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ABSTRACT

Using newly available data, we document that internal migrants do not enjoy the same access to local public goods and services as city residents in China. We estimate a spatial overlapping generations model with heterogeneous households to quantify the impact of the Hukou system on urban fiscal policies and access to educational opportunities. We find that migrants provide large fiscal externalities to all major cities. We show the feasibility of alternative internal migration policies that offer the potential of decreasing the inequality within China while at the same time increasing the overall level of human capital in the economy.

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1 Introduction

This paper studies the impact of internal migration controls on urban fiscal policies, access to educational opportunities, and the intergenerational transmission of human capital in China. We use new data to document differences in outcomes between migrants and city residents. We find that migrants do not enjoy the same access to local public goods and services as residents, which, among others, creates a gap in educational attainment. We develop and estimate a new spatial overlapping generations model that is consistent with the main institutional features that characterize fiscal decentralization in China. We find that migrants provide large positive fiscal externalities to all major cities ranging between 6 and 15 percent of total local revenues. We then evaluate the feasibility and effectiveness of alternative internal migration policies that offer the potential of decreasing inequality within China while at the same time promoting growth via increasing the overall level of human capital in the economy. We find that there is much scope for reallocating households from rural areas and small cities to tier 2 and tier 3 cities. Our analysis, therefore, suggests that it is feasible to grant equal access to local public goods for migrants in most major cities in China. These policies, however, require significant increases in local taxes.

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.[1] Using these novel data sets, we show that migrant households

[1]The micro sample of 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 China City Statistics Yearbook to measure heterogeneity in local fiscal policies across city tiers.

consume lower levels of public goods and services while contributing relatively higher tax revenues than city residents. These discrepancies arise for two reasons. On the expenditure side, migrants often do not have equal access to local primary and secondary schools and other local public goods and services. On the revenue side, the housing demand of migrants drives a large fraction of new housing construction, which is an important source of local revenues in growing cities in China. As a consequence, migrants provide large positive fiscal externalities for all major cities in China.

We document that internal migration policies have a large impact on access to and affordability of educational opportunities within the country. These policies designed around the Hukou registration system affect where households live and how much cities can spend on education and other public goods. Not surprisingly, there are large differences in school quality among Chinese cities, towns, and rural areas. Internal migration controls, therefore, affect the intergenerational transmission of human capital.

Our empirical analysis suggests that there are two important channels. First, a majority of migrants bring their children when they move, but children of migrant workers do not have the same access to educational opportunities as children of residents. Hence, these children accumulate less human capital than children of residents holding parental skills constant. Hence, there is a significant achievement gap or wedge between children of migrants and children of residents in the same city. Second, many migrants leave their children behind with grandparents or relatives. Average school quality is much higher in major cities than in less developed areas in China. As a consequence, children that are left behind do not have access to the same educational opportunities as children that attend schools in major cities. Hence, these left-behind children receive, on average, a lower quality of education, which also slows down the human capital accumulation in the overall economy and reduces aggregate growth. While migration increases the overall human capital accumulation, the inequalities built into the Hukou system imply that there is much scope for increasing the overall accumulation of human capital of migrant children and children left behind in less developed parts of the economy.

To quantify the effects of internal migration controls on human capital accumulation and to assess the feasibility and desirability of potential reforms, we develop and estimate a new overlapping generations model with heterogeneous households. The quantitative model captures the observed migration patterns within China since the era of housing market reforms in the late 1990s. 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] We combine the insights from this class of spatial OLG models with those obtained from modern Rosen (1979) & Roback (1982) models.[3] Finally, we use fiscal and housing market wedges to capture important distortions faced by migrants in the economy as suggested by Chari, Kehoe, and McGrattan (2007).

Our model has multiple locations that differ by local labor and housing market conditions as well as local tax and expenditure policies. Households, therefore, have strong incentives to migrate to higher productivity cities that pay higher wages and have a higher quality of local public good provision. Migrant households face mobility costs, wedges in housing markets, and restricted access to local public goods. 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 human capital accumulation.

We can only compute equilibria of the model numerically. Hence we estimate the model's parameters using a method of moments estimator. Since we condition on observed housing prices, local tax rates, and fiscal wedges in the estimation, the implied equilibrium is unique, which allows us to use a nested fixed-point algorithm in estimation. Some parameters can be estimated without computing the equilibrium of the model. Hence we use a sequential

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

[3]For a survey of the literature see Moretti (2011). The most recent research is discussed by Diamond (2016) and Coen-Pirani and Sieg (2019).

estimator and compute standard errors using a bootstrap algorithm.

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. 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 the parameter estimates are reasonable and that the model fits the data well. In particular, our model captures the heterogeneity in fiscal policies across city types, the differences in housing market conditions, and the broad migration patterns observed in the data.

Our findings suggest that migrants of all types produce significant positive fiscal externalities for all cities. The difference between total revenues paid by migrants and total local expenditures on migrants accounts for 6 to 15 percent of total city revenues. Not surprisingly, high-skill migrants provide a higher externality than low-skill migrants. While high-skill migrants tend to have better access to local public goods and services than low-skill migrants, they also pay significantly higher taxes. Moreover, the fiscal externality per migrant decreases by city tier, with tier 1 cities benefiting the most from migrants. We, therefore, conclude that migrants provide large fiscal subsidies to residents in all major cities in China.

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 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 exists feasible reforms of the Hukou system that could significantly increase the college attainment 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.

Our paper is related to numerous strands of the literature. First, a number of previous 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. There has been much less research that has studied the impact of internal migration controls on urban fiscal policies and the overall level of human capital accumulation in the economy. In contrast to the papers above, we use a different

model that focuses on differences in urban fiscal policies and fiscal decentralization on sorting and access to economic opportunities.

Third, there is a literature in macroeconomics 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 whole 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. Using the CHFS and other novel data sets, we document how the migration controls affect the flow of households over time from lower-tier to higher-tier cities. We also document important differences in access to local public goods and services between migrants and residents. Section 3 develops our overlapping generations model. Section 4 discusses our parameter estimates and the goodness of fit of our model. Section 5 provides our estimates of the fiscal externalities of migrants. 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

2.1 Fiscal Decentralization and Urban Fiscal Policies

Cities play an important role in the intergeneration transmission of human capital. In a decentralized system of provision of education, such as the one in China, there are often large differences in school quality among cities. As a consequence, we need to understand urban fiscal policies, i.e. we need to characterize the differences in revenues and expenditures among local governments. In this chapter, we show that Chinese cities primarily rely on three sources of revenues: 1) own source revenues that arise due to local taxes and fees as well as tax sharing agreements with the central government, 2) revenues from land and housing development, and 3) intergovernmental transfers from the central government. As a consequence, the central government plays a large role in determining city finances.

To illustrate the importance of tax sharing agreements and intergovernmental transfers, it is useful to consider the aggregate budgets of the central and local governments. For the central government, we focus on the general public budget.[4] Table 1 reports the latest publicly available statistics from the 2018 fiscal year compiled by China's Ministry of Finance.

Table 1 shows that the central government spends 32% of total expenditures for public goods and services such as national defense, science and technology, public security, and education. In contrast, 68 % of general budget expenditures are earmarked for transfers to local governments. That is a much larger fraction than in most comparable countries.

Central government revenues mainly come from two sources: 1) domestic value-added

[4]There are three other budgets: 1) the government managed fund, 2) the state capital fund, and 3) the social security fund. These three funds are relatively small at the central level of government and do not play a role in our analysis. At the local level, the government fund and the social security funds can be substantial. The state capital funds, which are related to state-owned enterprises, are relatively small at the local and central levels compared with the other three funds. The social security fund is mostly managed by local governments. We ignore state capital and social security funds in our analysis since they do not play an essential role in our model.

Table 1: Revenues and Expenditures in 2018

Central Government: General Public Budget		
	Total	Share
Total Revenues	8544	100%
– VAT & Consumption Taxes	4138	48%
– Corporate & Personal Income Taxes	3056	36%
– Other Revenues	1350	16%
Total Expenditures	10238	100%
– Central Spending	3270	32%
– Intergovernmental Transfers	6967	68%
Local Governments: General Public Budget		
	Total	Share
Total Revenues	17990	100%
– Local Revenues	9791	54%
– Intergovernmental Transfers	6967	39%
– From Government Fund	1232	7%
Total Expenditures	18819	100%
– Education	3044	16%
Local Governments: Government-Managed Fund		
	Total	Share
Total Revenues	8580	100%
– Land Sales	6509	76%
Total Expenditures	7747	100%
– Urban Development Related	6814	88%

The unit is billion Chinese Yuan.

Data source: annual report of China's Mistry of Finance.

taxes and consumption taxes (48%), and 2) corporate and personal income taxes (36%). As we discuss in more detail below, consumption and income taxes are shared between the central and local governments. We thus conclude that an important role of the central government is to collect revenues and to transfer these revenues to local governments.

Table 1 also presents the aggregate budget of local governments in China. We focus on the two most important local budgets: the general public budget and the government-managed fund.[5] The general budget of local governments is financed by local revenues (54%), central transfers (39%), and transfers from government-managed fund (7%). In addition, local governments receive significant revenues from the government-managed funds, 76% of which comes from the sale of land use rights.

Tax sharing agreements between the central and local governments are an essential part of fiscal decentralization in China. These agreements are based on fixed sharing rules. The current structure of tax sharing arrangements goes back to a reform of the fiscal system in 1994. Taxes were classified as central, local, and shared taxes. Table 2 illustrates the taxing sharing arrangement in the fiscal year 2018. Central taxes include customs duties, vehicle purchase taxes, and some consumption taxes. The value-added tax is the main shared tax. Note that VAT tax revenues are shared equally between the central and local governments.[6] Personal and corporate income taxes are also shared taxes. The corporate income tax is 25%, and the personal income tax ranges between 5% and 45%. Local governments receive approximately 40 percent of all income tax revenues. The progressive nature of the income tax system implies that top-tier cities can generate much higher revenues from income taxes than lower-tier cities. Local taxes also include a variety of real estate and property transaction taxes, land use and urban development tax, and other consumption taxes.

Equally important are expenditure assignments between the central and local governments. These assignments determine the responsibility of the central and local governments

[5]The third important budget at the local level is the social security fund which accounted for another 7.7 trillion Yuan in expenditures in 2018.

[6]The current VAT tax rate is 16 percent.

Table 2: Tax Sharing Arrangements

	Central	Local	Share of Taxes	Share of GDP
Central Taxes	100%		20.2%	3.8%
Shared Taxes			67.1%	12.6%
– Domestic VAT	50%	50%	35.7%	6.7%
– Corporate Income Tax	63%	37%	20.5%	3.8%
– Personal Income Tax	60%	40%	8.1%	1.5%
Local Taxes		100%	12.6%	2.4%

for the provision of certain public goods and services. Not surprisingly, the central government is primarily responsible for national defense, foreign affairs, and national transportation projects. In contrast, local governments are primarily responsible for education, urban development, social security, health, housing, community affairs, and the environment.

In our quantitative model, we distinguish among tier 1, tier 2, tier 3, and less developed cities as well as rural areas. To capture the essential components of fiscal decentralization in China we consider three sources of local revenues: 1) transfers from the central government as well as revenue sharing from the VAT, 2) revenues from land and housing sales, and 3) own-source revenues excluding VAT, which primarily include personal and corporate income taxes, fees, and charges. China's City Statistical Yearbook provides statistics that allow us to estimate the relevant revenue shares by city tier. As shown in Table 3, own-revenues account for 34% of total local revenues in tier 1 cities. Land and housing-related revenues account for 35 % of total revenues. The remaining revenues come from VAT sharing and other central government transfer 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. 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.

Table 3: 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, which reports expenditures for both the urban core and the whole prefecture.[7] We proxy rural expenditures using the total expenditures of the whole prefecture minus the expenditures for city proper in a prefecture.

Table 3 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, in 2017, rural educational expenditures and expenditures on other public goods were 791 and 3,485 Chinese Yuan per capita respectively. In summary, there are pronounced differences in both educational and other public expenditures among cities and less developed places in China.

2.2 The Hukou System, Temporary and Permanent Migrants

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

[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).

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 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, the importance of local governments in granting Hukou status has grown steadily. 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 requirements, 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 decision and educational achievement.[8]

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 who moves across these four location types.[9] 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 tier 1 and tier 2 cities who work and live in a location without local urban Hukou.

Table 4 shows the status of residents and migrants by city tier using data from the CHFS in 2017, which has more than 40,000 households. We use can 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

[8]Appendix A explains in detail how we measure Hukou status and Hukou transitions in our data set.

[9]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 migrants flows across city tiers, but still accounts for the large scale of rural-urban migration during China's rapid urbanization since 1990s.

Table 4: Migration by City Tier

Share of Migrants and Residents			
	Tier 1	Tier 2	Tier 3
Permanent Migrants (with urban Hukou)	13.5	15.8	20.3
Temporary Migrants (without urban Hukou)	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

to another. Migrants with a change in Hukou status (permanent migrants) account for a considerable proportion in the total population. The transition of Hukou status is an important feature in our analysis. Note that migrants constitute 40 to 50 percent of the population in tier 1, tier 2, and tier 3 cities. 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).[10]

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 4 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. These calculations are also based on the CHFS 2017. Table 4 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 larger for high-skill than low-skill households.

[10]Appendix B contains a more detailed analysis of Hukou change by age and time period.

Table 5: Characteristics of Residents and Migrants

				Fraction			
	City	Age	Years of Edu	Rural Hukou	Household Size	Annual Income	Annual Consump
Residents	Tier 1	51.9	12.4	0	2.69	176,351	103,779
Permanent Migr	Tier 1	46.6	13.4	0	2.92	209,166	106,397
Temporary Migr	Tier 1	41.1	10.9	71.7	3.08	169,251	101,768
Residents	Tier 2	50.1	11.7	0	2.88	128,317	79,889
Permanent Migr	Tier 2	46.9	12.1	0	3.08	142,850	80,043
Temporary Migr	Tier 2	43.5	9.6	87.3	3.20	95,814	68,273
Residents	Tier 3	49.3	11.1	0	3.15	104,303	68,799
Permanent Migr	Tier 3	47.4	11.4	0	3.43	114,659	70,032
Temporary Migr	Tier 3	45.1	8.6	97.4	3.68	79,989	62,377
Residents	Rural	51.4	7.58	1	3.78	65,862	47,800
Income and consumption are in 2017 Chinese Yuan.							

Residents and migrants differ along many observed dimensions. Socio-economic and demographic information on different types of households is reported in Table 5. It shows that residents tend to be older and thus have smaller household sizes, on average, than migrants. Moreover, they tend to have higher levels of education, higher income, higher consumption, and higher wealth than temporary migrants. Permanent migrants have, on average, the highest level of education and income. They have similar levels of wealth than residents. The majority of temporary migrants have a rural Hukou registration.

An important feature of the Hukou system is that it regulates access to a variety of local public goods and services. For example, the Hukou status restricts access to local schools, health insurance, pension, unemployment insurance, maternity benefits, and housing providence funds. Access to these public goods 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 6 documents the educational achievement of children, whose parents are either low- or high-skill, by migration status. These statistics are based on the 2017 CHFS data, for the age group 19 to 39. In total, 40.8% of all children in the CFHS receive some college education.[11] Moreover, migrant children have significantly lower college attainments than children of residents, even after conditioning on parental education levels. Not surprisingly,

[11]Note that this fraction is higher than the fraction reported in 2015 Census which is approximately 30 percent for the comparable group. That is because CHFS sample is slightly older than the census and has a higher fraction of educated households.

Table 6: Share of Children with College Attainment

	Residents		Migrants	
Parents	Low-skill	High-skill	Low-skill	High-skill
Tier 1	67.7	96.3	29.5	93.5
Tier 2	52.9	91.0	24.2	90.9
Tier 3	41.9	89.3	21.9	87.4
Rural	23.0	78.2		
	Permanent Migrants		Temporary Migrants	
Parents	Low-skill	High-skill	Low-skill	High-skill
Tier 1	59.8	94.5	23.6	92.8
Tier 2	38.9	93.2	19.8	88.7
Tier 3	32.1	88.5	18.0	85.8

attainment also decreases by city tier, with tier 1 cities producing the highest fraction of college-educated children. Children of permanent migrants have much higher achievement than children of temporary migrants, holding parental skills constant.

Table 7 shows that a significant share of migrants' children not enrolled 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 2011 Migrants Dynamic Monitoring Survey (MDMS), for which there are detailed information on the coverage of public services.[12] Table 7 also reports the proportion of children who are not living with their migrant parents, based on the 2011 version of the MDMS. 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

[12]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.

Table 7: Access to Educational Opportunities

Share of Temporary Migrant Children in Local Public Schools		
Parents	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		
Parents	Low-skill	High-skill
Tier 1	47.9	19.3
Tier 2	38.7	30.5
Tier 3	42.1	45.0

high-skill households, the fraction ranges from 19.3 percent to 45 percent. We conclude that a significant number of migrants leave children behind.

Migrants also 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 8 reports some statistics that summarize access to public goods by migrants. It is also based on the 2011 version of the MDMS

Table 8 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.[13]

[13]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. Similarly, rural areas offer the Rural Medical Cooperative Insurance program. Many migrants only have

Table 8: 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

In summary, the Hukou system primarily affects access to local public good and services and thus should be viewed as part of urban fiscal policies. We will demonstrate that a reform of the Hukou system requires significant changes in how cities are financed.

3 A Model

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

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.[14] Local public goods are financed by a combination of local revenues: a proportional

access to these programs in their Hukou registration place.

[14]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 the analysis. We discuss these issues in more details in the conclusions.

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.

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}.[15]

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 g_j and parental skills s_k. In our quantitative model, we use the following specification:

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

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 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

[15]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).

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 housing demand is higher when the child lives with the parent.

Adults can relocate to a city that is different for 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 their child behind. As in Bénabou (1996) and Fernandez and Rogerson (1996, 1998) adults make all decisions in the model, i.e. children are passive and do not make any decisions.

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, and public goods 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.[16] 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:

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

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: $a_{jk}^r = a(g_j, s_k)$.

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.[17] 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

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

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

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: 1) with Hukou (y) and with children $c = 1$; 2) with Hukou (y) and without children $c = 0$; 3) without Hukou (n) and with children $c = 1$; 4) without Hukou (n) and without children $c = 0$; We derive the the housing demand and achievement functions for each type of migrant in Appendix C. 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:

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

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

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

Now that we have characterized all conditional value functions, we can characterize optimal location decisions. Note that each households 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 $2 \times J + 1$ elements. Let ϵ^c_{ijk} 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:

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

where σ_ϵ is the scale parameter of the random utility shocks. The probability of staying is:

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

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^r_{jk} and note that:

$$n^r_{jk} \;=\; q_{jk}\, P_{jjk}. \tag{11}$$

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:

$$n^{m,c}_{jk} \;=\; \sum_{l\neq j} q_{lk}\, P^c_{ljk} \;=\; \sum_{l\neq j} n^{m,c}_{ljk}. \tag{12}$$

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

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:

$$H^d_j = H^{dr}_j \;+\; H^{dy}_j \;+\; H^{dn}_j \tag{13}$$

It is straightforward to derive each of these terms and details are reported in Appendix C. 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 combination 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 form 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 wedge (Δ_{jk}^g). Equilibrium requires that education expenditures are equal to the fraction of tax revenue earmarked for that purpose:

$$\zeta_j \, (T_j - S_j) \;=\; E_j^g \tag{24}$$

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

$$E_j^o \;=\; \left(n_j^r + \sum_k n_{jk}^m r_{jk} \right) \; o_j \;+\; \left(\sum_k n_{jk}^m (1 - r_{jk}) \; \Delta_{jk}^o \right) o_j \tag{25}$$

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:

$$(1-\zeta_j)\,(T_j - S_j) \;=\; E_j^o \tag{26}$$

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 estimate 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. Alternatively, we could assume that the externality depends only on the density of high-skill households as suggested by Moretti (2011). 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).[18]

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

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

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.[19]

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

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*

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

[19] 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:

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

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).

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.

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 $(K+3)(J+1)$ conditions. Thus, the solution can be found using standard numerical methods. Since we can only solve the model numerically we need to parametrize all relevant functions and estimate the parameters of our model.

4 Estimation

The first step of the estimation procedure 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 and major urban reforms were initiated in the early 1990s, including the privatization of some state-owned enterprises and 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, so 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 allows us to characterize the initial distribution of household types. In particular, the CHFS reports the household head's prior location of residence, which is useful to distinguish among migrants and residents. 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 9 summaries the estimated initial distribution of skills and endowments.

Table 9: 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.				

Note that tier 1 cities comprised 5.6 percent of the population in 2000. Tier 2 cities accounted for 15 percent, while tier 3 cities a 13.2 percent share of the total population. The remaining 66.2 percent of the population lived in less developed cities and rural area. Not surprisingly, the average education is declining by city tier, with tier 1 cities accounting 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 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 tax rate in each city as the ratio of own source revenues to local GDP. Table 10 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.[20]

Table 10: 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					

Tax revenues from land sales and new housing construction are proportional to the value of housing stock. Using the share of land revenues reported in Table 3, a reasonable estimate of the housing tax rate, denoted by t_j^h, is 40 percent for all cities. Recall from our discussion in Section 2 of this paper that 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 at 8 percent in our model.

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

[20]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.

3. Different public good wedges play an important role in our analysis. We estimate the educational wedge Δ_{jk}^{g} based on the share of migrant children in local public schools as reported in Table 7. We estimate the wedge for other public goods Δ_{jk}^{o} based on the fraction of migrants who have access to social security or medical insurance as reported in Table 8.

Next, we discuss the estimation 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 labor inputs n_{jk} 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.[21] Table 11 reports our production function parameter estimates and estimated standard errors. We find that more developed cities have higher TFP estimates than lower tier 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.

Given our functional form assumption, the housing demand function for residents is given by equation (4). The demands for migrants are derived in Appendix C. We can measure the permanent income and housing consumption of migrants and residents households using the CHFS.[22] Hence, we can estimate the parameters of the housing demand function using a moments estimator. Table 11 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 are range between 13 (6) and 22 (12) percent. Housing shares are

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

[22] Details are reported in a data appendix that is available from the authors upon request.

Table 11: 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)

even lower in rural areas and small cities.[23]

The remaining parameters of the utility and achievement functions are also identified given observed outcomes. The parameter ω_a captures the relative weight that households place on children's achievement. Migrants partially move to obtain access to better schools for their children. The larger ω_a the more locational decisions are driven by local school quality. The parameter ω_o is the relative weight on non-educational public goods in the utility. It determines the migration decisions of all households including those that leave their children behind. The larger this parameter the more locational decisions are driven by other spending. ω_j captures locational amenities that are not explained by fiscal policies.

We also need to identify the variance terms of the idiosyncratic shocks of the random utility function, σ_ϵ. The model implies that the larger the variance the more important are the random shocks in determining relocation decisions. Identification of the parameters of the achievement follows from the fact that we observe college attainment for children of residents and migrants in each city. Mobility costs determine the magnitude of the flows of different migrant types migrants. Moving cost parameters are primarily identified from the net migration rates observed in the CHFS and the fraction of households that move without children observed in the MDMS.

This discussion above suggests that we can 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 11 reports the remaining parameter estimates and estimated standard errors for our preferred specification of the model.[24]

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

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

Table 12: 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				

Table 11 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.

Table 12 evaluates the goodness of fit. 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 quite precise. Table 12 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, Appendix D shows that our model also fits the observed revenue and expenditure policies in each city. We thus conclude that our model fits the key dimensions of the data very well.

5 The Fiscal Externalities of Migration

Recall that migrants pay, on average, higher local taxes, but receive lower levels of public goods and services than residents. Hence, migrants provide positive fiscal externalities and subsidize residents. We can use our estimated model to quantify the magnitude of these fiscal externalities. Columns A-C of Table 13 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 13 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 than households without children. The higher schooling expenditures are more or less offset by the higher land taxes that households with children pay.

We thus conclude that residents in all major cities are heavily subsidized by migrants. They enjoy higher levels of public good provision and/or pay lower taxes due to the positive fiscal externalities generated by migrants. The Hukou system, therefore, has a significant effect on urban fiscal policies. Aggregating these fiscal externality measures at the city level, we find that the estimated aggregate fiscal externality ranges between 6 and 15 percent of total revenues. As a result, all major cities in China increase their fiscal capacities due to migration, which largely benefits residents.

6 Reforming the Hukou System

Our analysis of the Hukou system implies 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, a large fraction of migrant children are left behind and attend lower-quality schools

Table 13: 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.

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.[25] 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 neither be feasible nor desirable. 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 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

[25]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.

to migrants in both tier 2 and tier 3 cities. We consider both policies with and without agglomeration externalities.[26] 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 14 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 14.

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 the 91 million of these households 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 college attainment of migrant children.

[26] 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 14: 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.

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.

7 Conclusions

We have explored the impact of migration controls on urban fiscal policies and intergenerational transmission of human capital accumulation in China. Using a novel data set that allows us to track migrants and residents over time, we have documented that migrant children do not have the same access to local public schools as resident children. Moreover, many migrants leave their children behind with relatives in less developed cities and rural areas. These children also obtain a lower quality of education than children of residents. As a consequence, migrant children accumulate less human capital than resident children holding parental skills constant. We conclude that the Hukou system has a large impact on access to educational opportunities.

We have developed and estimated a new spatial overlapping generations model that captures the fact that the Hukou system implies unequal access to a variety of local public goods and services. The model is rooted in the institutional design of fiscal decentralization in China. We have shown that our approach yields reasonable parameter estimates and fits the data well. We show that migrants provide large positive fiscal externalities to major cities. The fiscal externality ranges between 6 and 15 percent of total local revenues. Hence, the Hukou system has a large impact on urban fiscal policies of all major cities in China.

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

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 leave it as future research to estimate the magnitude of the fiscal externality generated by the social security system.

We have evaluated 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. 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 good 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.

Our 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. Hence, some form of migration controls may be necessary and desirable, especially in tier 1 cities. Tier 2 and tier 3 cities, however, do not appear to be excessively large and offer some scope for population growth via migration. 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. It seems reasonable to conclude that reforms to the current Hukou policies in tier 2 and tier 3 cities are feasible. These reforms offer the potential of decreasing the inequality within China while at the same time increasing the overall level of human capital in the economy.

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A Definition of Migration Status

In our model, there are four locations: tier 1 cities, tier 2 cities, tier 3 cities, as well as less developed cities and rural places. Hence, we need to assign each household observed in the 2017 CHFS sample to one of these locations as initial condition and infer the Hukou status at birth. The 2017 CHFS survey did not ask respondents to state the place of birth or the Hukou status at birth. Instead, it asked households to report the previous place of residence and previous Hukou status. We, therefore, use that information on previous residence and Hukou status to infer the initial condition for all households in our sample. While this imputation is reasonable for most migrants, it may be problematic for those who move multiple times during their lives.

Based on these survey questions, we then can define residence and migration status for all households in the sample. Rural (Hukou) residents who never moved across locations are treated as rural residents (or residents in location 4); urban Hukou residents in tier 1-3 who never moved across location tiers are treated as urban residents in tier 1-3. Permanent migrants are those moved across city tiers and changed Hukou status to local urban. Transitory migrants are those moved across city tiers and have no local Hukou status.

As a sensitivity check, we also analyzed the 2019 wave of the CHFS. The main advantage is that all respondents were asked retrospective questions about the place of birth and the Hukou status at birth, so that we can define migrants and Hukou status in the initial period more cleanly as in the 2017 wave of the CHFS. We do not use the 2019 wave since it is much smaller than the 2017 wave.

B Hukou Transitions by Age and Calendar Year

One of the key advantages of the CHFS is that it allows us to measure and analyze Hukou transitions. In this section, we report some stylized facts characterizing the population with Nong-Zhuan-Fei (rural to urban) Hukou change based on 2017 CHFS data. The upper panel

of Figure 1 shows the distribution of the year of the Hukou change for the Nong-Zhuan-Fei population. The majority changed their rural Hukou to urban after the 1990s. This can be explained by the gradual relaxation of Hukou registration, especially for the status change from rural to urban Hukou, and the urbanization process during that period.

The lower panel of Figure 1 shows the distribution of age at the time of the Hukou change. We find that most individuals in the sample obtained their urban Hukou through Nong-Zhuan-Fei between the ages of 15 and 40. This reflects the preferences for young workers by city industries and governments and the expectation of higher returns on migration among younger rural households. These facts are broadly consistent with our modeling strategy which assumes that Hukou transitions happen between the first and the second period of life.

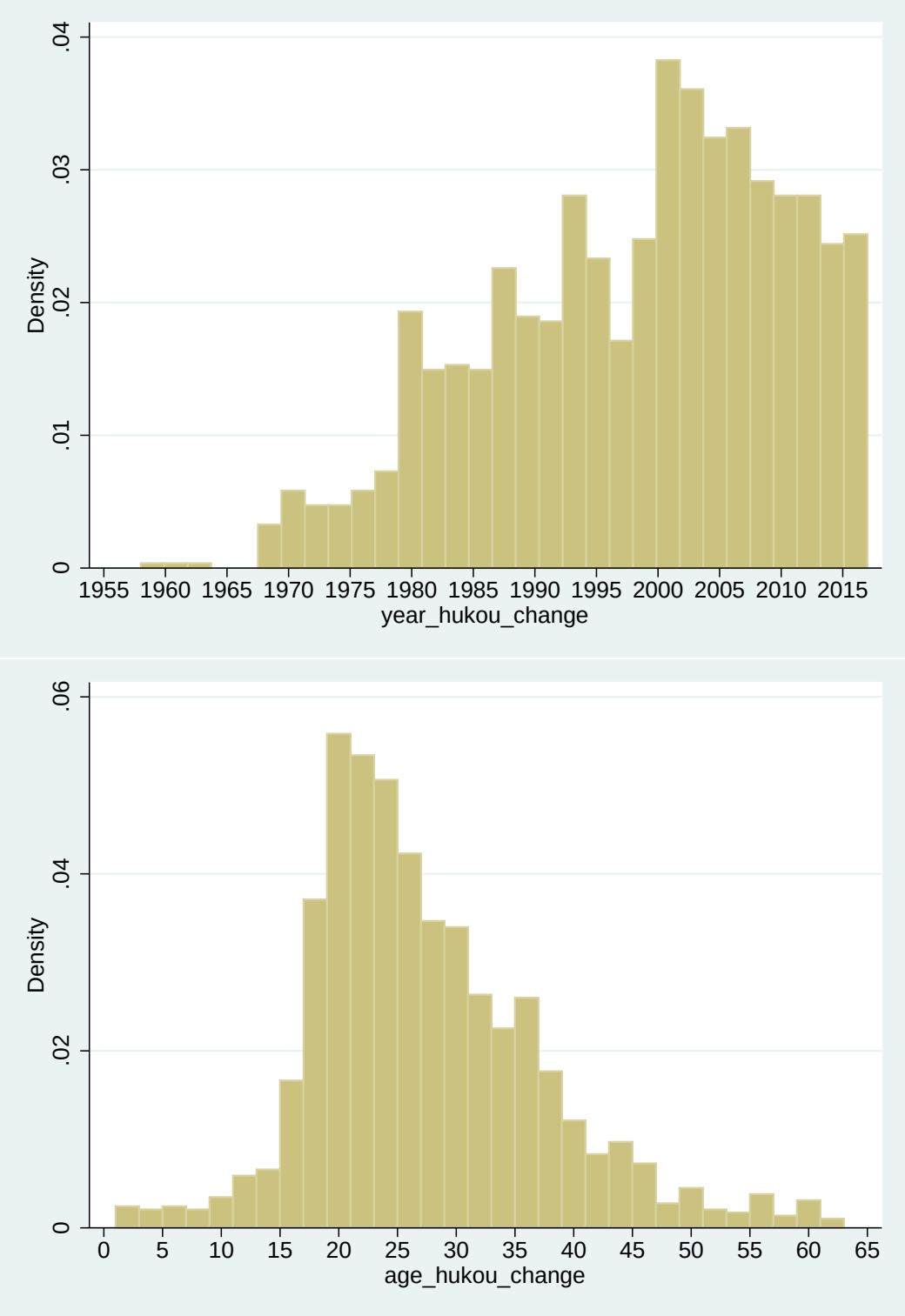
C Modeling Details

C.1 The Decision Problem of Migrants

Next, consider the consumption decisions of a household that decides to migrate to a different city. There are two decisions that the household must take. First, the household needs to decide where to relocate. Second, the household needs to decide whether to take the child with them ($c = 1$) or leave it behind ($c = 0$). The trade-off here is the following. If the parent leaves the child behind, the parent has lower housing needs and faces lower mobility costs. However, a child's achievement is potentially lower if schools are better in the destination city.

We capture the disadvantages of migrants without urban residency status using wedges. 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 $\Delta^o_{jk} \leq 1$. Effectively, migrants have to pay higher housing prices and their children obtain a lower quality education than residents. Lower quality education can be modeled straight forward as discussed below.

Figure 1: Distribution of Age and Year of Rural-Urban Hukou Change



The decision problem of a migrant of skill type k that was born in location i, has chosen to move to location $j \neq i$, brings the child along ($c = 1$) and has not received urban residency status can be written as:

$$\begin{aligned} \max_{b,h} \quad & U(a, b, c = 1, h, \Delta^o_{jk}\, o, \omega_j) \\ s.t. \quad & p_j h \; + (1 + t^b)\; b = (1 - t^w_j)\; w_{jk} \; + \; p_i \; e_{ik} \\ & a^{n,1}_{ijk} = a(\Delta^g_{jk} g_j, s_k) \end{aligned} \tag{30}$$

Similarly, the decision problem of a migrant of skill type k that was born in location i and that has chosen to move to location $j \neq i$, does not bring the children along ($c = 0$) and has not received urban residency status can be written as:

$$\begin{aligned} \max_{b,h} \quad & U(a, b, c = 0, h, \Delta^o_{jk}\, o, \omega_j) \\ s.t. \quad & p_j h \; + (1 + t^b)\; b = (1 - t^w_j)\; w_{jk} \; + \; p_i \; e_{ik} \\ & a^{n,0}_{ijk} = a(g_i, s_k) \end{aligned} \tag{31}$$

Solving these decision problems, we obtain the optimal demand for housing and other goods along the lines we discussed above. In the case of the Stone-Geary utility function, we obtain:

$$\begin{aligned} h^{n,c}_{ijk} &= \frac{\beta^c}{p_j}[(1 - t^w_j)\; w_{jk} \; + \; p_i \; e_{ik}] + (1 - \beta^c)\underline{h^c} \\ b^{n,c}_{ijk} &= \frac{1 - \beta^c}{1 + t^b}[(1 - t^w_j)\; w_{jk} \; + \; p_i \; e_{ik} - p_j \underline{h^c}] \end{aligned} \tag{32}$$

The main difference here is that migrants face higher housing prices than residents. Also, children of migrants that move from lower-tier to higher-tier cities obtain lower achievement than the children of residents holding parental skills constant since they are either educated at home or attend a school in the destination city that is of lower quality.

Some migrants obtain residency rights when they move. The decision problem of a migrant of skill type k that was born in location i, has chosen to move to location $j \neq i$, brings the

child along ($c = 1$) and has received urban residency status can be written as:

$$\begin{aligned} \max_{b,h} \quad & U(a, b, c = 1, h, o, \omega_j) \\ s.t. \quad & (1 - s_j^h)\, p_j h \; + (1 + t^b)\, b = (1 - t_j^w)\, w_{jk} \; + \; p_i\, e_{ik} \\ & a_{ijk}^{y,1} = a(g_j, s_k) \end{aligned} \tag{33}$$

Similarly, the decision problem of a migrant of skill type k that was born in location i and that has chosen to move to location $j \neq i$, does not bring the children along ($c = 0$) and has received urban residency status can be written as:

$$\begin{aligned} \max_{b,h} \quad & U(a, b, c = 0, h, o, \omega_j) \\ s.t. \quad & (1 - s_j^h)\, p_j h \; + (1 + t^b)\, b = (1 - t_j^w)\, w_{jk} \; + \; p_i\, e_{ik} \\ & a_{ijk}^{y,0} = a(g_i, s_k) \end{aligned} \tag{34}$$

Solving these decision problems, we obtain the optimal demand for housing and other goods along the lines we discussed above. In the case of the Stone-Geary utility function, we obtain:

$$\begin{aligned} h_{ijk}^{y,c} &= \frac{\beta^c}{(1 - s_j^h) p_j}[(1 - t_j^w)\, w_{jk} \; + \; p_i\, e_{ik}] + (1 - \beta^c)\underline{h^c} \\ b_{ijk}^{y,c} &= \frac{1 - \beta^c}{1 + t^b}[(1 - t_j^w)\, w_{jk} \; + \; p_i\, e_{ik} - (1 - s_j^h)\, p_j \underline{h^c}] \end{aligned} \tag{35}$$

Notice that the children of migrants with Hukou obtain the same education as children of residents ($a_{ijk}^{y,1} = a_{jk}^r$).

C.2 Housing Demand

The different terms of the aggregate housing demand are given by:

$$H_j^{dr} = \sum_{k=1}^{K} n_{jk}^r\, h_{jk}^r \tag{36}$$

$$H_j^{dn} = \sum_{k=1}^{K} \sum_{c=0}^{1} \sum_{l \neq j} n_{ljk}^{m,c}\, (1 - r_{jk})\, h_{ljk}^{n,c} \tag{37}$$

$$H_j^{dy} = \sum_{k=1}^{K} \sum_{c=0}^{1} \sum_{l \neq j} n_{ljk}^{m,c}\, r_{jk}\, h_{ljk}^{y,c} \tag{38}$$

C.3 Skill Accumulation

We use the following specification to capture the law of motion of skills conditional on achievement:

$$Pr\{s'_{jk} = \text{high-skill} \mid a_{jk}\} \;=\; \frac{\exp((a_{jk} - 14)/\sigma_a)}{1 + \exp((a_{jk} - 14)/\sigma_a)} \tag{39}$$

D Model Fit: Revenues and Expenditures

The table below shows that our model fits the observed fiscal revenue shares and the per capita expenditures for education and other public goods.

Table 15: Model Fit: Revenues and Expenditures

	Revenue Shares					
	Income Tax		Housing Tax		Transfers	
	Data	Model	Data	Model	Data	Model
Tier1	0.34	0.39	0.35	0.34	0.31	0.26
Tier2	0.24	0.37	0.45	0.22	0.31	0.41
Tier3	0.16	0.24	0.28	0.20	0.56	0.56
	Expenditures					
	Education Exp Per Capita		Education Quality	Other Exp Per Capita		Other Quality
	Data	Model	Model	Data	Model	Model
Tier 1	200	180	214	1093	974	1132
Tier 2	73	79	97	413	426	554
Tier 3	50	50	62	264	251	342
Rural	24	27	22	93	101	101