Model	Data	Model	Data	Model	Data	Model
Tier 1	65	61	80	85	40	43	68	80
Tier 2	72	72	95	90	60	60	91	88
Tier 3	87	91	100	100	85	86	105	107
Rural	130	123	120	119				

6 Reforming the Hukou System

Our analysis of the current system of migration control has documented that migrants do not have the same access to local public goods and services as residents. In particular, children of transitory migrants tend to have access to lower-quality schools than children of residents and permanent migrants. Moreover, many migrant children are left behind and attend lower-quality schools in rural areas and less developed cities. Hence, our analysis suggests that the Hukou system increases inequality, suppresses human capital accumulation, and in all likelihood reduces economic growth.

China's State Council has taken steps to address these problems and urged local governments to grant Hukou to approximately 100 million temporary migrants.[21] The new policy directive acknowledges that first-tier cities have limited scope to grow in population. However, tier 2 and tier 3 cities are encouraged to ease urban Hukou registration requirements. The new policy directive also asks many small and medium cities to completely remove restrictions on Hukou registration. The central government also provides financial incentives to complying cities by subsidizing infrastructure and the construction of affordable housing. Land use quotas for urban construction are also linked to the size of registered migrants. The new policy reforms promote the creation of a residential permit system to manage migrants' access to public service aiming to reduce the gap between migrants and residents in basic local public services.

In the spirit of these policy directives advocated by the central government, we simulate the impact of policy changes that extend full residency rights to all migrants in tier 3 cities and potentially also tier 2 cities. Recall that tier 1 cities are already so large that it may be difficult to increase their populations. Hence, additional migration to tier 1 cities may

[21] In March 2014, the National Urbanization Plan (2014-2020) emphasizes urban Hukou reform to ensure that 100 million non-Hukou migrants can get urban Hukou registration. Zhang, Wang and Lu (2019) and An, Qin Wu and You (2020) provide an analysis of this policy change.

neither be feasible nor efficient. We, therefore, keep the current Hukou policies in place in tier 1 cities. Tier 2 and tier 3 cities are better candidates for population growth induced by a more generous Hukou policy. Lifting the restriction of the current Hukou policy is undoubtedly expensive since migrants provide large positive fiscal externalities. We close the model by introducing a surcharge on the national consumption tax to finance the required transfers.

We consider two different policies in our counterfactual analysis. Policy 1 only lifts the residency requirements in tier 3 cities. In contrast, Policy 2 extends full residency rights to migrants in both tier 2 and tier 3 cities. We consider both policies with and without agglomeration externalities.[22] To implement the analysis, we fix the quality of public goods and local income tax rates in all cities. We then compute a new equilibrium that imposes a surcharge on the central consumption tax to finance the additional expenditures. Both policies distribute the costs of expanding the Hukou system to all residents including those in tier 1 cities as well as residents in rural areas.

Table 9 summarizes the main impact of the policy experiments. Policy 1 opens access to public goods in all tier 3 cities, which leads to a significant increase in the overall population share of these cities. Agglomeration externalities act as a multiplier since the inflow of households increases the population density, which makes tier 3 cities more productive. Hence, the overall effects on achievement are slightly larger in the model with agglomeration externalities than in the model without agglomeration. Overall, we use a fairly conservative estimate of the magnitude of the agglomeration externality here. If we use a larger estimate, we can generate larger multiplier effects than the ones reported in Table 9.

Our model predicts that Policy 1 can be financed by a consumption tax surcharge of approximately 1.3 percentage points. Note that the number of migrants with Hukou stays approximately the same in tier 1 and tier 2 cities. The number of low-skill migrants with hukou in tier 3 cities ranges from 147 to 156 million. Note that 91 million of these households

[22] To assess the impact of agglomeration externalities on our outcomes, we set $A_{1j} = 0.4$ for all cities and adjust A_{0j} such that A_j is equal to the estimated baseline value.

Table 9: Equal Access to Local Public Goods

	Baseline	Policy 1		Policy 2	
Agglomeration		no	yes	no	yes
City	Low-skill Migrants with Hukou				
Tier 1	7.40	7.29	7.14	7.16	7.00
Tier 2	35.18	34.15	33.43	149.00	156.75
Tier 3	41.00	147.93	155.75	142.36	144.04
City	Low-skill Migrants without Hukou				
Tier 1	21.07	20.74	20.31	20.38	19.94
Tier 2	92.73	90.03	88.15	0	0
Tier 3	91.34	0	0	0	0
City	High-skill Migrants with Hukou				
Tier 1	8.36	8.25	7.94	7.96	7.46
Tier 2	24.06	23.30	22.39	49.26	51.66
Tier 3	21.52	34.13	36.19	32.37	32.08
City	High-skill Migrants without Hukou				
Tier 1	9.43	9.30	8.95	8.98	8.41
Tier 2	21.77	21.08	20.26	0	0
Tier 3	10.55	0	0	0	0
City	Children of Low-skill Migrants: College Degree				
Tier 1	16.23	16.06	15.76	15.85	15.55
Tier 2	63.72	62.04	60.74	77.88	81.85
Tier 3	57.58	65.90	69.34	63.49	64.21
City	Children of High-skill Migrants: College Degree				
Tier 1	17.02	16.80	16.17	16.22	15.20
Tier 2	41.98	40.68	39.09	45.39	47.60
Tier 3	27.99	29.97	31.79	28.44	28.17

All numbers in million.

are temporary migrants and 41 million are permanent migrants in tier 3 cities in the baseline equilibrium. Thus the net increase in migrants to tier 3 cities ranges between 15 and 24 million. As a consequence of the policy changes of relaxing the Hukou registration, an additional 10 to 14 million children of migrants to tier 3 cities would receive a college education. We thus conclude that Policy 1 achieves the stated objectives of the State Council issued in 2016 and significantly increases the college attainment of migrant children.

Policy 2 also conveys full access to public goods in tier 2 cities. Policy 2 is more costly than Policy 1 and requires a tax surcharge of approximately 3.3 percentage points. However, the achievement gains are approximately twice as large under Policy 2 as the gains under Policy 1. This follows from the fact that schools are better in tier 2 cities than in tier 3 cities.

Summarizing, we have seen that reforms of the current Hukou system are feasible, but require significant tax increases. The magnitude of these tax increases is largely driven by the fiscal externalities provided by migrant households. These fiscal externalities arise because migrants contribute more local revenues than are needed to finance the public goods and services that they consume in all major cities. Aggregating these fiscal externality measures at the city level, our model predicts that the aggregate fiscal externality ranges between 6 and 15 percent of total city revenues.[23] Any reform of the current Hukou system increases expenditures on migrant households which then significantly lowers the fiscal externalities. In the limiting case of full residency rights, migrant households still provide some positive fiscal externalities due to the local revenues generated from new land development. Nevertheless, our model predicts that large tax increases are required to offset the reduction of the fiscal externalities provided by migrant households.

[23] See Appendix A for more details and a disaggregate analysis of the fiscal externalities.

7 Conclusions

We have explored the impact of migration controls on the intergenerational transmission of human capital accumulation and inequality in China. Using a novel data set that allows us to track migrants and residents over time, we have documented that children of temporary migrants have not enjoyed the same access to local public schools as children of residents. Moreover, many migrants leave their children behind with relatives in less developed cities and rural areas. We have shown that children of temporary migrants have obtained a lower quality of education than children of residents. Hence, these children accumulate less human capital than resident children. Given these drawbacks of the current system of migration controls, there is a need to study the feasibility and effectiveness of alternative migration policies that offer the potential of decreasing inequality within China while at the same time promoting growth via increasing the aggregate level of human capital in the economy.

To accomplish this goal we have developed a spatial overlapping generations model that is consistent with the institutional design of fiscal decentralization in China and the restrictions imposed by the current Hukou system. Our analysis suggests that it is feasible to accomplish the policy goals that were formulated by China's State Council in 2016 and to provide equal access to local public goods and services for, at least, 100 million migrants. However, the implementation of these policy changes requires significant tax increases and additional intergovernmental transfers to local governments. These tax increases are necessary since migrants provide large positive fiscal externalities which range between 6 and 15 percent of total local revenues. Large tax increases are, therefore, required to off-set the reduction of the fiscal externalities provided by migrant households.

This paper provides ample scope for future research. In our model congestion arises in the provision of public goods since we measure public goods as expenditures per capita. There may be other forms of congestion that affect the benefits of local amenities that we have not explicitly modeled. Our policy analysis may overstate the benefits of reforming the

Hukou system if these additional congestion costs are sufficiently large to make it undesirable for tier 2 and tier 3 cities to increase their populations. However, the analyses in Au and Henderson (2006), Desmet and Rossi-Hansberg (2013), and Tombe and Zhu (2019) suggest that, if anything, most Chinese cities are currently too small.

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A Fiscal Externalities

A.1 Model Predictions

It is important to understand why any potential reform is likely to require significant tax increases. This need arises to the fact that the current Hukou system implies that migrants provide large positive externalities to all major cities. We can use our quantitative model to measure the magnitude of these fiscal externalities. Columns A-C of Table 10 report the revenues generated from income, land sales, and consumption taxes for the four different migrant types in our model. Total revenues are reported in Column D. Educational expenditures and expenditures for other public goods are reported in Columns E and F. Housing subsidies are reported in column G. Total expenditures are reported in Column H. Subtracting total expenditures from total revenues then yields our measure of fiscal externalities reported in Column I.

Table 10 suggests that the fiscal externalities reported in the last column are positive for all migrant types. The fiscal externalities are declining by city tier, with tier 1 cities generating the highest externalities.

Comparing the externalities for different types of migrants, we find that fiscal externalities are larger for high-skill than low-skill households. While high-skill households require higher expenditures than low-skill households, they pay much higher taxes and consume more land. The revenue effect dominates the expenditure effect. Households with children generate similar externalities as households without children. The higher schooling expenditures are more or less offset by the higher land taxes that households with children pay.

There is another important fiscal externality generated by internal migration that we do not explicitly model. This externality arises because social security is administered at the local level in China. Workers and firms contribute to a social security account, which is shared by all residents with Hukou living in the same city. Retired workers obtain pensions

Table 10: Fiscal Externalities

	Income Tax A	Land Sales B	Sales Tax C	Total Revenue D	Edu Exp E	Other Exp F	Housing Subsidy G	Total Exp H	Total Dif I=(D-H)
Low-skill, no child									
Tier 1	332	430	195	958	0	566	7	573	385
Tier 2	145	143	157	445	0	228	3	231	214
Tier 3	60	99	135	294	0	141	3	144	150
Low-skill with child									
Tier 1	332	1041	54	1427	169	566	16	751	676
Tier 2	145	218	142	505	86	228	4	318	187
Tier 3	60	106	132	298	58	141	3	202	96
High-skill no child									
Tier 1	719	1172	368	2259	0	955	33	988	1271
Tier 2	293	264	324	881	0	424	10	434	447
Tier 3	126	144	304	574	0	284	9	293	281
High-skill with child									
Tier 1	719	1497	287	2503	195	955	42	1192	1310
Tier 2	293	280	313	886	91	424	11	526	360
Tier 3	126	119	293	538	60	284	8	351	188
All variables are in 1,000 Chinese Yuan and in per capita.									

that are financed using a pay-as-you-go system. Migrants are, on average, much younger than residents and, therefore, are net contributors to the social security account. Older residents benefit from migrants, because they did not pay much social security taxes when they were young, and experience a windfall gain from the introduction of the pay-as-you-go system. These gains are larger in cities with large migration inflows. Our estimates of the fiscal externalities of migrants do not account for this externality and are, therefore, lower bounds of the total externalities.

We thus conclude that residents in all major cities enjoy higher levels of public good provision and/or pay lower taxes due to the positive fiscal externalities generated by migrants. As a consequence of this fiscal externality, any reform of the Hukou system is likely to require significant tax increases as we document in this paper.

A.2 Empirical Evidence: Expenditures

In this section, we provide additional evidence that temporary migrants do not have equal access to a variety of other local public goods and services. For example, residents have better access to public housing and housing subsidies via the housing providence fund than migrants. As a consequence, migrants face higher housing costs than residents. Table 11 reports some statistics that summarize access to public goods by migrants. It is also based on the 2011 version of the MDMS.

Table 11 provides some useful insights into this problem. All employers in China are required by law to pay social security contributions for their employees regardless of their Hukou status. Temporary migrants, however, are often not protected by the law or unwilling to join the social insurance program because of high job uncertainty. Similar access problems arise for medical insurance programs.[24]

[24] All employees are supposed to have access to the Urban Employee Medical Insurance. Also, cities have an Urban Resident Medical Insurance program that primarily covers households with local urban Hukou.

Table 11: Fraction with Access to Other Public Goods and Services

	Housing Providence Fund		Social Security		Medical Insurance	
	Low-skill	High-skill	Low-skill	High-skill	Low-skill	High-skill
Tier 1	3.6	34.6	24.3	66.8	29.9	68.4
Tier 2	3.2	20.8	14.4	46.7	17.4	48.0
Tier 3	1.6	19.2	8.3	38.9	12.2	45.1

A.3 Empirical Evidence: Revenues

We have argued that migrants provide large positive fiscal externalities to major cities in China. As shown in the previous section, these fiscal externalities are partially explained by the fact that migrants do not have the same access to public goods and services as residents. In this section, we provide some evidence that supports the predictions of our model that migrants also provide positive revenue externalities.

Recall that cities have two main sources of own-source revenues: taxes and revenues from land development and housing construction. First, consider tax revenues which primarily consist of consumption and income tax revenues. Local revenues are generated by ta sharing agreements between the local and central governments. We can use data from the CHFS 2017 to gain some insights into differences in local tax payments by Hukou status. Table 12 reports estimates of income tax payments, consumption patterns, and housing purchases of residents and migrants. Again, we distinguish between temporary and permanent migrants. It reports regression coefficients in Columns (1) - (2) and marginal effects from logit models in Column (3). Each model controls for a variety of socio-economic characteristics and city fixed effects. Column (1) suggests that migrants pay the same amounts of income tax as

Similarly, rural areas offer the Rural Medical Cooperative Insurance program. Many migrants only have access to these programs in their Hukou registration place.

residents. Column (2) shows that migrants have slightly lower levels of total consumption than residents, but these differences are largely driven by the fact that migrants have to spend a higher income share on housing. Hence, we conjecture that there are only small differences in consumption tax revenues by residency status. Moreover, our model simulations reported above account for these consumption differences.

Table 12: Differences between Migrants and Residents

	Personal Income Tax	Total Consumption	New Housing Purchases
	(1)	(2)	(3)
Permanent migrants	-34	-4156	0.008
	(233)	(1444)	(0.003)
Temporary migrants	-316	-3271	-0.001
	(214)	(1268)	(0.003)
Household characteristics	Y	Y	Y
City Fixed Effects	Y	Y	Y
Observations	13645	17160	16900
R^2	0.4257	0.2937	0.0231

Note: regression coefficients in (1) and (2), marginal effects from logit in (3).

Second, fiscal revenues from land development and new housing construction can account for around 40 percent of local revenues. Since most residents benefited from the initial privatization of the housing stock in the late 1990s, the additional housing demand, therefore, is largely driven by young residents that did not participate in the initial privatization and older residents that want to increase or upgrade their housing consumption. In contrast, migration has increased the population of many coastal cities which created the need for new housing construction. Hence migrant flows have driven a significant part of new land

development and housing construction. Using the CHFS data, we estimate logit models of new housing purchases. Column (3) in Table 12 suggests that permanent migrants are more likely to purchase new housing in a two-year period than residents.

Finally, we provide some evidence regarding the relationship between land development, new housing investment, and population growth in Chinese prefectural cities. The empirical analysis in this section is based on city statistics from 2008-2016. We focus on four outcome variables that measure new housing supply: the value of new land development, the area of new land development, housing prices, and residential housing investments. The data for housing investments are from the China Statistical Yearbook. Housing prices, land sale areas, and land values are from the CEIC database. Note that the outcome variables differ in the amount of missing values which explains the variation in sample sizes. We regress each outcome variable on population size controlling for time fixed effects using a log-log specification. Hence the coefficient of population is identified because of differential changes in population growth among the sample of cities. Since population growth may be endogenous, we also report IV estimates using Bartik instruments. The results are summarized in Table 13.

We find that there are strong positive correlations between the different measures of land and housing supply and population growth. Since population growth is mainly driven by migration flows, we view these findings as supportive of our main hypothesis that migrants provide positive fiscal externalities. In Table 13, we also estimate the model using Bartik shock to instrument population growth for possible endogeneity problems caused by unobserved productivity shocks. The IV estimates show a much stronger positive relationship between land and housing measures and population growth.

Table 13: Land and Housing Market Development and Population Growth (2008-2016)

	Land Sale Area		Land Sale Value		Housing Price		Housing Investment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Population	0.279	2.032	1.208	5.757	0.159	1.196	0.835	3.822
	(0.045)	(0.349)	(0.083)	(0.986)	(0.013)	(0.127)	(0.041)	(0.320)
Observations	1,232	1,122	986	896	2,205	2,011	2,764	2,514
Number of cities	248	228	248	228	280	260	280	260
R^2	0.144	0.140	0.346	0.347	0.249	0.244	0.459	0.463
First Stage		Pop		Pop		Pop		Pop
Bartik Shocks		0.1061		0.0727		0.029		0.0306
		(0.018)		(0.014)		(0.003)		(0.003)
Wald Statistics		33		26		76		99

Notes: The data are from the period 2008-2018; all quantities are in logs. Standard errors are reported in parentheses.