Of Cities and Slums*

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Abstract

The emergence of slums is a frequent feature of a country's path toward urbanization, structural transformation, and development. Based on salient micro and macro evidence from Brazilian labor, housing, and education markets, we construct a simple dynamic model to examine the conditions for slums to emerge. We use the model to determine whether slums are barriers or stepping-stones for the ascension of low-skilled households and the development of the country as a whole, exploring the dynamic interaction of slums, housing costs, and sectoral productivities with the human capital formation and structural transformation of a country. We calibrate our model to Brazilian data and use it to conduct counterfactual experiments. We find that cracking down on slums could slow the acquisition of human capital at the lower-end of the distribution, slow the growth of formal cities (outside slums) and induce the formation of even larger slums in the future. We find that the impact of housing costs in the city depends crucially on the human capital distribution of the country. Finally, procuring access to city schools for slum-dwelling children would eventually result in larger cities and smaller slums.

Keywords: *Human capital formation; School locations; Occupations; Structural transformation.*

JEL Codes: O15, O18, O64, R23, R31.

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"The new residents brought garbage, bins, mongrel dogs... poverty to desire wealth...legs for waiting for buses, hands for hard work, pencils for state schools, courage to turn the corner and...asses for the police to kick". Paulo Lins, City of God: A Novel

1 Introduction

This paper studies the causes and consequences of urban slums along the structural transformation of countries.[1,2] We explore the conditions on education, labor, and housing markets that lead to the emergence and persistence of urban slums as equilibrium outcomes.[3] Then, we explore whether slums are barriers or stepping-stones for the ascension of low-skilled households and for the development of the country as a whole. To answer these questions, we construct a growth model with endogenous skill formation, structural transformation, and urbanization. The model is based on salient micro and macro aspects of the Brazilian data. We use the model to analyze the interaction between the country's distribution of human capital, sectoral productivities and housing costs that lead to the emergence of slums. Then, we examine the resulting evolution of human capital formation and structural transformation under different initial conditions and alternative housing and education conditions. Our calibrated model replicates the observed rise of slums, urbanization, sectoral employment, and education distribution observed in Brazil from 1950 to 2010. We use the calibrated model to conduct counterfactual experiments, such as policies that crack-down on slums, reduce housing barriers, or integrate the schools of rural areas, cities and slums.

We document a number of salient aspects of the Brazilian data on structural transformation, urbanization, and slum formation as well as earnings and education in different locations. We use macro data, such as the evolution of the population through the years across locations (i.e., urban and rural and slums and cities proper), and across employment sectors. We also use micro data, such as relative income differences, housing costs, access to employment and education opportunities, and education outcomes (in the form of intergenerational transitions of schooling attainment levels). Three features stand out in the Brazilian experience. First, living in a slum imperfectly circumvents the housing costs of the city. It gives the adults in a household access to the urban labor markets at large, but this access comes with direct costs, as highlighted by our opening quote from Lins. More importantly, it reduces the schooling options for children to the slum itself or its near vicinity. Second, the location of households has a very large impact on the education attainment of their children. We find that marginal urban areas are much worse than the main city with respect to education attainment but far superior to rural areas. Third, city housing costs are much higher than those in rural areas, precluding some low-skilled households from entering the city.

We construct a general equilibrium model around these micro observations. The model can be used to analyze *(i)* structural transformation, *(ii)* urban development, *(iii)* the country's distribution

[1] For studies on structural transformation, see Duarte and Restuccia (2010), Herrendorf, Rogerson, and Valentinyi (2014), Herrendorf and Valentinyi (2012), Herrendorf and Schoellman (2017), and Silva and Ferreira (2011).

[2] Data from UN Habitat indicate that in Argentina, Brazil, Peru, Uganda and Irak, the urban slum population was higher than the entire population in rural areas. For the years 1990–2007, the simple average of LDCs in their sample was around 18%–20% of the entire population in urban slums, and across all the countries in their sample, 1.91 billion persons live in urban slums. The data were taken from "Housing, Slums and Informal Settlements", UN Habitat, https://data.unhabitat.org/pages/housing-slums-and-informal-settlements.

[3] Urbanization has rarely been a smooth process. The story of the world's leading cities (e.g., London, Paris, New York, Tokyo) cannot be told without paying attention to the rise, expansion, and eventual fall of their slums, as well as to the lives of their dwellers and the advancement of their descendants. For example, see Anbinder (2001) for an engaging account of the life stories of some residents of Five Points, one of New York's most prominent slums in the 19^{th} century. More recently, since World War II, many developing countries have transitioned from rural to urban economies, with quite different experiences. For example, the urban population in South Korea moved from only 28% in 1960 to 93% in 2010; in Brazil, the same population increased from 36% in 1950 to 85% in 2010. Urban slums in Korea have all but disappeared; in Brazil, they have grown substantially.

of human capital, and, to some extent, *(iv)* social mobility. Ours is a discrete-time, infinite-horizon economy populated by dynasties of two-period-lived individuals with a cross-sectional distribution of skills that endogenously evolve over time. There are three goods, agricultural, nonagricultural goods (encompassing a construction sector), and personal services, and three occupations: an unskilled rural occupation and routine or non-routine occupations. The market-clearing price of goods and the earnings across occupations and skills are driven by non-homothetic preferences as used in recent models of structural transformation. In equilibrium, the skill population is endogenously sorted across the locations of the country, and the human capital formation of children is determined by the average human capital in each location. Altruistic parents take into account the human capital formation of their children at the time they choose their location of residence. To live in the city proper, a household needs to pay for a house, a fixed cost whose level is determined in equilibrium. Slums offer the option of entering urban labor markets while avoiding housing costs, but this option involves a utility cost, which varies directly with the household's earnings, and inferior schooling options for the children.

A calibration of our model replicates the observed rise of slums, the expansion of the urban population, and the changes in the distribution of workers across employment sectors and education levels observed in Brazil from 1980 to 2010. We use the model as a basis for counterfactual exercises on potential policies that drive housing decisions and schooling outcomes. First, we find that cracking down on slums could slow the acquisition of human capital in the lowend of the distribution, slow the growth of cities proper (outside slums), and induce the formation of even larger slums in the future. Second, we find that housing costs can reshape the urban configuration of a country, but their impact in the city depends crucially on the human capital distribution of the country. Third, we show that giving slum-dwelling children some access to schools in the city would initially exacerbate the formation of slums, but would eventually lead to larger cities and smaller slums as a result of a higher skill formation in the lowerend of the urban distribution.

Our paper is connected to the extensive literature on structural transformation by focusing on the reallocation of workers from agricultural occupations to urban occupations.[4] Recently, Duarte and Restuccia (2010) study the role of sectoral labor productivity in structural transformation for the trajectory of the aggregate productivity of 29 economies. Duarte and Restuccia (2010) note that the catch-up of productivity (relative to the U.S.) in manufacturing can account for about half of the productivity gains. As a counterpart, the low productivity and lack of catching up of the service sector explains cases of stagnation and decline, which is consistent with our emphasis on the expansion of low-skill services to explain the low growth in productivity in the Brazilian economy. In this aspect, our work is closest to Silva and Ferreira (2015), who look at six Latin American countries during the period 1950-2003. Silva and Ferreira (2015) use a four-sector model (agriculture, manufacturing, modern services, and traditional services) and conclude that the expansion and poor productivity of the traditional services sector is a major source of the slowdown in productivity growth after the mid-1970s in Latin America. By highlighting the expansion of low-skilled workers in urban occupations, we provide a contrapositive result to that of Buera and Kaboski (2012) and Buera et al. (2021), who find that the growth in output per worker for developed and fast-growing developing countries is mostly accounted for by the expansion of high-skill service sectors. With our model, we examine the conditions under which a country's urbanization and structural transformation is directed to high-skill or low-skill urban jobs.

Our paper is connected to the extensive literature on urbanization and development.[5] Much empirical work has studied the forces that "pull" migrants to urban destinations (e.g., better economic opportunities and better amenities and public services, including schools), as well as the

[4] For a recent review of the structural transformation literature, see the handbook chapter by Herrendorf, Rogerson, and Valentiny (2014).

[5] For a recent review of urbanization and development, see the handbook chapter by Brueckner and Lall (2015).

forces that "push" migrants away from rural areas (e.g., low productivity in agriculture, environmental changes, and lack of access to basic public services). For Brazil, Lall et al. (2009) find that wage differences are the main factor driving migration but also that access to basic public services matters a lot. Indeed, Lall et al. (2009) find that poor households are willing to accept lower wages in order to get access to better amenities.[6] These findings are consistent with the equilibrium of our model, where the marginal migrants, in both slums and cities, would sacrifice some income in order to access better schools for their children.

We emphasize the role of urbanization in a country's accumulation of human capital, as in Lucas (2004). Our most substantial difference with Lucas (2004) is that the learning opportunities in urban areas are fragmented between cities and slums. Thus, our paper is related to Benabou (1996), Durlauf (1996), Fernandez and Rogerson (1998), Fogli and Guerrieri (2019), and others, who examine the fragmentation of schools within urban areas. While part of our analysis and policy counterfactuals are similar to those papers, our goal here is on the causes and consequences of slums with respect to the development of countries. For example, with Fogli and Guerrieri (2019) we share an interest in the allocation of urban households between poor and richer urban areas and the implications for children's human capital formation. But a key margin in our analysis is also the size of urban areas, which in our model is endogenous. For us, the key issues are not only the allocation of households between the city and its slums, but also the allocation between these two locations and the countryside.

On whether slums are barriers or stepping-stones, the experience of developed countries would suggest that slums are stepping-stones, a temporary phase in the urbanization of countries. Slums were pervasive during the Industrial Revolution in European cities and in the surge of American cities (e.g., London and New York). Before giving way to formal and even refined parts of their cities, those slums were the playground of children whose descendants were to become some of the country's most prominent academic, cultural, and entrepreneurial leaders.[7] In contrast, on the basis of the more recent experience of developing countries, authors such as Marx, Stocker and Suri (2013) conclude that slums are poverty traps driven by policy failures, government neglect, housing restrictions, low human capital accumulation, and low levels of public and private investments.[8] In this vein, Cavalcanti et al. (2019) construct a structural general equilibrium static model and show how urban poverty, rural-urban migration, and land-use regulations affected the growth of slums in Brazil between 1980 and 2000.

Our paper complements the work of these authors along multiple dimensions. First, we empirically explore the intergenerational transition probabilities in education attainment for households located in rural areas, urban slums, and cities. We indeed find evidence that relative to the city, slums act as barriers for the human capital accumulation of their children. However, relative to the rural areas, slums provide a valuable stepping-stone, one which can substantially improve the odds that, after two or three generations, some of the descendants of a low-skill household would attain high levels of education and earnings. Second, we construct a simple dynamic general equilibrium model that can be used to explore the conditions under which the path of structural transformation involves the formation of slums. We show that a simple calibration of the model can replicate salient features of the Brazilian experience. Third, we use the model to conduct policy counterfactuals, such as restricting the formation of slums, reducing the cost of housing, and integrating the schools of the city with those of the slums and the rural areas. In doing so, we explore the implications not only for the different individuals but also for the country as a whole.

[6] Along the same lines, for Nepal, Dudwick et al. (2011) find that migrants are most attracted to destinations with better access to schools, hospitals, and markets.

[7] See the discussions in Frankenhoff (1967), Turner (1969), and Glaeser (2011). For vivid descriptions of the slums in New York, see Riis (1970) and Anbinder (2001).

[8] See the extensive policy discussions in Annez et al. (2009), Hammam (2013), and Lall et al. (2007).

In our model, the emergence of slums is driven by housing costs in the cities. Therefore, we connect to a rich literature on the reallocation costs of labor across cities (e.g., Demset et al., (2016) and Hsieh and Moretti (2015)) and on the sorting of skills across multiple cities (e.g., Eeckhout et al. (2014)). Differing from those papers, however, we focus on the urbanization that takes place in the early stages of development, when much of a country's labor is still in agriculture. To do so, we abstract from the rich geographic aspects in some of those papers and instead center our attention on the location decisions of rural-urban migrants with low human capital.

The paper is organized as follows. Section 2 underlines a number of salient facts about the structural transformation, urbanization, and emergence of slums in Brazil. Section 3 sets out our model and defines an equilibrium. Section 4 characterizes the equilibrium allocations, explores the conditions for the emergence of slums, and analyzes the impact of slums on the structural transformation of a country. Section 5 calibrates our model to the Brazilian experience from 1950 to 2010 and explores a number of counterfactual experiments. Section 6 concludes. An appendix includes additional details of our data, provides a brief historical overview of the slums in Brazil, and contains the proofs.

2 Urbanization and *Favelas* in Brazil

The term *favelas* emerged in the 1890s to designate the slums formed in Rio de Janeiro by displaced soldiers of the War of Canudos.[9] Since then, slums have been growing in their prominence for Brazil's growth, structural transformation, and urbanization. We argue that slums are also crucial for understanding inequality, social mobility, and human capital formation of the country. This section overviews the Brazilian experience, focusing on the formal education and labor market characteristics of the population living in urban slums. We also examine data on the workings of slums in terms of labor market access, housing costs, and, most importantly, the impact of living in a slum on the educational attainment of the children living there.

We first describe our data sources.[10] Then, we briefly discuss the macro patterns of urban slum formation along with the urbanization and structural transformation in Brazil. Next, we describe key selection patterns in the composition of the population living in the slums relative to the rural areas and formal cities. We continue by analyzing the barriers to entry into formal cities, specifically housing price differences between rural areas, urban slums, and formal cities. Then, we examine the workings of slums. Here, we explore data on the labor and education choices and outcomes of adults and children, respectively. First, we explore micro data from slums in Rio de Janeiro and find insightful differences between the school access of the children living in the slums relative to the labor market of the adults in their households. Second, we find that Census and intergenerational data suggest large and asymmetric differences in the consequences of living in slums for the children of parents of different education groups.

On the whole, the essential workings of urban slums in Brazil lies in providing access to lower-skilled households to the overall urban labor markets but to segmented education opportunities of their children. We argue that slums are both stepping-stones and blockades for human capital formation. On the one hand, for lower-education households the evidence suggests that slums are stepping-stones for their children, as their prospects there are superior to those in rural areas. On the other hand, the evidence suggests that for children of higher-education households, slums are blockades and they would fare better by remaining in rural areas. Of course, these comparisons are mediated with the costlier but superior option of living in the formal cities, which we examine in

[9] *Favela* is a flowering plant that was abundant in the hills where these first slums were located. For more details about the history of slums in Brazil, see Appendix B.

[10] Additional details are in Appendix A.

the subsequent sections using a general equilibrium model.

2.1 Data Sources

We combine data from multiple sources. The *Brazilian Census* from the Brazilian Institute of Geography and Statistics (IBGE) contains data on the distribution of the population across rural and urban areas, and across levels of education and personal income, occupations and sectors of employment.[11] The Census also contains data on the school attendance of school-age children. The Household Survey, *Pesquisa Nacional por Amostra de Domicílio* (*PNAD,)* provides data on the intergenerational transitions of education levels for households. Conducted annually since 1976, in 1988 and 1996 the PNAD includes a special supplement with information about the education levels of the parents of the household, both head and spouse. From it, we trace the intergenerational transition probabilities of education levels for different urban and rural regions. Employment by sectors and other aggregate data were taken from the the National Accounts (from IBGE) and the Brazilian Census.

We use two main data sources on slums. Our first source is the Brazilian Census itself. In the Census for the years 1991 and 2000, the IBGE included a question about whether households live in a *"subnormal agglomerate."* The IBGE defines a subnormal agglomerate as a set of 51 or more contiguous housing units that are characterized by the absence of a proper ownership title and at least one of the following two aspects: *(i)* irregular traffic routes or land plots of irregular size or shape; or *(ii)* lack of essential public services, such as garbage collection, a sewage system, electricity, and public lighting. This definition is close to the definition of "slums" employed by the UN Habitat, which does not require the household to be in an agglomerate.[12] Our second main source is the *Favela Census* conducted by the state government of Rio de Janeiro in 2010.[13] This initiative is unique in the country and collects information on the households residing in Alemão, Manguinhos, and Rocinha, three of the most prominent slums in Rio. The Favela Census contains data on the access to labor markets and schools for households living in urban slums.[14,15] We complement the information from these datasets with information published in other studies.[16]

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[11] Since 1950, the Census has been conducted every 10 years by the IBGE. See Instituto Brasileiro de Geografia e Estatistica, www.ibge.gov.br/english/. The Census for 1990 was conducted in 1991.

[12] UN Habitat defines a slum household as a group of individuals living under the same roof and lacking one or more of the following amenities: (i) access to improved water; (ii) access to improved sanitation; (iii) sufficient living area; (iv) durability of housing; or (v) security of tenure.

[13] For more details, see *www.emop.rj.gov.br/trabalho-tecnico-social/censos-comunitarios.*

[14] For Complexo do Alemão, we have 69,586 responses out of an estimated population of 89,912. For Complexo do Manguinhos, we have 27,073 responses out of 31,535 residents. For Complexo do Rocinha, the numbers are 73,410 respondents out of an estimated population of 98,319.

[15] There is reassuring evidence that these three large slums in Rio represent well the population living in other urban slums in Brazil. For starters, Alemão, Manguinhos and Rocinha account for 10.4% of the entire slum population of Rio de Janeiro, according to 2010 census data. When comparing Alemão and Rocinha to the slums in the six largest metropolitan regions of the country using data from the 2000 census, we find that the average years of schooling in the former, 5.2 years, is very close to that in the latter, 5.1, and considerably smaller than the education of an adult that does not live in a slum in the same areas (8.9 and 7.1, respectively). Likewise, the shares of adults with one or less year of education in these two slums and in all slums of the six largest metropolitan regions are also very close (26.8 and 27.5, respectively). In both Alemão and Rocinha and in the six metropolitan regions, a slum worker earns only 31% of a non-slum worker in the same region. Finally, the share of people living in extreme poverty in both regions is high (26% and 35%, respectively) and twice as large as in the corresponding non-slums areas.

[16] The 1950 Census has a supplement with detailed information about slums in Rio de Janeiro. The Instituto Pereira Passos, a statistical bureau in Rio de Janeiro, has a number of tables slums in 1960. Magalhaes (2010) also discusses the broad historical behavior of urban slums in Brazil.

2.2 Urbanization and the Emergence of Slums

Like other countries during the 20th century, Brazil experienced a large-scale reallocation of its population from rural to urban areas, most markedly towards the end of the century.[17] From being predominantly rural and agricultural in 1950, the country transitioned to a mostly urban economy. Employment outside agriculture steadily increased from 36% in 1950 to 60% in 1980 and to 84% in 2010. At a superficial level, the country's structural transformation and urbanization conforms with the broad historical patterns observed in most advanced countries at the onset of their development.[18] Yet, two salient aspects in the evolution of Brazil –and of other countries– are often overlooked in the urbanization and structural transformation literatures. First, much of the expansion of employment outside agriculture was driven by low educated workers that migrate to the urban areas to provide low-skill services. Second, much of the urbanization was driven by an expansion in the urban population living in marginalized or informal housing, slums.

For low-skill rural-to-urban migrants in Brazil, living in a slum has consistently been a pertinent option. According to Magalhães (2010), the percentage of the total urban population in Rio living in favelas was already 7.0% in 1950, climbing steadily to 10.2% and 13.3% in 1960 and 1970, respectively. For much of those years, Rio was the main urban location of the country. Since 1960, with Brasilia founded as the country's capital, São Paulo started to grow faster than Rio, eventually overtaking it both as the main city and as the main destination for slum dwellers in the country.

Indeed, for Brazil as a whole, urban slums have been persistent, growing and widespread. Table 1 illustrates the fact that slums are present in all the main cities of Brazil.[19] For 1991 and 2000, Table 1 shows that the share of *favelas* for Salvador (northeast of the country) and Belo Horizonte (southeast) is similar to that in São Paulo. Even in smaller cities such as Belém, a city located in the north of the country and the 11^{th} largest city in Brazil, the prevalence of urban slums can be quite large. Slums have grown rapidly since 1991 in Rio and in São Paulo. In the latter, the share of the urban population living in slums grew more than 2.5 times between 1991 and 2010.[20] According to IBGE (2011), 4 million individuals were living in slums in São Paulo and Rio de Janeiro for 2010.

Table 1: Urban Population Living in Slums (%)

	Cities				
Year	Rio de Janeiro	São Paulo	Salvador	Belo Horizonte	Belém
1991	17.4	9.2	10.1	14.2	25.8
2000	18.5	11.1	9.6	12.3	34.6
2010	22.0	23.2	N/A	N/A	N/A

Source: Brazilian Census, IBGE (2011).

To be sure, internal migration flows have been largely directed towards Rio and Sao Paulo. Respectively, these cities account for 15% and 16% of all internal migrants in the country, while the

[17] The World Bank (2008) estimates that in the 1960s alone, 40 million Brazilians migrated to the larger cities.

[18] In terms of sectoral productivity and output growth, from 1950 to 1980, Brazil also exhibited the standard patterns highlighted in the literature. Labor productivity outside agriculture was consistently much higher than labor productivity in agriculture, and so the sustained reallocation of workers from agriculture to non-agriculture was a significant factor for the overall growth of Brazil. Silva and Ferreira (2011) find that 45% of the 1950-1980 growth in Brazil is accounted for by labor reallocation across sectors.

[19] See Pearlman (2010).

[20] The growth is even more impressive in absolute terms, since São Paulo's total population has grown rapidly too. There was a methodology change in the accounting for "aglomerados subnormais" in the 2010 census, although its definition did not change. Krause, Mation, and Nadalin (IPEA, 2014) estimate that the 2000 census may have underestimated the share of slum residents in many large cities of Brazil (less so in Rio de Janeiro), so that the table might overestimate the growth of slums in São Paulo. It is unlikely that the corrections would revert the main conclusion that slums grew substantially and continuously during the period.

other metropolitan areas received less than 4% each.[21] [22]

At the individual level, inhabitation in slums is also persistent, i.e., slums are not temporary ports of entry for rural families that quickly transit to the city proper. Table 2 shows that despite the fast growth in the slum population, a very high share of those living in favelas in 1991 grew up there. The ratio of migrants-to-population are slightly higher for slums than for the formal part of cities, e.g: 19.3% for slums and 18.8% for formal cities for the country as a whole, but the key message is that the descendants of the first rural-to-urban migrants tend to stay in the location where their ancestors entered, whether cities or slums.[23]

Table 2: Origin of Migrants, 1991 (%)

	Brazil		São Paulo		Rio de Janeiro	
	Slums	City	Slums	City	Slums	City
Migrants/Population	19.3	18.8	20.6	9.4	7.1	6.3
from Rural Areas/Migrants	34	22.4	41.1	27.4	35.6	15.8
from Urban Areas/Migrants	66	77.6	58.9	72.6	64.4	84.2

Source: Brazilian Census, IBGE.

In terms of origin, notice that the shares of rural migrants are much higher in the slums than in the formal cities. Slums appear as a major destination for rural families, which is a key aspect for the regional allocation of the skills of the country as we now discuss.

2.3 The Skill Composition of Cities and Slums

We now use census data for the cities of Rio and São Paulo and for Brazil as a whole. We examine the allocation of households across three broadly grouped locations: rural areas, urban slums, and formal cities. We uncover a clear ordering in the spatial sorting of households across these types of locations. Specifically, the cross-section education attainment distribution in formal cities dominates –in the first-order sense– the distribution in urban slums, and the distribution in the slums dominates that in the rural areas. Similar patterns are also observed in terms of occupation sectors and labor earnings. However, after controlling for education levels, the data suggests a much less sorting between cities and slums.

Table 3 draws Census data for 1991 on the regional cross-sectional distributions of school attainments.[24] For the whole country, columns 2 and 3 show the results for rural and urban areas, while columns 4 and 5 show them for formal cities and slums. For São Paulo, columns 6 and 7 report the distributions for the formal city and the urban slums. Columns 8 and 9 do the same for Rio de Janeiro. The table clearly shows that rural areas are predominantly populated by the very low educated, slums are predominantly populated by the low- to medium-educated, and formal cities are populated by more educated individuals. For rural areas, almost 40% of the residents are illiterate and more than 80% have at most four years of schooling. For slums, the households

[21] Belo Horizonte received only 3.8% of the total migrants, and Belém received 0.9%.

[22] There was a methodology change in the accounting for "aglomerados subnormais" in the 2010 census, although its definition did not change. Krause, Mation, and Nadalin (IPEA, 2014) estimate that the 2000 census may have underestimated the share of slum residents in many large cities of Brazil (less so in Rio de Janeiro), so that the table might overestimate the growth of slums in São Paulo. It is unlikely that the corrections would revert the main conclusion that slums grew substantially and continuously during the period.

[23] Because of data restrictions, migrants are defined as those individuals who were born in a city different from where they live by the time of the survey (1991) in the last 10 years. We only have data about the origin of the migrants (rural or urban areas) for those who migrated in the last 10 years. If we consider migrants who were born in a different city, the percentage of migrants in the total population is 40.3 in formal cities and 41.1 in slums for the whole country; 26.7 in the formal city and 29.8 in slums for the city of Rio de Janeiro; and 36.9 in the formal city and 48.2 in slums for the city of São Paulo.

[24] Similar patterns hold for 2000.

with one to eight years of education account for around 72% of their population. For formal cities, the dominant groups are individuals in the higher groups (i.e. 5-8, 9-11, and 12 or more years of schooling). These three groups account for more than 54.3% of the population in all cities of the country and 64.4% and 73.9% for São Paulo and Rio de Janeiro, respectively. The share of 12+ years of education in formal cities is an order of magnitude higher than in the slums and rural areas. All the shares are similar for Brazil as a whole as well as the main cities.

Table 3: Population Distribution by Years of Schooling, 1991 (%)

	Brazil				São Paulo		Rio de Janeiro	
Years of Schooling	Rural	Urban	City	Slums	City	Slums	City	Slums
0	36.1	11.7	11.2	19.6	6.4	22.1	3.9	15.0
1 to 3	26.9	15.5	15.0	22.6	9.4	24.2	6.8	18.5
4	20.4	19.5	19.4	21.2	19.8	21.7	15.4	23.3
5 to 8	12.3	27.5	27.5	28.0	28.8	27.1	25.7	30.6
9 to 11	3.8	17.8	18.4	7.6	20.7	4.2	28.3	11.1
12 or +	0.6	8.0	8.4	0.9	14.9	0.8	19.9	1.5
Average Schooling years	2.7	6.0	6.1	4.7	7.4	3.7	8.5	4.8

Source: Brazilian Census.

Regional sorting in terms of education is even clearer from the average years of education perspective: inhabitants of rural areas have an average of 2.7 years of schooling. In the slums of Brazil, São Paulo, and Rio, the same averages are 4.7, 3.7, and 4.8, respectively. In the formal cities, the averages are substantially higher – 6.1, 7.4, and 8.5 years of education – for Brazil, São Paulo, and Rio, respectively.

Along with education, the data shows regional sorting by occupations and employment sectors. Table 4 also uses data from the census to break down the employment shares by locations.[25] Here the focus is comparing formal cities and urban slums, hence we look only at the urban populations of Brazil as a whole and for the two leading cities. We classify workers according to the production sectors. Here, *Agriculture* includes mining; *Manufacturing* includes construction; *Low-skill services* includes personal services (e.g., housekeeping, retail, transportation, restaurants, etc.); *High-skill services* includes health, education, government, and financial services.[26]

Table 4: Employment Distribution by Sector , 1991 (%)

	Brazil		São Paulo		Rio de Janeiro	
	Slums	City	Slums	City	Slums	City
Agriculture	2.8	7.4	0.9	1.2	1.1	1.4
Manufacturing	35.1	27.6	41.2	31.1	29.3	18.5
Low-skill services	44.7	35.3	42.8	33.8	48.7	34.0
High-skill services	16.6	29.1	14.2	32.9	20.3	45.7
Not defined	1.0	0.6	1.1	1.0	0.7	0.4

Source: Brazilian Census.

Low-skill services are crucial to understanding the urbanization and structural transformation of Brazil. Table 4 shows that low-skill services account for a large share of employment in slums and cities, but that high-skill services are much more likely to live in the formal cities. In sum, Tables 3 and 4 indicate that for the lower-education workers, employment is dominated by manufacturing

[25] For brevity, here we review the patterns for 1991, but those for 2000 are very similar.

[26] Silva and Ferreira (2011) show that this classification correlates closely with the education levels of the workers in the sectors. Classifying occupations into "Routine" and "Non-routine" as in Autor, Levy, and Murnane (2003), we find that the personal service sector is composed mainly by routine occupations. Manufactures and high-skill services sectors employ routine and non-routine workers.

and low-skill service sectors and slums are observed as a more frequent location choice. For higher education workers, their employment tends to be dominanted by high-skill services sectors and the formal cities are the most relevant location options.

We now examine whether the sorting of individuals between formal cities and slums directly affect their labor market earnings. To this end, Table 5 computes the ratio of incomes between comparable workers in terms of education across locations.[27] For Brazil as a whole, columns 2-4 compare the ratios of average earnings of workers in all urban areas, formal cities, and slums, with respect to the average earnings of workers of similar education levels in the rural areas. Columns 5-6 do the same for workers in formal cities and slums, respectively for Rio de Janeiro, and columns 7-8 do the same for São Paulo.

Table 5: Total Income Ratios by Education and Location, 1991

	Brazil			Rio de Janeiro		São Paulo	
Education	$\frac{\text{Urban}}{\text{Rural}}$	$\frac{\text{City}}{\text{Rural}}$	$\frac{\text{Slum}}{\text{Rural}}$	$\frac{\text{City}}{\text{Rural}}$	$\frac{\text{Slum}}{\text{Rural}}$	$\frac{\text{City}}{\text{Rural}}$	$\frac{\text{Slum}}{\text{Rural}}$
0	1.6	1.6	1.6	2.1	1.7	2.8	2.7
1 to 3	1.6	1.6	1.3	1.7	1.3	2.7	2.0
4	1.9	1.9	1.3	2.0	1.4	2.9	1.8
5 to 8	1.8	1.9	1.3	2.1	1.3	3.0	1.9
9 to 11	1.6	1.6	0.9	1.8	0.9	2.5	1.2
12 or +	1.3	1.3	0.6	1.5	0.5	1.8	0.6

Source: Brazilian Census. Earnings averages for those who are 25 to 65 years old.

Except for small percentages of highly educated workers living in slums, urban workers earn substantially more than rural workers. Table 5 reports that urban individuals earn from 30% to 90% more than their rural peers. More interestingly, very low-skill workers seem to obtain similar income gains whether they migrate into slums or into formal cities. This is clearly true for Brazil as a whole and for the city of Sao Paulo but less so for Rio.[28] For the higher-education groups, the rural-to-urban gains tend to be lower and even negative for the highly educated living in an urban slum.[29] In the model developed in the subsequent sections, these patterns are explained by heterogenous labor market skills which, beyond education, drive the household selection between formal cities and slums.

2.4 Housing Costs as Barrier to Entry

Table 6 reports data from the 1991 census on the cost differences of renting an apartment. The table makes the same breakdown of the country and its two main cities as in the previous two tables, comparing the average rent costs of housing units grouped by their number of bedrooms.[30] Table 6 shows the urban-to-rural rents ratio (column 2) of Brazil and the city-to-rural and city-to-slum ratios for the cities of Rio (columns 3 and 4) and São Paulo (columns 5 and 6).

[27] Total income includes pensions; hence, some non-workers can be included here.

[28] This is also true for most large cities in Brazil, with the exception of Salvador, where incomes are about the same for people living inside slums and in rural areas.

[29] These lower ratios may be explained by the fact that some high-skilled workers can earn high incomes in rural areas (e.g., the town's doctor, lawyers, and school principals). Unobserved negative factors that explain why some highly schooled individuals end up living in a slum may also be associated with their lower incomes.

[30] Rent information from the Census is the only source of data on housing costs that is comparable between the different locations. Yet, it is subject to noise. Indeed, among people who live in rural areas, only 1.7% said they pay rent. This figure is 17.7% for the urban population. Regarding the city of Rio de Janeiro, for those living in slums, around 7.7% said they pay rent, while in the city proper the number is 24.3%. For São Paulo the percentages are 2.9% and 27.9%, respectively.

Table 6: Ratio of Monthly Rents, 1991

	Brazil	Rio de Janeiro		São Paulo	
# Bedrooms	Urban/Rural	City/Rural	City/Slum	City/Rural	City/Slum
1	2.0	3.2	1.8	3.5	1.5
2	2.3	3.5	1.9	4.7	2.0
3	2.9	4.8	2.7	6.5	2.6
Average	2.3	3.6	2.3	4.1	1.9

Source: Brazilian Census.

Two simple but fundamental messages emerge from the data. First, housing costs differences are quite substantial across different types of locations, especially between urban and rural areas. For Brazil as a whole, rents in urban areas are usually two to three times as expensive as in rural areas. This difference is stronger in Rio and even more so in São Paulo, where renting a three-bedroom housing unit costs 6.5 what it costs on average in rural areas. Second, housing costs are substantially lower in slums. Housing units in the formal cities can be more than twice as expensive as units with the same number of bedrooms in slums. On average, the city-slum ratios are around half of the city-rural ratios.

As expected, housing costs are substantial barriers to entry into urban areas. They determine the volume of rural-to-urban reallocation and the selection in terms of schooling and the labor market skills of those who migrate to the urban areas. Sidestepping the high housing costs in the formal cities by locating in a slum is a pertinent option for low-skill households to live and work in urban areas.

2.5 The Asymmetric Workings of Slums for Children and Adults

We now explore the labor market and education implications for households who live in urban slums. To this end, we turn to micro data from the Favela Census of Rio de Janeiro (2010) on households living in Alemão, Manguinhos, and Rocinha. We uncover a simple but very relevant asymmetry in the daily of a household living in a slum. On the one hand, despite additional costs and inconveniences, by locating in a slum adults get access to the labor markets in the overall urban area. On the other hand, by locating in a slum, parents are essentially circumscribing their children to the school options within the slums and the locations nearby.

Table 7 reports the job location for the adult residents in each of the three slums. Adults living in a slum work mostly outside the slum, in the formal parts of Rio. More than 6 out of 10 work well outside the slum, and adding those working outside but in the vicinity, raises the number to almost 8 out of 10. Despite some differences in the composition, in all the three slums only 1 adult out of 5 work inside the slum.[31]

Table 7: Job Location of Adults Living in Three Slums in Rio (%)

	Alemão	Manguinhos	Rocinha	All
Inside slums	22.7	22.4	22.0	22.4
In the close vicinity	15.7	19.3	6.9	13.9
Well outside slums	61.6	58.4	71.1	63.7

Source: Favela Census of Rio de Janeiro.

[31] The oldest favela, Rocinha, is favorably located in the proximity to affluent neighborhoods, Leblon and Ipanema, where retail stores and well-off households employ many low-skill workers. For this *favela*, we see a higher rate of employment outside the slum. On the other hand, Alemão and Manguinhos are much far away from rich neighborhoods. The difference is not whether they work inside the slums or outside, but more how far inside the formal city they find employment.

There is a stark contrast in the children's school location. Table 8 reports the location of the schools attended by elementary school-age children living those slums. Indeed, Table 8 shows that 7 out of 10 of those children go to schools inside their own slums or go to schools that are located less than one kilometer (two thirds of a mile) away. The number rises to more than 8 out of 10 if we consider schools that are three kilometers (two miles) away from the respective slum.[32] The table also shows heterogeneity across the three slums. The circumscription of children to schools within or near the slums is abundantly clear. This holds even for Rocinha, which despite its priviledged location exhibits that 7 out of 10 children end up in schools two miles or less away from the slum.

Table 8: School Location of Children Living in Slums in Rio (%)

	Alemão	Manguinhos	Rocinha	All
Inside slums	86.3	55.9	43.3	61.8
Outside: <1km away	8.9	21.3	0.5	10.2
Outside: 1-3km way	0.0	12.3	26.0	12.8
Outside: >3km	1.5	7.8	30.2	13.2
Could not locate school	3.3	2.7	0.0	2.0

Source: Favela Census of Rio de Janeiro.

Granting access to urban labor markets for adults while restricting children to schools and most formative interactions within or near slums is, in our consideration, an essential aspect of the workings of slums.

2.6 Locations, Schooling Attainment and Intergeneration Mobility

We now explore the education outcomes of children growing up in slums and the other two types of locations. First, we follow Paes de Barros and Mendonça (2000), in using the Brazilian Census to explore the school attendance of children as a function of their parent's education and the average education of the region. We extend the work of Paes de Barros and Mendonça (2000) by distinguishing among three types of locations: rural areas, urban slums, and formal cities. To this end, we use the Census of 1991, which contains explicit indicators for whether the household resides in an urban slum, but also indicates the education of the parents in the households and whether or not the school-age children are attending school.

Table 9 reports the results from probit regressions that relate a child's school attendance (1 if the child is attending school, 0 if not) with the average schooling of the adult women residing in the municipality and with the child's own mother's school attainment. Households are classified according to five groups of completed schooling years, specifically 0, $1-4$, $5-8$, $9-11$, and 12 or more years of education. To allow for different impacts of the location type (rural, slums, cities) across the parents' education groups, the probits are run on the product of location dummies with parental education group dummies. The table reports the estimates and standard errors for Brazil as a whole (columns 2 and 3) as well as for the states (estados) of Rio de Janeiro (columns 4 and 5) and São Paulo (columns 6 and 7).

[32] Using the school name available from the Favela Census, we codified the location of the school and complemented the information with the distance to the slum of the respondent.

Table 9: Probit Estimates, Attendance Frequency, School-Age Children

	Brazil		Rio de Janeiro		São Paulo	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Location's Average Schooling, Women	0.0931	0.0003	0.1170	0.0013	0.1155	0.0010
Mother with Schooling=0						
×Rural Areas	-0.3020	0.0012	-0.3444	0.0101	-0.2711	0.0055
×Urban Slums	-0.0375	0.0037	-0.0881	0.0121	-0.0076	0.0104
×City formal	0.2457	0.0015	0.1133	0.0081	0.1208	0.0051
Mother with Schooling:1-4						
×Rural Areas	0.1736	0.0013	0.1207	0.0098	0.1054	0.0049
×Urban Slums	0.3060	0.0033	0.2401	0.0107	0.1398	0.0089
×City formal	0.6683	0.0014	0.5358	0.0076	0.5416	0.0049
Mother with Schooling:5-8						
×Rural Areas	0.4592	0.0034	0.4484	0.0253	0.4340	0.0101
×Urban Slums	0.4338	0.0053	0.4032	0.0145	0.2352	0.0151
×City formal	0.8800	0.0020	0.7219	0.0087	0.7826	0.0056
Mother with Schooling:9-11						
×Rural Areas	0.8176	0.0060	0.7451	0.0444	0.9705	0.0234
×Urban Slums	0.6966	0.0112	0.4161	0.0254	0.9548	0.0578
×City formal	1.1836	0.0025	1.0049	0.0101	1.2262	0.0070
Mother with Schooling:12 or +						
×Rural Areas	0.9358	0.0151	1.6417	0.1738	1.1133	0.0364
×Urban Slums	0.6809	0.0337	-0.0726	0.0586	no data	no data
×City formal	1.3144	0.0037	1.1205	0.0130	1.4791	0.0091
pseudo-R^2	0.1296		0.0790		0.0852	
Number of Observations	1,632,074		103,472		310,467	

Source: Brazilian Census (1991).

The results in Table 9 suggest that a family's location strongly influences the education outcomes of children but also that the effects are quite different across families with a different educational background. To begin, the average education in the location has a direct (positive) impact on the frequency with which children attend school. The effect is large and statistically significant, in the order of 10%, for the three samples (Brazil as a whole and the two main states.) This finding by itself would lead to heterogeneity in mobility across regions that attract households with different education levels. However, the schooling of the child's mother has an even stronger (and statistically significant) influence on the child's own education. The table shows that, in the three location types, mothers with low levels of schooling (no schooling or just $1-4$ years) severely hinder their child's frequency in attending schools, while mothers with high levels of education (5-8, 9-11, or 12+ years) strongly boost the school attendance of their children.

The most interesting results are in terms of the regional differences across family backgrounds and locations. In general, formal cities are by far the best performers for the education attendance of children. Regardless of the mother's education, the children in cities attend school at a much higher rate than children with similar mothers in urban slums and rural areas. Yet, for our purposes, the key comparison can be between rural areas and urban slums, since that comparison would settle the issue of whether slums are stepping-stones or blockades for the children. The results in Table 9 provide a nuanced and interesting view. On the one hand, urban slums appear to be significant stepping-stones for the lower-education households (i.e., those with mothers in the bins with 0 and

$1-4$ years of education). The effects are very large, indicating that children of those households attend school 13%-26% more frequently if they are in an urban slum than in a rural area. These numbers, which apply for the country as a whole and the state of Rio and are a bit smaller for São Paulo, can easily overshadow regional variations in average education. On the other hand, the effects are quite the opposite for higher education households. For them the results are also significant, indicating that children of those households attend school 12%-25% more frequently if they are in a rural area than in an urban slum. For the group in the middle, families with mothers with $5-8$ years of education, the results are smaller and much less clear to decipher. All in all, slums appear to be clear stepping-stones for children in low-education households but seem to be blockades or traps for children in high-education households.

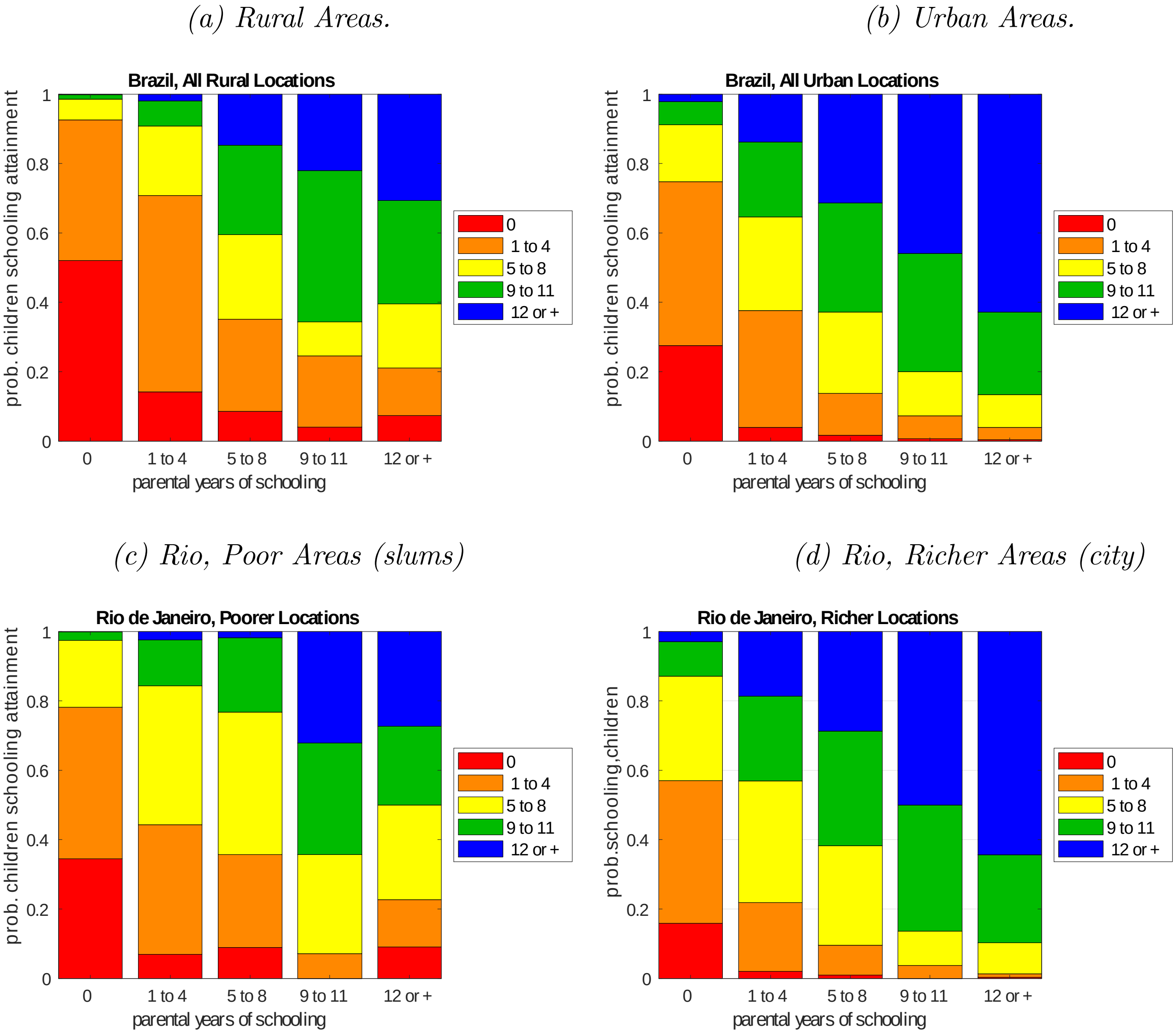
School attendance frequency is very informative for lifetime education prospects, as frequently missing school naturally leads to the failure of passing a given year, ultimately compounding into low levels of lifetime education attainment. For the country as whole, the impact would be in observed intergenerational transition probabilities in education, which we now explore using the 1988 supplement of the National Household Sample Survey (PNAD). We compute location-specific intergenerational transition probabilities in education (i.e. the probability distribution for children attaining different bins of education conditional on their own parents' education.) The data allow us to directly separate those living in urban and rural locations for the country as a whole. Unfortunately, the PNAD data do not provide an explicit indicator for residents of a slum, and thus, we constructed a proxy. To this end, we focus on the city of Rio, dividing its residents into two groups: those with an income level in the 35^{th} percentile or lower and all the remainder. Albeit imperfect, we view this as a good proxy for two reasons. First, the overwhelming majority of those in slums have incomes below the 35^{th} percentile within the population in Rio. Second, as is well-known, Rio is a very segregated city, where most of those with incomes below the 35^{th} percentile must be living within the geographic proximity of others with equally low incomes.

Figure 1 presents the probability distributions of schooling attainment for children (sons) growing up in different regions. In each panel, the horizontal axis indicates the education of the parent (fathers), which are grouped into the same five education groups as before. The vertical heights in all the graphs all add up to 1, but the heights of each of the segments indicate the probability that the child attains 0 (red), $1-4$ (orange), $5-8$ (yellow), $9-11$ (green), or 12 or more (blue) years of education. For Brazil as a whole, panel (a) reports the intergenerational transition probabilities for all the rural areas, while panel (b) does so for all urban areas. For the metropolitan area of Rio de Janeiro, panel (c) reports the intergenerational transition probabilities for households with low-income levels associated with slum dwellers, while panel (d) does so for all households associated with being into the formal city.

In all the panels, we observe intergenerational persistence in education attainment: in all the locations, the probability of attaining low levels of schooling is much higher for children of parents with a low level of education than children with a higher level of education. In all the locations, we also observe a stronger force for upward mobility than for downward mobility, as the expected years of education are on average higher than those of the parents.[33]

[33] See Ferreira and Veloso (2003) for an extensive study of the intergenerational transition probabilities in schooling attainment levels.

Figure 1: Brazil, Education Attainment Probabilities: Different Parents and Locations, 1988



Source: Supplement of the PNAD 1988.

Figure 1 reveals stark differences in the education outcomes of children for the different locations. First, across all parental education levels, the expected education attainment of children is higher in urban locations than in rural counterparts, as can easily be seen by comparing panels (a) and (b) of the figure. Second, with the exception of the more highly educated parents, raising children in the poor, slum-like regions of Rio also dominates doing so in rural areas. Third, for all education groups, raising children in the formal city of Rio greatly dominates raising children in both the *favelas* and the rural areas.

The most dramatic rural-urban differences are in the extremes. Consider first parents with no formal schooling (i.e., those who are illiterate). If they live in rural areas, they mostly raise children that will be very low educated, illiterate (probability 52%), or with 1-4 years of schooling (probability 40%). The chances of attaining the higher bins are simply negligible. In contrast, illiterate parents in urban areas raise illiterate children with a 27% probability, about half that in the rural area. They mostly raise children with lower levels of education: 47% for 1-4 years and 16.3% for 5-8 years of schooling attainment. While still low, the probabilities of their children reaching the higher two bins are substantially higher than in the rural areas. Consider now the other extreme, parents whose schooling is 12 or more years. The children of highly educated rural parents attain the top two bins of education with a 30% probability each; yet, the probability of falling into the bottom two bins is not low, 20% in total. In contrast, children of highly educated urban parents attain the highest 12+ bin with a 63% probability and the second highest 8-11 bin with a 24% probability. Those children fall into the lower two bins with a much lower probability, 3.5%, with a negligible probability of being illiterate. In sum, relative to rural areas, growing up in urban areas in Brazil fosters the upward intergenerational mobility of low-education families and reduces the downward mobility of high-education ones.

Comparing the transitions between rural areas and urban slums (Figure 1.a. and Figure 1.c.), we see that urban slums dominate the rural areas for families with parents with low education, but this dominance fades and then reverts as we move up in the education levels of parents. First, families with illiterate parents seem to attain much of the potential gains to move into urban areas from moving into a slum in Rio. This is also the case for families with parents with 1-4 years of schooling. For them, slums add a substantial force for the children moving toward the higher mid-levels of education. This finding is quite relevant since mid-low-skilled households comprise the highest share of the slum population. Of those parents who raised children in rural areas, they saw 14% of their children fall back to the 0 years of education group, 57% remain in the 1-4 group and 20% move up into the 5-8 group. Similar parents with 1-4 years of schooling who raised their children in the slums of Rio saw only 7% of them fall back into the illiterate category, 37% of them remain in the 1-4 group, and 40% move up into the 5-8 years of schooling group. The advantages of slums effectively disappear for the children of parents with 5-8 years of education and become negative for families with parents with either 9-11 or 12+ years of education. For the latter group, the probability of children reaching the top two bins is substantially lower in the slums (around 50%) than in the rural areas (around 60%.)

Lastly, comparing a formal city (Figure 1.d.) with rural areas and urban slums (Figure 1.d. vs. Figure 1.a. and Figure 1.c.) makes clear that the education attainment probabilities are much better in the cities than in the other two alternatives. The gaps are more pronounced for families with parents with high levels of education. For city parents, those with 12+ years of schooling raised children who attained 12+ years of education with a 64% probability; the same probability but for parents with 9-11 years of education was also quite high: 50%. The contrasts are remarkable with the rural areas and urban slums, where these probabilities are much lower: 30% and 22% for rural and 27% and 32% for slums. But the advantages of the city are substantial for increasing upward mobility and reducing the lower mobility of children from all schooling levels.

In sum, the results from intergenerational data complement those from the 1991 census, suggesting that slums provide a stepping-stone for low-education families moving from rural areas, since, despite the obvious costs and disutility involved in living in a *favela*, education opportunities for those children are better than in rural areas. For higher-education households, slums would be more of a blockade to the children's education. For all households the dominant choice for the education of their children would be to live in the formal city, and we now develop a model to understand the determinants of the volume and selection of households locating in rural areas, cities and slums.

3 The Model

We construct a general equilibrium model of a country's structural transformation, urban development, human capital formation, and intergenerational social mobility. We focus on the allocation of heterogeneous individuals across locations, occupations, and production sectors and then explore how this allocation reshapes the education and skill formation of future generations. We first specify the environment and then define a competitive equilibrium, examining the dynamics of human capital accumulation and the role of slums.

3.1 The Environment

Consider an overlapping generations (OLG) economy populated by a continuum of two-period-lived individuals, adults and children. Periods are indexed by $t = 1, 2, 3, ...$. Adult individuals differ in their education and working skills. The *country's overall* adult population is described by a probability measure, μ_t, defined over the product of a finite set of educational attainment levels, $\mathcal{E} = \{e_1, e_2, ..., e_{\#E}\}$, $\#E < \infty$,[34] and the support of two labor market skills $z = (z_r, z_n) \in \mathbb{R}^2_+$, which are continuously distributed. The core of the analysis is the endogenous time evolution of the sequence $\{\mu_t\}_{t=1}^{\infty}$ as determined by the equilibrium decisions of all families. We abstract from fertility dynamics and normalize the size of the adult population to one. Hence, adding up over all education levels e and skills z, the adult population satisfies $\sum_{e\in\mathcal{E}} \int_0^{\infty} \mu_t(e, dz) = 1$ for all periods t.

Location decisions (described below) split the country's μ_t into subpopulations across regions. Given our focus on the formation of slums along a country's structural transformation, we restrict the analysis to *three locations*: *rural areas, slums (favelas),* and *city*, indexed by $\ell = R,\ F,\ C$, respectively. For some purposes, it is useful to denote urban areas as U, and the union of the cities and the slums as $U = C \cup F$.[35] We denote by $\mu_t^{\ell}(\cdot)$ the positive measures that add up to the country's population:

$$\mu_t(\cdot) = \sum_{\ell\in\{R,F,C\}} \mu_t^{\ell}(\cdot). \tag{1}$$

For each family, the adult's years of schooling e and labor market skills z endogenously shape the education prospects of the children. Each adult first realizes an education attainment e and then, conditional on e, draws a vector of labor market skills, $z = (z_r, z_n) \in \mathbb{R}^2_+$. The conditional probability distributions of z are time-invariant. The first entry, z_r, represents the level of routine skills, while the second entry, z_n, is the level of non-routine skills. We follow Heckman and Sedlacek (1985) and specify the skill distributions, conditional on schooling attainments, to be jointly lognormal and given by

$$\begin{bmatrix} \ln z_r \\ \ln z_n \end{bmatrix} | e \sim N \left[\begin{pmatrix} \mu_{r,e} \\ \mu_{n,e} \end{pmatrix}, \begin{pmatrix} \sigma_{rr,e} & \sigma_{rn,e} \\ \sigma_{rn,e} & \sigma_{nn,e} \end{pmatrix} \right], \tag{2}$$

where the subindex e denotes the dependence of the first and second moments of the lognormal.

In addition to their skills $(z_r, z_n) \in \mathbb{R}^2_+$, all adults also have the option of providing *one* unit of *unskilled* labor. Unskilled labor is used exclusively in the agricultural sector. For brevity, here we simply write $G(z|e)$ to denote the cumulative distribution function of labor market skills z conditional on each $e \in \mathcal{E}$. The three occupations or types of jobs, *unskilled, routine,* and *non-routine (cognitive),* are indexed as $j = u, r, n$, respectively.

There are *three production sectors*: *agriculture, non-agriculture* (manufactures and major services), and *personal services*, indexed by $i = A,\ N,\ S$. The locational structure of the goods, labor, and housing markets and schooling institutions is as follows: In terms of *goods markets*, both agricultural A and non-agricultural goods N are fully tradeable across the country's three regions. Personal services, however, are fully segmented between rural and urban regions and *fully tradeable within the two urban regions*, cities and slums. In terms of *labor markets* (for all three skills) they are also segregated between rural and urban areas. Thus, rural labor markets are completely isolated from the rest, while dwellers of slums and cities are fully integrated within the same urban markets for routine and non-routine skills. Last, *schools* are completely segregated across the three regions. That is, children growing up in slums go to schools and interact with children and adults

[34] The finite set $\mathcal{E}$ in the model will be mapped to a finite set of bins of schooling years observed in the data.
[35] Appendix G extends the model with distant formal but poorer locations inside urban areas.

living in slums. The same is true for those in rural areas and formal cities. This is the form of segregated human capital formation that the previous section uncovered in Brazil.

We now specify these assumptions in the model. The *production functions* of all goods are constant returns to scale over different types of labor inputs. We assume that agricultural goods are produced only in rural areas, manufactures (and tradeable services) are produced only in urban areas, and personal services are produced in both rural and urban areas. The sectoral total factor productivity (TFP) levels are exogenous. First, given an agricultural TFP, X_t^A, the country's aggregate output of production of agricultural goods Q_t^A is

$$Q_t^A = X_t^A L_t^u, \tag{3}$$

where L_t^u is the aggregate units of unskilled labor in the rural regions. Second, given a non-agricultural TFP, X_t^N, the aggregate production of manufactures and other tradeable services uses both routine labor, $L_t^{r,N}$, and non-routine labor, L_t^n, and is given by

$$Q_t^N = X_t^N \left(L_t^{r,\,N}\right)^{\vartheta} \left(L_t^n\right)^{1-\vartheta}, \tag{4}$$

where $0 \leq \vartheta \leq 1$ is a share parameter. Third, given the regional productivities, $X_t^{S,\ell}$, the aggregate output of personal services is given by

$$Q_t^{S,\ell} = X_t^{S,\ell} L_t^{r,S,\ell}, \tag{5}$$

where $L_t^{r,S,\ell}$ is the aggregate amount of routine skills applied to personal services, respectively, in rural and urban regions, $\ell \in \{R, U\}$.

In each location, households face *housing costs.* Specifically, a house in location ℓ requires $\xi_t^\ell > 0$ units of the non-agriculture good N. We allow these costs to be a function of the population size (or density) of the particular location by assuming that these fixed costs are given by

$$\xi_t^\ell = \xi^{0,\ell}(1 + \mu_t^\ell)^{\xi^{1,\ell}}.$$

As a normalization, we assume that living in the rural area entails no direct resources for housing, $\xi^{0,R} = 0$, but living in urban areas $\ell \in \{F, C\}$ would entail a fixed cost per family, $\xi^{0,\ell} \geq 0$, $\xi^{1,\ell} \geq 0$ for $\ell \in \{F, C\}$.

Schools and all other aspects of human capital formation are completely segregated across the three regions. Children growing up in each location ℓ have education attainment probabilities that depend directly on the education of their *own parents*, e_j, and the *average education attainment of the region*, E_t^ℓ. Those probabilities may also depend on other factors that differ across regions. We capture these forces by assuming a location-specific multinomial logistic equation:

$$\Pr\left[e_{\text{child}} = e_i | e_{\text{parent}} = e_j, E_\ell, \ell\right] = \frac{\exp\left\{\alpha_{j,i}^\ell + \beta_{j,i}^\ell E_\ell\right\}}{\sum_{k=1}^{\#E} \exp\left\{\alpha_{j,k}^\ell + \beta_{j,k}^\ell E_\ell\right\}}. \tag{6}$$

Within this fairly parsimonious model, the parameters $\left\{\alpha_{j,i}^\ell, \beta_{j,i}^\ell\right\}$ can capture fairly rich variation across regions ℓ and differing degrees in the sensitivity to own parent's education $\left(\alpha_{j,i}^\ell\right)$ and to peer effects $\left(\beta_{j,i}^\ell\right)$. To see this, consider a few special cases. First, if $\alpha_{j,i}^\ell, \beta_{j,i}^\ell$ do not vary across ℓ, then schools would be fundamentally similar across locations, and observed differences are completely driven by the endogenous determination of E^ℓ, as driven by the sorting of the population across locations. Second, if $\beta_{j,i}^\ell = 0$, then regional averages have no impact on the education outcomes of the young generations. The education outcome of each child would depend entirely on their parents, and observed variations are completely driven by composition differences. Third, if $\alpha_{j,i}^\ell, \beta_{j,i}^\ell$ do not vary across j, then parents have no direct input on their own children. Those are just special cases and in the quantitative sections we estimate these parameters from within-type-location variations observed in Brazil.

At the beginning of each period, based on the realized idiosyncratic values (e, z), the anticipated market prices, and all other payoff-relevant variables, each adult in the country must choose a location ℓ. Location decisions are consequential for the labor market options, education prospects, housing and other costs, and, possibly, the price of some consumption goods, all of which are evaluated by household according to their *preferences.* The utility of an adult at time t is defined over the consumption of goods, the expected education attained by his or her children, e_{t+1}, and other non-pecuniary costs of each location. Specifically, the utility $V_t^{\ell,e}$ of a type e adult living in location ℓ at time t is given by

$$V_t^{\ell,e} = \frac{\left[c_t\left(1-\tau_t^{\ell}\right)\right]^{1-\gamma}}{1-\gamma} + \beta\frac{\left[\mathbb{E}\left(e_{t+1}\right|\, e, E^{\ell}\right)\right]^{1-\gamma_e}}{1-\gamma_e} + \eta^{\ell}.$$

The first term is the utility of consumption. It is a strictly increasing and weakly concave function (i.e. $\gamma \geq 0$), of a consumption basket $c \equiv \left(c^A - \bar{c}^A\right)^{\alpha}\left(c^N\right)^{\varrho}\left(c^S + \bar{c}^S\right)^{\varsigma}$ composed of agricultural goods (c^A), manufactures and other major services (c^N), and personal services (c^S). We assume standard Stone-Geary non-homothetic preferences with $\bar{c}^A > 0$ and $\bar{c}^S > 0$, $\alpha, \varrho, \varsigma \geq 0$ and $\alpha + \varrho + \varsigma = 1$. Here, c^A and c^N are necessities consumed by all households, while c^S represents "luxuries" consumed in positive amounts only by households with sufficiently high income. The second term is the valuation that parents obtain from the expected education attainment of their children, $\mathbb{E}\left(e_{t+1}\right|\, e, E^{\ell}\right)$.[36] Here, $\beta \geq 0$ governs the relative weight that parents put on their children's education. The curvature parameters γ and γ_e control the relative strength of the income effects of the utility over consumption versus utility from the expected education of the children. The expectation $\mathbb{E}\left(e_{t+1}\right|\, e, E^{\ell}\right)$ is based on the adult's own education and the average education of the location where the family lives according to the probabilities (6.)

Besides housing costs, living in the different locations entails two forms of non-pecuniary costs. First, there is a deterministic, common component, τ_t^{ℓ}, that reduces the well-being of all the inhabitants of location ℓ. For our purposes, we focus on the non-pecuniary costs of living in a slum, assuming $1 > \tau_t^F > 0 = \tau_t^R = \tau_t^C$ (i.e. we normalize the other regions as having zero non-pecuniary costs or benefits of living there.)[37] The second non-pecuniary component is an idiosyncratic random preference shock η^{ℓ} for each location ℓ, which we assume to be Gumbel distributed.

3.2 Equilibrium

In any period, the equilibrium in the country is driven by a predetermined distribution μ_t of the adult population in terms of schooling and skills and an exogenous vector $\left(X_t^A, X_t^N, X_t^{S,\ell}, \tau_t^F\right)$. The price system $\{p_t\}_{t=0}^{\infty}$ is composed of time sequences of the vector $p_t \equiv \left(p_t^N, p_t^{S,\ell}, p_t^{h,\ell}, w_t^u, w_t^{r,\ell}, w_t^n\right)$ containing the prices of goods, housing, and labor market skills across the different locations ℓ. The components of these vectors are in units of agricultural goods, i.e. $p_t^A = 1$. Given the prices $\{p_t\}_{t=0}^{\infty}$, production firms hire workers, workers choose occupations, and households choose consumption. Aside from p_t, each household considers the vector $E_t \equiv \left(E_t^R, E_t^F, E_t^C\right)$ of average education attainments in each region, as it affects the education attainment of the children. Like prices, the vector E_t is endogenously determined as part of the equilibrium, and each household takes it as given.

[36] Fernandez and Rogerson (1998) and many others use this form of impure altruism because it greatly helps with tractability. For us, this is very useful since the inherent lack of a balanced-growth-path (BGP) in models of structural transformation makes it really difficult to adapt numerical methods that rely on BGP approximations.

[37] This formulation is isomorphic to one in which cities and rural areas provide positive amenities which are neglected in the slums.

A competitive equilibrium requires individually rational choices of firms and of household choices, aggregate consistency and the clearing of all markets. In this section, we sequentially develop each of these components.

3.2.1 Individual Optimization

Production. Firms in this economy have standard profit maximization problems that lead to simple pricing conditions. First, agricultural firms, all of which are in rural areas, hire unskilled labor, L_t^u, to maximize their profits, $\max_{\{L_t^u\}} \{p_t^A Q_t^A - w_t^u L_t^u\}$. Since agriculture is our numeraire, and $Q_t^A = X_t^A L_t^u$, then the wages for unskilled workers are just the productivity in agriculture,

$$w_t^u = X_t^A. \tag{7}$$

Second, non-agriculture firms, all of which are in urban areas, hire routine and non-routine labor, $L_t^{N,r}, L_t^n$, to maximize their profits, $\max_{\{L_t^{N,r},\, L_t^{N,n}\}} \left\{p_t^N Q_t^N - w_t^r L_t^{N,r} - w_t^n L_t^n\right\}$. With the production function (4), the equilibrium wage conditions are given by

$$w_t^n = (1-\vartheta)\, p_t^N X_t^N \left(\frac{L_t^{r,N}}{L_t^n}\right)^{\vartheta}, \tag{8}$$

and

$$w_t^r = \vartheta p_t^N X_t^N \left(\frac{L_t^n}{L_t^{r,N}}\right)^{1-\vartheta}, \tag{9}$$

where L_t^n *and* $L_t^{r,N}$ denote the aggregate non-routine and routine skills applied to the N sector, respectively. Third, personal services firms in location ℓ (rural R or urban U) hire only routine labor, $L_t^{r,S,\ell}$, to maximize their profits, $\max_{\{L_t^{r,S,\ell}\}} \left\{p_t^{S,\ell} Q_t^{S,\ell} - w_t^r L_t^{r,S,\ell}\right\}$. The production function is linear, then the unitary wages for routine skills in each in rural and urban areas are

$$w_t^{r,R} = p_t^{S,R} \cdot X_t^{S,R}, \tag{10}$$

and

$$w_t^{r,U} = p_t^{S,U} \cdot X_t^{S,U}. \tag{11}$$

Households. First, consider the *occupation choices.* Notice that the education level e does not matter for the optimal occupation choices, which are entirely driven by the realized labor market skills (z_r, z_n). For *rural adults*, unskilled and routine occupations are the available options. The optimized earnings are

$$y_t^R(z_r, z_n) = \max\left\{w_t^u, w_t^{r,R} z_r\right\}.$$

Hence, a rural adult becomes an unskilled worker if and only if his routine skills are below the threshold $w_t^u / w_t^{r,R}$. In such cases, the household income is $y_t^R = w_t^u$. Otherwise, the adult becomes a routine worker with income $y_t^R = w_t^{r,R} z_r$ which varies proportionally with the worker's routine skills z_r. To keep track of the population of workers and aggregate skills in the rural area, define the dichotomical variables:

$$\varphi_t^{u,R}(z) \equiv \begin{cases} 1 & \text{iff } w_t^u > w_t^{r,R} z_r \\ 0 & \text{otherwise,} \end{cases} \tag{12}$$

and

$$\varphi_t^{r,R}(z) \equiv 1 - \varphi_t^{u,R}(z). \tag{13}$$

For *urban adults* in either F or C, the two options are routine or non-routine jobs. The earnings are

$$y_t^U(z_r, z_n) = \max\left\{w_t^{r,U} z_r,\, w_t^n z_n\right\}.$$

Routine occupations are the optimal choice if and only if the worker has a *comparative advantage* in those occupations, i.e., $z_r/z_n > w_t^n/w_t^{r,U}$. If so, the optimized earnings are $y_t^U = w_t^{r,U} z_r$. Otherwise, non-routine occupations are optimal comparative advantage is reverted and $y_t^U = w_t^n z_n$. To keep track of the population of workers and aggregate skills in the urban areas, define the dichotomical variables:

$$\varphi_t^{r,U}(z) \equiv \begin{cases} 1 & \text{iff } z_r > \left(w_t^n/w_t^{r,U}\right) z_n \\ 0 & \text{otherwise,} \end{cases} \tag{14}$$

and

$$\varphi_t^{n,U}(z) \equiv 1 - \varphi_t^{r,U}(z). \tag{15}$$

We now consider the *demand for goods* of each household. Consumption optimization does not directly depend on (e, z) or the location, except for the implied earnings, y, and expenditures in housing, $p_t^{H,\ell}$. Optimal consumption solves $\max_{\{c^A, c^M, c^S,\}} u\left(c^A, c^M, c^S\right)$ s.t. $c^A + p_t^M c^M + p_t^{S,\ell} c^S \leq y - p_t^{H,\ell}$. Notice that goods A and N have prices that do not vary by location, whereas personal services and housing vary with ℓ. In Appendix F, we derive two simple thresholds for each of the regions. The first, $\underline{y}_t^\ell$, is a *subsistence threshold*:

$$\underline{y}_t^\ell \equiv p_t^{H,\ell} + \bar{c}^A.$$

Households whose income is below $\underline{y}_t^\ell$ cannot subsist in region ℓ since they cannot afford the food and housing expenses that living there entails. The second is a *minimum income for personal services*, $\bar{y}_t^\ell$, which is given by

$$\bar{y}_t^\ell \equiv p_t^{S,\ell} \bar{c}^S \left(\frac{1-\varsigma}{\varsigma}\right) + p_t^{H,\ell} + \bar{c}^A.$$

Households with incomes above $\bar{y}_t^\ell$ demand a positive amount of personal services from the market, splitting their income among in all three goods. Households with income below that minimum do not buy personal services in the market and spend all their market income in A and N.

The individual demand functions in each location ℓ are only defined for incomes above $\underline{y}_t^\ell$. These functions are

$$c_t^{A,\ell}(y) = \begin{cases} \bar{c}^A + \frac{\alpha}{\alpha+\varrho}\left(y - p_t^{H,\ell} - \bar{c}^A\right) & \text{iff } \underline{y}_t^\ell \leq y < \bar{y}_t^\ell \\ \bar{c}^A + \alpha\left(y + p_t^{S,\ell}\bar{c}^S - p_t^{H,\ell} - \bar{c}^A\right) & \text{otherwise;} \end{cases} \tag{16}$$

$$c_t^{N,\ell}(y) = \begin{cases} \frac{\varrho}{\alpha+\varrho}\left(\frac{y - p_t^{H,\ell} - \bar{c}^A}{p_t^N}\right) & \text{iff } \underline{y}_t^\ell \leq y < \bar{y}_t^\ell \\ \varrho\left(\frac{y + p_t^{S,\ell}\bar{c}^S - p_t^{H,\ell} - \bar{c}^A}{p_t^N}\right) & \text{otherwise;} \end{cases} \tag{17}$$

$$c_t^{S,\ell}(y) = \begin{cases} 0 & \text{iff } \underline{y}_t^\ell \leq y < \bar{y}_t^\ell \\ -\bar{c}^S + \varsigma\left(\frac{y + p_t^{S,\ell}\bar{c}^S - p_t^{H,\ell} - \bar{c}^A}{p_t^{S,\ell}}\right) & \text{otherwise.} \end{cases} \tag{18}$$

In each case, the first branch is for the poorer household in the location, $y \leq \bar{y}_t^\ell$, and the second branch is for the richer households.

Location Decisions. We can now solve for the utility levels attained by the households across the different locations and for the probabilities that the different households choose each of those locations. Given the prices p_t, utility costs τ_t^F, and the education averages E_t^ℓ, a household with school, skills, and preferences $\left(e, z, \eta^\ell\right)$ attains utilities $V_t^\ell\left(e, z, \eta^\ell\right) = \bar{V}_t^\ell(e, z) + \eta^\ell$, where the $\bar{V}_t^\ell(e, z)$ is a fundamental or common utility in location ℓ, defined as

$$\bar{V}_t^\ell(e, z) = \begin{cases} -\infty & \text{if } y \leq p_t^{H,\ell} + \bar{c}^A; \\ \dfrac{\left\{ \frac{\left(1-\tau^\ell\right)\alpha^\alpha \varrho^\varrho \left(\bar{c}^S\right)^\varsigma}{(\alpha+\varrho)^{\alpha+\varrho} \cdot \left(p_t^N\right)^\varrho} \left[y_t^\ell(z) - p_t^{H,\ell} - \bar{c}^A\right]^{\alpha+\varrho} \right\}^{1-\gamma}}{1-\gamma} + \beta \dfrac{\left[\mathbb{E}\left(e_{t+1} \mid e, E^\ell\right)\right]^{1-\gamma_e}}{1-\gamma_e}, & \text{if } y \in \left(\underline{y}_t^\ell,\, \bar{y}_t^\ell\right); \\ \dfrac{\left\{ \frac{\left(1-\tau^\ell\right)\alpha^\alpha \varrho^\varrho \varsigma^\varsigma \cdot}{\left(p_t^M\right)^\varrho \left(p_t^{S,\ell}\right)^\varsigma} \left[y_t^\ell(z) + p_t^{S,\ell}\bar{c}^S - p_t^{H,\ell} - \bar{c}^A\right] \right\}^{1-\gamma}}{1-\gamma} + \beta \dfrac{\left[\mathbb{E}\left(e_{t+1} \mid e, E^\ell\right)\right]^{1-\gamma_e}}{1-\gamma_e}, & \text{if } y \geq \bar{y}_t^\ell. \end{cases}$$

Here, $\bar{V}^\ell(e, z) = -\infty$ holds for (e, z) combinations for which households cannot afford location ℓ.

At the onset of each period, adults choose locations weighting housing costs, labor market opportunities, and schooling prospects for their children:

$$V_t\left(e, z, \eta^\ell\right) = \max\left\{V_t^R,\, V_t^F,\, V_t^C\right\}. \tag{19}$$

Given the Gumbel distribution for the idiosyncratic preference shocks η^ℓ, the probability $q_t^\ell(e, z)$ that a household led by an adult with education and skills (e, z) chooses location ℓ is given by

$$q_t^\ell(e, z) = \frac{\exp\left\{\varkappa \cdot \bar{V}_t^\ell(e, z)\right\}}{\sum\limits_{k=\{R,F,C\}} \exp\left\{\varkappa \cdot \bar{V}_t^k(e, z)\right\}}, \tag{20}$$

where $\varkappa$ is the curvature parameter of the Gumbel distributed η^ℓ. Obviously, if $\bar{V}^\ell(e, z) = -\infty$, then $q_t^\ell(e, z) = 0$ as no household would choose a location is not affordable.

Given the initial population μ_t, the *location choices* $\left\{q_t^\ell(e_j, z)\right\}_{\ell \in \{R,F,C\}}$ define the population and average education in each location. We now proceed to derive how they also shape the aggregate demand for goods and housing and equilibrium prices.

3.2.2 Market Clearing and Aggregate Consistency

Demographics: Given the initial μ_t we can compute the country's marginal distribution over education levels, $\left\{\pi_t^{e_j}\right\}_{j=1}^{\#E}$,

$$\pi_t^{e_j} \equiv \int_0^\infty \mu_t(e_j, dz),\; e_j \in \mathcal{E}, \tag{21}$$

and the location probabilities, $q_t^\ell(e_j, z)$, define the following *weighted skill densities* over routine and non-routine skills in each location:

$$\phi_t^\ell(z) \equiv \sum_{e \in \mathcal{E}} \pi_t^{e_j} q_t^\ell(e_j, z)\, g(z; e_j),$$

where $g(z; e_j)$ is the density of the joint lognormal in (2).

Likewise, the total mass of individuals with education attainment $e_i \in \mathcal{E}$ in each of the regions ℓ is

$$\pi_t^{e_j,\ell} = \pi_t^{e_j} \int q_t^\ell(e_j, z)\, g(z; e_j)\, dz.$$

Consequently, given these masses, $\pi_{t,\ell}^{e_j}$, the average education in region ℓ is equal to

$$E_t^{\ell} = \frac{\sum_{e_j \in \mathcal{E}} \pi_t^{e_j,\ell} e_j}{\sum_{j=1}^{\#\mathcal{E}} \pi_t^{e_j,\ell}}. \tag{22}$$

Labor and Goods Markets: Using these weighted densities, the aggregate supply of skills in each region results from the weighted skill densities $\phi_t^{\ell}(z)$ and occupation choices. In rural areas, aggregate unskilled labor is

$$L_t^u = \int \varphi_t^{u,R}(z)\, \phi_t^R(z) dz, \tag{23}$$

and aggregate rural routine skilled labor is

$$L_t^{r,R} = \int z_r \varphi_t^{r,R}(z)\, \phi_t^R(z) dz. \tag{24}$$

For urban areas, the aggregate supply of routine skills is

$$L_t^{r,U} = \int z_r \varphi_t^{r,U}(z)\, \phi_t^U(z) dz, \tag{25}$$

and the aggregate supply of nonroutine skills is

$$L_t^n = \int z_n \varphi_t^{n,U}(z)\, \phi_t^U(z) dz. \tag{26}$$

The supply of goods $\left(Q_t^A, Q_t^N, Y_t^{S,R}, Y_t^{S,U}\right)$ arise from the assignment of these aggregate skills across the production sectors in the different locations. In this economy, the relevant assignment is of the aggregate urban routine labor $L_t^{r,U}$. In equilibrium, the marginal product of those skills must be equalized between manufactures, $L_t^{r,U,N}$ and personal services $L_t^{r,U,S}$. Given prices $p_t^N, p_t^{S,U}$ and TFPs X_t^N, $X_t^{S,U}$ the condition boils down to

$$\vartheta p_t^N X_t^N \left(\frac{L_t^n}{L_t^{r,U} - L_t^{r,U,S}}\right)^{1-\vartheta} = p_t^{S,U} \cdot X_t^{S,U}.$$

This condition holds because the full support of the lognormal distributions for (z_r, z_n) means that the demand for personal services in both urban and rural markets is always a positive amount.

Regarding the demand for goods, it is convenient to define some additional objects. First, in units of agricultural goods, the *country's aggregate income* is given by[38]

$$Y_t = w_t^u L_t^u + w_t^{r,R} L_t^{r,R} + w_t^{r,U} L_t^{r,U} + w_t^n L_t^n.$$

Second, define the *population size* of each location as

$$\Phi_t^{\ell} \equiv \sum_{j=1}^{\#\mathcal{E}} \int \mu_t^{\ell}(e_j, z)\, dz, \quad \text{for } \ell \in \{R, F, C\}.$$

Obviously, $\Phi_t^{\ell} \geq 0$ and $\sum_{\ell} \Phi_t^{\ell} = 1$. Third, the country's *aggregate expenditure in consumption* goods net of housing expenditure is given by

$$Y_t^C = Y_t - p_t^{h,F} \Phi_t^F - p_t^{h,C} \Phi_t^C,$$

[38]Using (7), (10), (11), (8), and the respective production functions, it is easy to show that aggregate income is also equal to the nominal value of production, $Y_t = Q_t^A + p_t^N Q_t^N + p_t^{S,R} Q_t^{S,R} + p_t^{S,U} Q_t^{S,U}$.

which is simply total income minus aggregate expenditure in housing. At the regional level, the *rural aggregate expenditure* in consumption goods is

$$Y_t^{RC} = w_t^u L_t^u + w_t^{r,R} L_t^{r,R},$$

since the cost of housing was normalized to zero. Similarly, the *urban aggregate expenditure* in consumption goods is,

$$Y_t^{UC} = w_t^{r,U} L_t^{r,U} + w_t^n L_t^n - \sum_{\ell \in \{F,C\}} p_t^{h,\ell} \Phi_t^\ell.$$

as the aggregate rural and urban aggregate expenditure in goods, respectively. Fourth, the *regional mass of households consuming personal services* from the marketplace is

$$\Phi_t^\ell \equiv \int_{y_t^\ell(z) \geq \bar{y}_t^\ell} \phi_t^\ell(z) dz, \quad \text{for } \ell \in \{R, F, C\}.$$

Using these equations after aggregating over (16), (17), and (18) and simplifying, the aggregate demand for the different goods in the different regions can be written as

$$C_t^A = \bar{c}^A + \alpha \left[Y_t^C - \bar{c}^A + \bar{c}^S \sum_{\ell \in \{R,F,C\}} p_t^{S,\ell} \Phi_t^\ell \right], \tag{27}$$

$$C_t^N = \frac{\varrho}{p_t^N} \left[Y_t^C - \bar{c}^A + \bar{c}^S \sum_{\ell \in \{R,F,C\}} p_t^{S,\ell} \Phi_t^\ell \right], \tag{28}$$

$$C_t^{S,R} = (1 + \varsigma) \bar{c}^S \Phi_t^R + \varsigma \left[\frac{Y_t^{RC} - \bar{c}^A \sigma_t^R}{p_t^{S,R}} \right], \tag{29}$$

$$C_t^{S,U} = (1 + \varsigma) \bar{c}^S \sum_{\ell \in \{F,C\}} \Phi_t^\ell + \varsigma \left[\frac{Y_t^{UC} - \sigma_t^U \bar{c}^A}{p_t^{S,U}} \right]. \tag{30}$$

3.2.3 Equilibrium

We can now define a competitive equilibrium in this economy.

Definition 1 *Given an initial schooling and skill distribution μ_0 and exogenous sequences $\left\{X_t^{i,\ell}, \tau_t^F\right\}_{t=0}^\infty$ of productivities and utility costs of living in a slum,* ***a competitive equilibrium*** *is: (a) a price system, $\{p_t\}_{t=0}^\infty$; (b) households' decisions on location $\{q_t^\ell(e,z)\}_{t=0}^\infty$, occupation $\left\{\varphi_t^{r,\ell}(e,z)\right\}_{t=0}^\infty$, and consumption $\left\{c_t^{i,\ell}(e,z)\right\}_{t=0}^\infty$; (c) aggregates of output $\{Q_t^i\}$, consumption $\left\{C_t^{i,\ell}\right\}_{t=0}^\infty$, location average education levels, $\{E_t^\ell\}_{t=0}^\infty$, population sizes $\{\sigma_t^\ell\}_{t=0}^\infty$, mass of consumers of personal services $\{\Phi_t^\ell\}_{t=0}^\infty$; and (d) a sequence of population probability distributions over school attainments and labor market skills, $\{\mu_t\}_{t=0}^\infty$, such that:*

1. *Given prices, $\{p_t\}_{t=0}^\infty$,* and education levels, *$\{E_t^\ell\}_{t=0}^\infty$, the individual decisions (b) on location, occupation, and consumption are optimal for each household.*

2. *Aggregate variables are consistent with individual choices and with each other, that is, equations* (1), (22), (23), (24), (25), (26), (27), (28), (29), and (30) *hold.*

3. *The goods markets clear:*

$$Q_t^A = C_t^A; \tag{31}$$
$$Q_t^N = C_t^N + \xi_t^F \sigma_t^F + \xi_t^C \sigma_t^C; \tag{32}$$
$$Q_t^{S,R} = C_t^{S,R}; \tag{33}$$
$$Q_t^{S,U} = C_t^{S,U}. \tag{34}$$

4. *The population evolves according to*

$$\mu_{t+1}(e_j, B) = \sum_{i=1}^{\#E} \pi_t^{e_i} \frac{\exp\left\{\alpha_{j,i}^\ell + \beta_{j,i}^\ell E_\ell\right\}}{\sum_{k=1}^{\#E} \exp\left\{\alpha_{j,k}^\ell + \beta_{j,k}^\ell E_\ell\right\}} \Gamma(B; e_j),$$

for any $e_j \in \mathcal{E}$ and Borel set $B \subset R_+^2$. Here, (21) defines $\pi_t^{e_i}$, and $\Gamma(B; e_j)$ are the probability measures associated with the lognormals (2.)

Before quantifying and calibrating the model, it is worth exploring two of the equilibrium implications of the model. They will help in the analysis of the results in the next sections about the emergence and consequences of slums. The first of is the determination of the relative price of goods, and hence, of the relative price of labor skills. We shall see that they are crucial to understanding the rural-to-urban reallocation of workers in our counterfactuals. Integrating over all the marginal rates of substitution of all households, we can solve for the equilibrium relative price p_t^N of the urban-produced N good as

$$p_t^N = \frac{\varrho}{\alpha}\left(\frac{Q_t^A - \bar{c}^A}{Q_t^N - \sum_{\ell\in\{R,F,C\}} \Phi_t^\ell \xi_t^\ell}\right).$$

The price p_t^N is proportional to the ratio between the net-of-subsistence aggregate output of agricultural goods A and the net-of-housing costs aggregate output of the urban-produced goods N. The response of this price from improvements in agriculture productivity drives a very large response on the urban population, and, possibly, on the formation of slums.

Similarly, integrating (18) with respect to the densities $\phi_t^\ell(y)$ of households incomes in rural and urban locations, and using the market-clearing conditions (33) and (34), we obtain that the price of personal services in the rural area is

$$p_t^{S,R} = \varsigma\left(\frac{\int_{\bar{y}_t^R}^\infty y\phi_t^R(y)\,dy - \bar{c}^A\Phi_t^R}{Q_t^{S,R} - (1+\varsigma)\,\Phi_t^R\bar{c}^S}\right),$$

and in the urban area is

$$p_t^{S,U} = \varsigma\left(\frac{\sum_{\ell\in\{F,C\}}\left[\int_{\bar{y}_t^\ell}^\infty y\phi_t^\ell(y)\,dy - \Phi_t^\ell\left(p_t^{H,\ell} + \bar{c}^A\right)\right]}{Q_t^{S,U} - (1+\varsigma)\sum_{\ell\in\{F,C\}}\Phi_t^\ell\bar{c}^S}\right).$$

In each location, the price of personal services is driven by the total aggregate income *in the right tail of the distribution* net of subsistence costs $p_t^{H,\ell} + \bar{c}^A$, since $\int_{\bar{y}_t^\ell}^\infty y\phi_t^\ell(y)\,dy$ is all the income of the households that are rich enough to demand personal services from the marketplace, Φ_t^ℓ is the total mass of those households, and $p_t^{H,\ell} + \bar{c}^A$ is the amount of income needed to subsist in location ℓ. The combination of non-tradeability of personal services with the simple non-Gorman aggregation in the model leads to an interesting result: A high amount of income at the top, $\int_{\bar{y}_t^\ell}^{\infty} y\phi_t^\ell(y)\,dy$, pushes up the prices of personal services. These services require routine skills which are predominantly provided by workers with low levels of education. Thus, the presence of rich households in the formal city may lead to immigration of low-skill workers to urban areas, some of whom might opt to live in slums.

The second key implication relates to human capital dynamics. Under our assumptions, the dynamics of $\{\mu_t\}_{t=0}^{\infty}$ is entirely driven by the population distribution across education groups in each location, $\pi_t^{e_j,\ell}$. These shares determine the averages E_t^ℓ and along with the education distribution for the entire country in the next period $t+1$:

$$\pi_{t+1}^{e_i} = \sum_{\ell \in \{R,F,C\}} \sum_{j=1}^{\#\mathcal{E}} \pi_t^{e_j,\ell} \cdot \frac{\exp\left\{\alpha_{j,i}^\ell + \beta_{j,i}^\ell E_t^\ell\right\}}{\sum_{k=1}^{\#E} \exp\left\{\alpha_{j,k}^\ell + \beta_{j,k}^\ell E_t^k\right\}}.$$

Urbanization and the emergence of slums can drive the dynamics of the country's evolution in the education distribution $\{\pi_t^{e_i}\}_{t=0}^{\infty}$ through two related but distinct mechanisms. We call the first one *composition through fundamentally different schools,* that is, shifts in $\left\{\pi_t^{e_j,\ell}\right\}$, the population across locations with different parameters $\left\{\alpha_{j,i}^\ell,\ \beta_{j,i}^\ell\right\}$. The second one is the *configuration of peer effects* in each location, that is, changes in the equilibrium configuration of regional averages, $\left\{E_t^\ell\right\}_{t=0}^{\infty}$, and thus the conditional transitional probabilities.

These mechanisms are in the center stage in all the policy counterfactuals in Section 5, for which we now calibrate the model to the Brazilian economy.

4 Calibrating the Model to Brazil 1980-2010

In this section we set the values for the parameters and exogenous variables of the model. We then discuss how well the model accounts for multiple aspects of the country's observed data for 1980 and 2010, in terms of structural transformation (sectoral employment and value-added shares), urbanization (population in rural areas, urban slums, and cities), and the sorting of population across locations.

We use both external estimation and internal calibration. External estimation is used to set the values for the vast majority of the parameters and exogenous variables. These parameter values are set without using equilibrium conditions or moments of the model, but instead are directly measured in the data, or they are estimated using available data on sectoral productivities, factor production shares, the distribution of earnings of workers with different labor market skills, intergenerational transition probabilities, and housing prices elasticities. In this set we also include a small number of preference parameters calibrated from the literature on structural transformation. Internal calibration is used to estimate the parameter values for a few of the preference parameters and location-dwelling costs. These parameters are admittedly more difficult to measure directly on the data and no counterparts are available in the literature. This small set of parameters that are obtained by approximating a large number of equilibrium moments of the model with their counterparts in the Brazilian data. Tables 10-12 summarize the resulting parameter values, and Figures 2 and 3 illustrate different aspects of the calibration. Appendices C, D and E provide additional details.

We test the calibrated model's implications for the subsequent generation of Brazilians (thirty years later) with respect to the cross-section distribution of schooling attainment. Specifically, with the initial distribution of $\left\{\pi_{t,\text{census}}^{e_i}\right\}$ of Brazil in 1980, we compare the model's implied distribution next period distribution, $\left\{\pi_{t+1,\text{ model}}^{e_i}\right\}$, with its data counterpart, $\left\{\pi_{t+1,\text{ census}}^{e_i}\right\}$, from the Brazilian

Census.[39] We also calibrate the model to the year 2010. We find that the model with the 1980 calibration and appropriate variations with sectoral productivities and dwelling costs accounts well for the data in 2010.

4.1 External Estimation

We now explain in detail how we set the values for each subsets of the externally estimated parameters and exogenous variables.

Labor Market Skills. We follow Heckman and Sedlacek (1985) and Heckman-Honore (1990) and posit a joint lognormal distribution for routine and non-routine skills *conditional on the schooling attainment of the worker.* The parameters of these log-normals are estimated using the labor market earnings of employed workers observed in the 1980 census. We consider the total income of 25- to 40- year-old employed individuals, grouping them according to the same set $\mathcal{E}$, i.e., bins 0, 1-4, 5-8, 9-11, and 12 or more years of schooling. The sample of workers is also partitioned between routine and non-routine occupations as explained in Appendix D.

As shown in Appendix C, for workers in each bin $e \in \mathcal{E}$, we derive systems of five equations on the five unknowns. Omitting the explicit dependence on e, the five unknowns are the two means, $(\mu_r,\ \mu_n)$, the two variances, $(\sigma_{rr},\ \sigma_{nn})$, and one covariance, σ_{rn}. The observables are: (a) averages of log-earnings, (b) standard deviations of log-earnings, and (c) fraction of workers in non-routine occupations, i.e., $\bar{m}_y^r \equiv E\left[\ln y^r | \ln y^r > \ln y^n\right]$, $\bar{m}_y^n \equiv E\left[\ln y^n | \ln y^n > \ln y^r\right]$, and $\bar{S}_y^r \equiv var\left[\ln y^r | \ln y^r > \ln y^n\right]$, $\bar{S}_y^n \equiv var\left[\ln y^n | \ln y^n > \ln y^r\right]$ and f^r, respectively.[40]

Table 10 shows the observed moments and implied equilibrium solution for these Heckman and Sedlacek (1985) conditions for each education group e. Average routine and non-routine skills are increasing in the education level of the worker with the increments being much steeper for non-routine skills. To account for the sorting of workers between the two types of occupations, the model requires a low or negative conditional correlation between the two skills.

[39] We use the information from the census of 2000 and other available data as explained, since the census of 2010 does not contain the "subnormal agglomerate." We discuss this further below.

[40] For each e, the equilibrium moment conditions in Heckman and Sedlacek (1985) lead to the 5×5 system:

$$\begin{aligned}
\bar{m}_y^r &= \bar{\mu}^r + \left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^*}\right)\lambda\left(c_r\right), \\
\bar{m}_y^n &= \bar{\mu}^n + \left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^*}\right)\lambda\left(c_n\right), \\
\bar{S}_y^r &= \sigma_{rr}\left\{\left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{rr}}}\right)^2\left[1 - c_r\lambda\left(c_r\right) - \left[\lambda\left(c_r\right)\right]^2\right] + \left[1 - \left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{rr}}}\right)^2\right]\right\}, \\
\bar{S}_y^n &= \sigma_{nn}\left\{\left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{nn}}}\right)^2\left[1 - c_n\lambda\left(c_n\right) - \left[\lambda\left(c_n\right)\right]^2\right] + \left[1 - \left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{nn}}}\right)^2\right]\right\}, \\
f^r &= \Phi\left(\frac{\bar{\mu}^r - \bar{\mu}^n}{\sigma^*}\right),
\end{aligned}$$

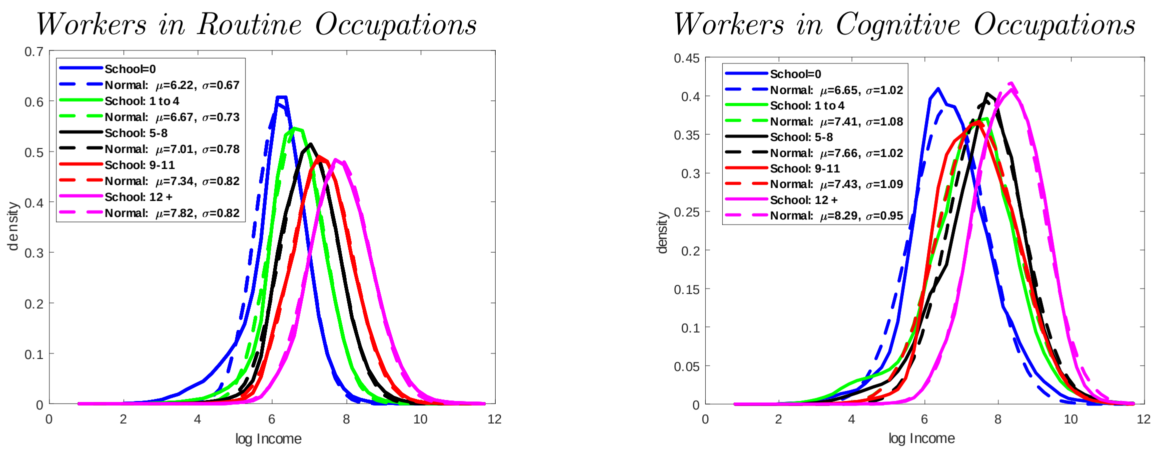
where $\sigma^* \equiv \sqrt[2]{\sigma_{rr} + \sigma_{nn} - 2\sigma_{rn}}$.

Table 10: Labor Market Skills: Moments and Parameter Estimates

Workers' Schooling Group (e_j)	Observed Moments					Implied Parameters				
	$\bar{m}_y^r$	$\bar{m}_y^n$	S_y^r	S_y^n	f^r	μ_r	μ_n	σ_r^2	σ_n^2	$\rho_{r,n}$
0	-0.22	0.21	0.67	1.02	0.964	-1.22	-7.30	0.67	2.74	-0.02
1-4	0.23	0.98	0.73	1.08	0.944	0.23	-4.62	0.73	2.48	0.20
5-8	0.57	1.22	0.78	1.02	0.925	0.57	-2.65	0.78	1.97	0.34
9-11	0.90	0.99	0.82	1.09	0.783	0.68	-2.30	0.95	2.21	-0.68
12+	1.38	1.85	0.83	0.96	0.359	1.21	1.16	0.84	1.17	0.47

Figure 2 shows the fit of the estimated lognormal distributions (dashed lines) to the observed earnings data (solid lines.) A good fit holds across the workers of different education levels (by colors in each panel) and across the two types of occupations, routine (left panel) and non-routine (right panel).[41]

Figure 2: Labor Market Earnings: Data and Estimated Lognormal Distributions



Intergenerational Mobility Parameters. We use data from the PNAD to estimate the parameters $\{\alpha_{i,j}^{\ell}, \beta_{i,j}^{\ell}\}$ that govern the education intergenerational transition probabilities, $P_{i,j}^{\ell}$, in our model. The identification of the parameters $\{\alpha_{i,j}^{\ell}, \beta_{i,j}^{\ell}\}$ is based on the variation in the values of E_t^{ℓ} and $P_{i,j}^{\ell}$ observed across Brazilian locations of the same type. For example, the parameters $\{\alpha_{i,j}^{R}, \beta_{i,j}^{R}\}$ are identified from *observed variations across rural areas* in Brazil on the intergenerational education probabilities.

We start by computing the observed values $\{P_{i,j}^{\ell}, E_t^{\ell}\}$ for 72 locations, composed of 20 rural locations, 26 urban slums, and 26 formal cities.[42,43] In total, we have 1,800 observed transition probabilities $P_{i,j}^{\ell}$ (500 for rural areas, 650 for slums, and 650 for formal cities) and 72 regional

[41] Similar parameters and results emerge when using the earnings data from the census of 1991.

[42] In 1988 there were 26 Brazilian states, and PNAD provides information about the urban areas in all of them. However, for rural areas there is no information for the six states located in the north region.

[43] The PNAD directly provides data to distinguish only households living in rural or urban areas. It does not provide a flag to separate urban households living in slums from those living in formal cities. However, in general, Brazilian cities are highly segregated by income levels. We proceeded by assuming that households are geographically perfectly clustered by income. Moreover, from the census of 1991, we observe that most urban households in slums have income levels that are in the 35^{th} percentile or lower in the distribution of the respective urban areas. Along this division, we constructed the two clustered groups of households, which we map to the model's grouping of slums and formal cities, respectively.

averages E_t^ℓ (20 rural, 26 slums and 26 cities proper.) For each location type ℓ, denote by M_ℓ the number of observed locations in the PNAD that are of that type ℓ, and index by $l = 1, 2, ...M_\ell$ each of these locations. For each location type, $\ell \in \{R, F, C\}$, and parent education level j, we only need to estimate eight parameters, $\left\{\alpha_{j,i}^\ell\right\}_{i=2}^5$ and $\left\{\beta_{j,i}^\ell\right\}_{i=2}^5$, because conditional probabilities must add up to one. Our simple estimates for $\left\{\alpha_{j,i}^\ell, \beta_{j,i}^\ell\right\}_{i=2}^5$ minimize the quadratic distance between the observed data on $\left\{P_{i,j}^l\right\}_{l\in M_\ell}$ with those of the model, given the data values for $\left\{E_t^l\right\}_{l\in M_\ell}$.[44] The identification of $\left\{\beta_{j,i}^\ell\right\}_{i=2}^5$ is driven by variations E_t^l across locations of the same type, i.e. $l \in M_\ell$. The identification of $\left\{\alpha_{j,i}^\ell\right\}_{i=2}^5$ is driven by the observed differences in the children's education attainment across households with different parental education, controlling for the variations $\left\{E_t^l\right\}_{l\in M_\ell}$ across locations $l = 1, 2, ...M_\ell$ of the same type ℓ.

Table 11 reports our parameter estimates. Panel A shows the results for rural locations, Panel B for urban slums, and Panel C for formal cities. Panel D complements these results by showing the estimates for urban areas (i.e., integrating the data for urban slums and formal cities). The last column of the table reports the model's R^2, which measure its ability to account for the variation in the conditional transition probabilities within each type of region ℓ (rural, slums, and cities) for each level of parental education $e \in \mathcal{E}$. Table 11 shows that for higher-education groups, the model's fit is quite high for some education groups in some regions, e.g.: high education parents in formal cities, but lower for other groups and areas, e.g.: those high-education households, in rural areas and slums. But even in those cases, the R^2 values are not small, and all in all, our model captures a large share of the variation $P_{i,j}^\ell$ from the variations in E^ℓ across the different rural areas and across urban slums, respectively.[45]

[44] Specifically,

$$\min_{\left\{\alpha_{j,i}^\ell, \beta_{j,i}^\ell\right\}_{i=2}^5} \frac{1}{M_\ell} \sum_{l=1}^{M_\ell} \left[\left(P_{j,1}^\ell - \frac{1}{1 + \sum_{k=2}^5 \exp\left\{\alpha_{j,k}^\ell + \beta_{j,k}^\ell E_t^l\right\}} \right)^2 + \sum_{i=2}^5 \left(P_{j,i}^\ell - \frac{\exp\left\{\alpha_{j,i}^\ell + \beta_{j,i}^\ell E_t^l\right\}}{1 + \sum_{k=2}^5 \exp\left\{\alpha_{j,k}^\ell + \beta_{j,k}^\ell E_t^l\right\}} \right)^2 \right].$$

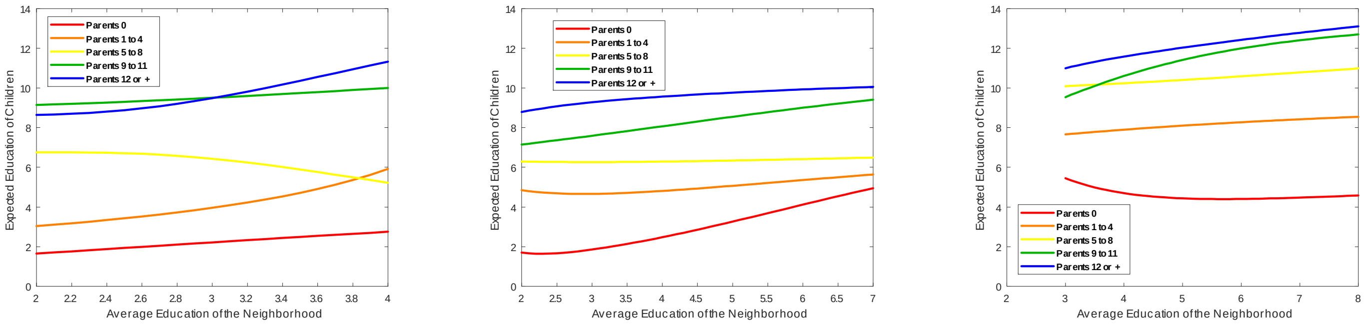
[45] We take the estimates for top-education families in rural areas and slums with qualified conviction given the small and possibly highly selective samples. Similarly, for those of the bottom-education families in the formal cities

Table 11: Parameter Estimates, Education Intergenerational Transitions

Parents' Schooling (j)	Impact on Children's Education: Parents' e_j $\alpha^{\ell}_{j,2}$	$\alpha^{\ell}_{j,3}$	$\alpha^{\ell}_{j,4}$	$\alpha^{\ell}_{j,5}$	Location's E^{ℓ}_t $\beta^{\ell}_{j,2}$	$\beta^{\ell}_{j,3}$	$\beta^{\ell}_{j,4}$	$\beta^{\ell}_{j,5}$	Model's Fit (R^2)
Panel A: Rural Locations ($\ell = R$)									
0	-1.40	-3.78	-153.06	-343.93	0.56	0.73	0.46	0.68	0.91
1-4	0.26	-2.53	3.17	-11.61	0.28	1.06	-3.58	2.96	0.81
5-8	-5.07	-2.32	0.17	-1.94	1.84	0.91	-0.10	0.59	0.70
9-11	2.50	1.47	3.44	1.85	-0.09	0.18	-0.40	0.28	0.36
12+	0.03	2.82	3.50	-0.96	-0.06	-0.91	-1.02	0.69	0.36
Panel B: Urban Slums ($\ell = F$)									
0	-1.39	-4.32	1.73	5.66	0.35	0.85	-2.24	-6.06	0.94
1-4	0.38	-1.34	-0.84	0.73	0.19	0.50	0.18	-0.91	0.89
5-8	0.12	-0.26	0.11	-0.40	0.14	0.36	0.12	-0.22	0.47
9-11	0.36	0.88	-0.12	-0.32	0.08	0.02	0.43	0.11	0.35
12+	-0.54	-0.74	-0.81	-0.55	1.00	1.08	1.26	1.08	0.51
Panel C: Formal Cities ($\ell = C$)									
0	0.38	-0.28	-1.46	2.20	0.06	0.06	0.15	-0.87	0.93
1-4	0.35	-0.52	0.60	-0.65	0.26	0.42	0.23	0.39	0.94
5-8	0.56	2.67	3.53	1.80	0.06	-0.21	-0.18	0.09	0.77
9-11	-0.05	-0.37	-0.74	-0.93	0.21	0.39	0.71	0.79	0.88
12+	-2.99	-1.58	-1.21	-1.74	1.31	1.23	1.33	1.55	0.89
Panel D: All Urban Locations ($\ell = U$)									
0	-1.34	-4.01	-6.50	-0.22	0.32	0.66	0.98	-0.55	0.95
1-4	1.57	0.79	1.99	1.25	-0.02	0.11	-0.12	-0.08	0.94
5-8	2.14	1.46	3.25	1.84	-0.09	0.08	-0.07	0.15	0.78
9-11	1.00	2.52	3.32	2.87	0.03	-0.07	-0.06	0.06	0.91
12+	2.94	4.14	4.31	3.82	-0.04	-0.08	0.04	0.26	0.88

The estimates in Table 11 reproduce the data patterns observed in Section 2. First, parental education is a major driver of the education attainment of children. In particular, the higher the education of the parents (the higher j), the lower the values of $\{\alpha^{\ell}_{j,i}, \beta^{\ell}_{j.i}\}$ for the low i and the higher the values of $\{\alpha^{\ell}_{j,i}, \beta^{\ell}_{j.i}\}$ for the high i. In a nutshell, more educated parents are more likely to have highly educated children. This positive intergenerational correlation holds for all three regions. Second, the model has a substantial explanatory power to explain the variations in the transition probabilities within locations of the same type, as indicated by the substantial R^2 values. This simple finding supports our model's elaboration that the location where children grow affects their lifetime education attainment. It also supports the notion that these location effects can be captured, at least partially, by the region's average education, an endogenous variable driven by the sorting of households across the different locations. Third, and most importantly, the values for $\{\alpha^{\ell}_{j,i}, \beta^{\ell}_{j.i}\}$ vary across parental education e_j and location ℓ, in a way that is consistent with the notion that, relative to rural areas, moving to urban slums creates a stepping-stone for the children of low-educated households but that such a move would present a blockade for the children of high-educated households.

Figure 3: Expected Education Attainment of Children: Different Parents and Locations



(a) Rural Areas *(b) Urban Slums* *(c) Formal Cities*

Figure 3 illustrates this double-edged nature of slums, simultaneously being stepping-stones for some and blockades for others. The figure displays that the children's *expected* education attainment of parents in each education group e in the three different locations. Children of parents with zero (red) and 1-4 (orange) years of education attain on average higher education in urban slums than in rural areas for most of the relevant range of the average education E^{ℓ} in each location ($2-3.5$ in rural areas and $2.5-5$ in urban slums.) The comparison between rural areas and slums switches sign for the children of parents with higher education levels, those with $9-11$ (green) and 12+ (blue.) On average, these children attain lower education in urban slums than in rural areas.

Housing Costs Elasticities. We use the 1991 census data, at the household level, to estimate the elasticity of housing costs to urban location sizes. The Census provides only rents data, which we use as a proxy for housing costs. We obtain the rent costs $P_i^{h,\ell}$ paid for all $i = 1, ..., N^{\ell}$ households living in location $\ell \in$ {slums, cities}. For each household, we record the size of the location s_i^{ℓ} and other controls T_i^{ℓ} (individual income, sanitation, room density, and so on).[46] Then we run a simple log-linear regression on a constant, s^{ℓ} and T_j^{ℓ}, obtaining a size-house price elasticity of 0.3 for formal cities and 0.24 for urban slums.[47] These values are in the ballpark of those of Saize (2010). Moreover, our estimates support the notion that land supply is less elastic in formal cities than in urban slums, which are consistent with Saiz (2010) findings for U.S. cities.[48] We normalize rural housing costs to be zero.[49] Appendix E explains further the different estimatation strategies for these elasticities.

Productivities and Factor Shares. We fix the value of the productivities, X_t^i, to match the labor productivity series for 1980 and 2010 and to match the production and employment shares of each sector in 1980 and 2010. Output data for total, agriculture, and personal services GDP are from the IPEADATA database.[50] Labor force data were obtained from all available censuses from 1950 to 2010. Agriculture and personal services variables (A and S, respectively) are measured directly, while the "non-agriculture" sector variables (N) are constructed by subtracting the corresponding values for agriculture and personal services from the total variables (GDP, employment).

To fix the value of the parameter ϱ, we first classify all the non-agricultural workers between routine and non-routine/cognitive occupations, consistent with our classification of the labor market skills to estimate the conditional lognormal distributions for labor market skills. Since the

[46] We normalize s_i^i by the sample average.

[47] We experimented with $\log(P_i^{h,\ell}) = a_\ell + \xi_1^\ell \log\left(1 + s^\ell\right) + \delta^\ell T_j^\ell + \varepsilon_{i,}^\ell$ and $\log(P_i^{h,\ell}) = a_\ell + \xi_1^\ell \log\left(s^\ell\right) + \delta^\ell T_j^\ell + \varepsilon_i^\ell$, which led to similar results.

[48] Our results are robust to different values within empirically relevant elasticity intervals.

[49] Saiz (2010) and Gyorko(2008) show that a much more elastic housing supply results from higher land availability. We argue that this is the case in the rural areas of Brazil relative to the cities and slums, which justifies taking prices as given. The implicit Cobb-Douglas assumption of housing in the utility function would cause housing prices for the rural areas to act closely as a shifter in the total amount of resources spent by the household.

[50] For 1947-2019, total GDP and agriculture GDP are available in Brazilian reais of 2010. For personal services, we use the series "Serviços - Outros" in real terms from 1980 to 2019.

production function of Q_t^N is Cobb-Douglas, the output share of routine occupations equals ϱ. The value of 0.54 is the average of the data from the censuses in 1980, 1991, 2000, and 2010 for the share of routine labor in the production of the non-agricultural sector, excluding personal services. The listing of all the occupations groups and their breakdown between routine and non-routine is reported in Table D1 in Appendix D, which also contains additional details on the productivity values X_t^i.

Preferences for Consumption. We follow the extensive literature on structural transformation using Stone-Geary preferences to model the structural transformation process. Along these lines, we follow Herrendorf et al. (2014) and set $\alpha_A = 0.01$. For the utility function $u(\cdot)$, we experimented with CRRA preferences with varies values for γ. We settled on $\gamma = 1$, i.e. $u(x) = \ln x$, thus, letting the relative income effects between household consumption and children's expected education to be driven by the parameters β and γ_e, which, along the remaining parameters we calibrated using the equilibrium conditions of the model.

4.2 Internal Calibration

The remaining parameters $\{\alpha_S, \bar{c}_S, \bar{c}_A; \beta, \gamma_e, \varkappa, \tau_F, \xi_{0,F}, \xi_{0,C}\}$ are calibrated by minimizing the distance between the equilibrium implications of the model and the observed data. These parameters affect the general equilibrium of the model, and hence the location, employment, consumption shares, and urbanization patterns. We divide the aggregate shares targets between "Aggregate Location Shares" and "Aggregate Sectoral Shares." Location shares include total population shares in rural and urban locations (slums and cities when available), and per-education bin group across locations. Sector shares include output and employment shares across the different production sectors. The baseline year for the internal calibration is 1980 but we also use the year 2010. The advantage for 1980 is that we can then confront the model's implications for 2010 with Brazilian data. The advantage for 2010 is that we have better data for the break-down of the population across rural areas, urban slums, and formal cities.

We organize the search for the parameter values into two steps. First, conditional on different values of $\{\alpha_S, \bar{c}_S, \bar{c}_A\}$, we search for the values for $\{\beta, \gamma_e, \varkappa, \tau_F, \xi_{0,F}, \xi_{0,C}\}$ most closely associated with Aggregate Location Shares. Second, using these minimization results, we search for the values for $\{\alpha_S, \bar{c}_S, \bar{c}_A\}$ that minimize the distance between the model and the Aggregate Sectoral Shares in the data. In both steps, we minimize the simple quadratic distance between the model's shares and those in the data.

Table 12 summarizes the calibration for the values of all parameter and exogenous state variables. We find that $\alpha_S = 0.147$, $\bar{c}_A = 1.90$, and $\bar{c}_S = 0.20$ lead the model to approximate well the employment shares in personal services and agriculture in 1980. In particular, they reproduce an aggregate consumption share of expenditures on personal services of around 11.63%, as in the Family Budget Research (POF.)[51]

The more interesting parameters are (β, γ_e), which govern the value of the education of children. The parameter β gives the relative weight of the value of children's education relative to that of the household's consumption; the higher its value, the more motivated households are in choosing locations with better education prospects for children. The parameter γ_e governs the strength of the income effect of this valuation relative to the income effect on the valuation of the utility of consumption. Since we normalize consumption utility $u(\cdot)$, if γ_e is higher than one, the income

[51] "Pesquisa de Orçamentos Familiares" (POF, 2017-18.) POF is a sample survey conducted by IBGE to investigate the consumption and spending patterns of the Brazilian population. The survey was first carried in 1998, and it is conducted every six or seven years. It covers the entire country, and households are monitored for 12 months. The main use is for constructing consumption baskets and consumer price indexes. A table defining which consumer products are considered personal services is available upon request to the authors.

effects would be stronger for consumption; if γ_e is less than one, they would be stronger for the education of children. Interestingly, we find that a specification very close to a log-log utility with $\beta = 0.2$ gives the best fit for the model. For the location parameters, we find that the Gumbel curvature shocks are given by $\varkappa = 1.89$ with $\tau_F = 0.86$ provide the closes sorting of of households across regions in 1980. We find that with lower values for $(\varkappa, \tau_F)$, the implied slum population can be much higher than in the data; higher values of $\varkappa$ would push much more of the population toward cities, especially the low-to mid-skilled households. For 2010, we only allowed τ_F to vary from the 1980 calibration. The best approximation was $\tau^F_{2010} = 0.36$.

Table 12: Calibration of the Model to Brazil

Parameter/Exogenous Variable	Value	Target/Criterion/Source
I. Preferences		
α	0.01	Herrendorf et al.(2014)
$\bar{c}^A$	0.20	Aggregate Consumption & Employment Shares, 1980
ς	0.147	Aggregate Consumption & Employment Shares, 1980
$\bar{c}^S$	1.90	Aggregate Consumption & Employment Shares, 1980
γ	1.00	Log-preferences for consumption
β	0.20	Aggregate Location Shares, 1980
γ_e	1.02	Aggregate Location Shares, 1980
$\varkappa$	1.89	Aggregate Location Shares, 1980
τ^F_{1980}	0.86	Aggregate Location Shares, 1980
τ^F_{2010}	0.36	Aggregate Location Shares, 2010
II. Technology		
ϱ	0.54	Share routine labor in non-agriculture.
X^A_{1980}	9.49	Labor Productivity, Agriculture, 1980
X^M_{1980}	5.50	Labor Productivity, Non-Agriculture, 1980
X^S_{1980}	1.99	Labor Productivity, Personal Serv., 1980
X^A_{2010}	25.00	Labor Productivity, Agriculture, 2010
X^M_{2010}	8.67	Labor Productivity, Non-Agriculture, 2010
X^S_{2010}	5.56	Labor Productivity, Personal Serv., 2010
III. City & Slum Dwelling Costs		
$\xi_{0,F}$	0.34	Aggregate Location Shares, 1980
$\xi_{0,C}$	1.80	Aggregate Location Shares, 1980
$\xi_{1,F}$	0.23	Rent data, census 1991
$\xi_{1,C}$	0.30	Rent data, census 1991

4.3 Results

Tables 13, 14, and 15 report the equilibrium implications of our calibrated model and how they compare with the observed data. For 1980 we do not have education data split between slums, and formal cities; thus, the calibration is done using just rural and urban populations.[52] For 2010 we have both cities and slums and can compare the shares from the model and the data. Table 13 shows the overall location and employment shares as well as the average education in the different locations. Table 14 shows the conditional cross-sectional distribution in education for the different locations in 1980 and 2010. Table 15 reports the cross-sectional distribution of education attainments for 2010 predicted by the model calibrated to 1980 and compares it with the observed one in the Brazilian census.

[52] That is, after solving the full model, we add up the populations and compute the population weighted average of cities and slums and compare with the data for urban locations.

Table 13: Calibrated Model and Observed Data for Brazil

Variable	1980 Data	1980 Model	2010 Data	2010 Model
Population: (%)				
Slum Population: μ_t^F	10.69	11.17	18.99	18.84
City Population: μ_t^C	60.57	53.19	67.33	62.23
Agriculture: (%)				
Employment Share: L_t^A	25.72	30.81	12.85	16.82
Output Share: Y_t^A/Y	3.44	2.56	4.11	1.78
Personal Services: (%)				
Employment Share: L_t^S	12.28	9.83	16.69	14.87
Output Share: Y_t^S/Y	11.28	9.34	13.31	12.09
Average Schooling: (years)				
Rural Areas:	1.96	2.28	3.81	4.02
Urban Slums:	NA	2.29	5.95	6.16
Cities, Formal:	NA	6.41	7.49	7.86
Urban Areas:	5.43	5.69	7.41	7.47
Education Mobility: Brazil (%)				
Upward mobility	50.24	55.29	54.90	60.90
Immobility	38.29	37.79	36.14	30.89
Downward mobility	19.95	17.71	15.13	15.89

Overall, we find that the model approximates the data rather well, especially in light of the large ratio of targets to internally calibrated parameters. To be sure, the fit is not perfect. In terms of employment shares, Table 13 shows that the agriculture labor share is overestimated while that of personal services is underestimated. In terms of value-added shares, the model underestimates the output share of agriculture but overestimates that of personal services. These patterns hold for both 1980 and 2010. In terms of population shares across locations, the model fits the data more closely. It closely resembles the population shares in urban slums, albeit it under-predicts the shares in formal cities. Interestingly, Table 13 shows that the model is very successful in replicating the allocation of household types across average education attainment in the rural and urban locations in 1980 and across rural areas, urban slums, and formal cities in 2010.

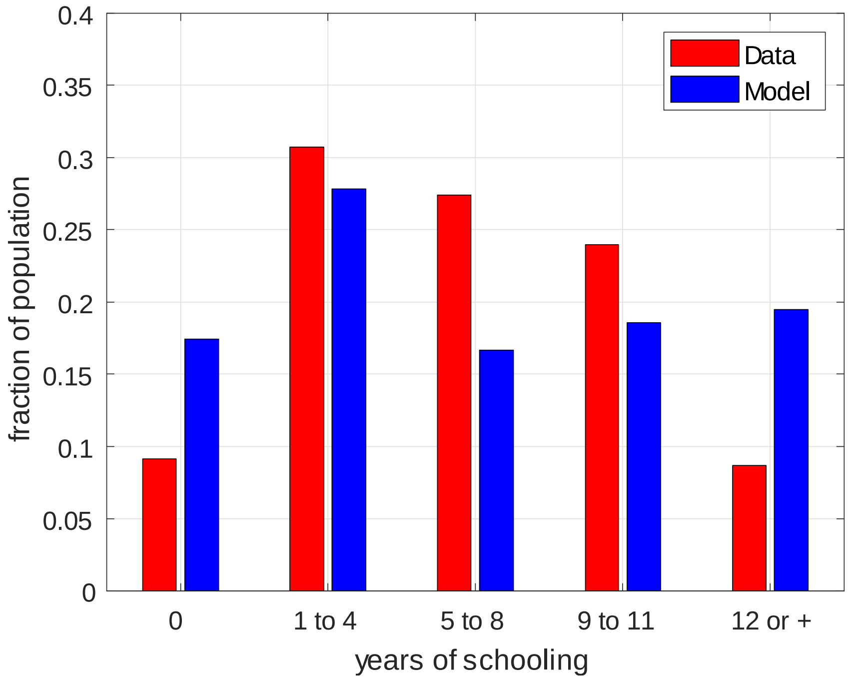
Consistent with this last finding, Table 14 shows that, indeed, the model does very well at replicating the observed allocation of the households with different education attainment levels across locations.

Table 14: Cross-Sectional Education Distributions (%): Model and Data for Brazil

	1980				2010					
	Rural		Urban		Rural		Slums		Cities	
Schooling	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data
0	50.63	47.19	8.06	14.83	29.95	19.47	11.25	7.39	0.47	5.90
1-4	35.97	45.92	52.52	46.17	40.42	51.50	36.04	32.50	26.60	23.95
5-8	8.45	4.27	16.11	16.77	14.06	19.89	24.41	36.74	33.01	29.42
9-11	4.25	1.94	12.87	12.77	13.22	7.85	21.02	21.10	28.68	29.32
12+	0.70	0.68	10.45	9.45	2.35	1.29	7.27	2.27	11.24	11.41
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

More interestingly, despite not being targets of our calibration, the model reproduces remarkably well the overall aspects of the distribution of human capital across rural and urban areas. The numbers of average years of schooling in rural areas obtained from the model are very close to the data. The same applies to the numbers for urban areas.

Figure 4: Brazil's Population in 2010: Model and Data



Finally, we confront the model's implied cross-section distribution of education for the country in 2010. This distribution was in no measure a target of the calibration. Figure 4 shows that the model misses some aspects but also reproduces some aspects of the observed distribution.[53] On the negative side, the model overpredicts the fractions of the Brazilian population at both extremes of the education distribution. On the low end, the percentage of population with no education is around 9.16% in the data, and the model predicts it would be 17.46%. On the high-end, those with 12+ years of schooling account for 8.71% of the population in 2010 while the models would predict them to be much higher, 19.49%. On the positive side, the model predicts much better the fraction with 1 to 4 years of education (30.74% in the data and 27.83% in the model) and the fraction with 9 to 11 years of schooling (23.97% and 18.57%.) These two groups are pivotal for the conformation of slums. The first group contains the majority of the households deciding between the rural areas or the urban slums, while the second group contains the majority those deciding between the slums or the formal cities. All in all, we consider the calibrated model can be insightful for counterfactual experiments.

5 Counterfactuals: Causes and Consequences of Slums

In this section, we use our general equilibrium calibrated model to explore the causes and consequences of urban slums. We also explore the implications of school reforms. Using our simple but fully specified general equilibrium model allows us to capture the endogenous response in the goods and labor markets and, more importantly, the endogenous determination of peer effects across locations. These general equilibrium responses can amplify or dampen the responses in the economy.

[53] Here we use the census of 2000 because only some ranges and not actual years of schooling were available in the census of 2010.

5.1 Causes: Emergence of Slums in General Equilibrium

We consider two different baselines, Brazil in 1980 and Brazil in 2010. Compared to these baselines, we ask how would the equilibrium change if: *(a)* Housing prices in the city would have been reduced by 50%, possibly as the result of relaxing regulatory restrictions; *(b)* agricultural productivity would have been 50% lower; *(c)* the fundamental quality of the schools in the rural areas would have been the same as in the formal cities. Exercises *(a)* and *(b)* have counterparts in the literature but in models without slums, while exercise (c) has been much less explored.[54]

Not surprisingly, housing costs in the formal city must be part of the reason why slums arise. Table 15 shows the results for Brazil in 1980. Column 3 of the table considers the resulting equilibrium when the units of the N good needed for a house are reduced by 50%. This reduction in housing costs for the city decreases by almost half the slum dwelling population (from 11.6% to 6.5%.) The rural population is reduced, but the main adjustment would be in the formal city population, going from 55.4% to 65.25%. The overall urban population increases, as well as the shift of employment away from agriculture. Notice that this reduction in ξ_0^c leads to housing costs falling by more than 50%, and this is driven by a large general equilibrium response in the non-agricultural prices from 21.7 to 15.5, which more than compensates for the increase in housing prices from the size of the city. This also explains the substantial fall in housing costs in the slums, from 7.9 to 4.05. Also, the skill prices of all urban occupations fall substantially as a result of the expansions in the supply of those skills and the reduction in the demand for housing construction.

These general equilibrium responses in goods and labor prices dampen the expansion of the formal cities that would have arisen from the reducing in housing prices. Yet, perhaps the most interestingly general equilibrium response is on the re-configuration of the peer effects E_t^ℓ across the three regions. Notice that relative to the benchmark, all the regional averages E_t^ℓ are lower. This is a natural result of the re-composition of the population across locations: the expansion of the cities is driven by lower-than-average educated households, while the contraction of rural areas is driven by higher-than-average dwellers moving away from the countryside. Most of the recomposition in the slums is by an expansion of less educated households from rural areas and a contraction by losing their higher education who are more likely to go to formal cities. This general equilibrium regional reconfiguration of the peer effects in education also plays an important role in the other counterfactual exercises, and we discuss them further below.

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[54] For example, (a) echoes Hsieh and Moretti (2019), and (b) is inline with the focus of Duarte and Restuccia (2010), Herrendorf et. al. (2014) and others.

Table 15: Causes of Slums: Counterfactuals in 1980

	Baseline	City Housing Costs	Agricult. Productiv.	School Quality
Variable	1980 Calibration	$\xi_0^c \times \frac{1}{2}$	$X_{1980}^A \times \frac{1}{2}$	$\{\alpha^R, \beta^R\} = \{\alpha^C, \beta^C\}$
I. Country's Aggregate Shares and Averages				
Population (%)				
Rural	32.95	28.30	63.51	39.52
Slums	11.64	6.47	1.62	5.47
Cities	55.40	65.23	34.87	55.01
Agriculture (%)				
Employment	32.10	27.34	61.78	38.24
Output	2.56	3.45	28.64	1.92
Pers.Serv.(%)				
Employment	10.23	11.64	31.06	9.73
Output	9.34	9.92	1.71	9.46
Prices:				
Non-agriculture.	21.72	15.51	1.61	35.40
Pers.Services, Rural.	3.31	2.96	0.96	3.19
Pers.Services, Urban.	24.32	15.61	1.12	39.95
Housing, Slums.	7.92	4.05	0.57	12.62
Housing, Cities.	44.44	17.94	3.15	72.36
Wages:				
Unskilled, Rural	9.49	9.49	4.75	9.49
Routine, Rural	6.60	5.93	1.91	6.35
Routine, Urban	48.39	31.22	3.68	79.50
Non-Routine, Urban	77.03	50.36	5.51	124.34
Aver.School.yrs.				
Rural	2.28	1.85	3.15	2.11
Slums	2.29	1.88	3.89	3.05
Cities	6.41	6.02	7.19	6.49
Urban Areas:	5.70	5.64	7.04	6.18

As expected from previous models, a lower level of agricultural productivity reduces the size of urban areas. Our model adds the fact that much of the response is in the incidence of urban slums. Indeed, column 4 of Table 15 reports that if the Brazilian economy in 1980 had its agricultural productivity to be just half of the baseline estimated level then Brazilian slums would have all but disappeared. They would have accounted for just 1.6% of the entire population. The economy would have been much more rural, with 63.5% of the population outside urban areas. The population of the formal cities would also have been substantially lower. The lower agricultural productivity would make the economy allocate three times more of its employment, 31%, towards agriculture, and routine and non-routine skills would be much lower. Indeed, the Brazilian economy would mimic much more closely the observations of much less developed economies in Africa and Asia or even the Brazilian economy of 1950. Notice also that the average schooling levels of all regions would go up, since the regional recomposition is towards the lower education locations, namely the rural areas.

The most unexplored and innovative counterfactual is in terms of school quality. Here, we show that lower school quality in rural areas relative to the city can be a substantial driver in the slum formation for a country with conditions similar to those of Brazil in 1980. The last column of Table 15 explores the counterfactual results if in Brazil 1980 the schooling opportunities in rural areas would have been fundamentally the same as in the cities. Specifically, we consider the resulting allocations if the parameters $\left\{\alpha_{i,j}^R, \beta_{i,j}^R\right\}$ that govern the intergenerational transition probabilities in rural areas were set equal to those in the cities, $\left\{\alpha_{i,j}^{C},\, \beta_{i,j}^{C}\right\}$, but allow the endogenous reconfiguration of exposure effects, $\left\{E^{R}, E^{F}, E^{C}\right\}$ to determine the equilibrium difference in the education prospects across the three regions.

Results in the table suggest that, indeed, the lower quality in the rural schools induced a higher fraction of the population living in urban slums. If households had access to the same fundamental quality of the schools in rural areas, then the country would have had less than 50% of the slums that were observed in 1980 in Brazil. In terms of sizes, the adjustment of the population would have been from the rural area, but there would have been a substantial reconfiguration in the composition of the education groups across the different regions. Having access to better schools would lead to almost 40% of the population being retained in rural areas and an expansion in agricultural output and employment. However, in general equilibrium, the reduction in the supply of routine and non-routine skills in urban areas would lead to much higher prices of non-agriculture goods and of personal services in urban areas and higher housing prices on one hand, and much higher prices for both routine and non-routine skills in urban areas on the other. Higher skills prices in urban areas dampen the otherwise stronger de-urbanization force of the improvement in rural areas.

Interestingly, the school reform would increase the urban-rural disparity in the average education, as the urban E^{F} and E^{C} both go up and the rural E^{R} go down. This is driven by higher selectivity in both cities and slums, in the sense that only those with high levels of urban valuable routine or non-routine skills would opt to live there, and that those with higher labor market skills are more likely to have higher levels of education.

While the main directions are very similar, the quantitative results for the Brazilian economy in 2010 are remarkably different. Compared to 1980, the baseline productivity and the adult population's cross-section distribution of schooling are both higher in 2010, and, as shown by the first column of Table 16, the economy is much less rural and agricultural. Under these circumstances, the response is driven more by the realignment between the two urban locations, cities and slums. In general, we obtain much smaller contractions in the equilibrium slum population to the same forces explored above. First, a reduction in units of non-agricultural goods N needed for a house, i.e. reducing ξ_0^c by $\frac{1}{2}$ reduces the slum population by just 3 percentage points (p.p.). Interestingly, the selectivity of the formal cities does not fall with the expansion and this is driven by the housing cost elasticity which implies a relatively smaller decline in the city. Both rural areas and slums end up with a lower average education levels E^{ℓ} relative to the baseline. Second, a 50% collapse in agricultural productivity, despite inducing a 28% increase in the rural population, will not lead to a collapse of the urban slums. Instead, the slum population would fall by only 2 p.p. and the population in the formal city would fall by 3 p.p. By 2010 the agricultural productivity is high enough that even with such a large decline, the economy would remain mostly non-agricultural. Notice, however, that the equilibrium prices of skills, goods and houses would all fall, as driven by the non-homotheticity of preferences.

Table 16: Causes of Slums: Counterfactuals in 2010

	Baseline	City Housing Costs	Agricult. Productiv.	School Quality
Variable	2010	$\xi_0^c \times \frac{1}{2}$	$X_{2010}^A \times \frac{1}{2}$	$\{\alpha^R, \beta^R\} = \{\alpha^C, \beta^C\}$
I. Country's Aggregate Shares and Averages				
Population (%)				
Rural	17.98	15.82	23.03	21.18
Slums	19.06	16.02	17.15	18.71
Cities	62.96	68.16	59.82	60.11
Agriculture (%)				
Employment	17.03	14.98	21.74	19.85
Output	1.78	2.17	3.25	1.60
Pers.Serv.(%)				
Employment	15.04	16.05	14.36	15.06
Output	12.09	12.88	11.96	12.28
Prices:				
Non-agriculture.	20.08	15.03	7.04	26.58
Pers.Serv, Rural.	2.17	2.11	0.97	2.05
Pers.Serv, Urban.	13.03	11.72	4.59	17.35
Housing, Slums.	7.10	3.45	2.48	9.85
Housing, Cities.	41.78	34.47	14.57	55.04
Wages:				
Unskilled, Rural	25.00	25.00	12.50	25.00
Routine, Rural	12.08	12.08	5.38	11.41
Routine, Urban	72.45	65.19	25.50	96.45
Non-Routine, Urban	108.69	65.54	37.96	143.02
Aver.School.yrs.				
Rural	4.02	2.81	4.20	4.36
Slums	6.16	5.74	6.54	6.08
Cities	7.87	8.01	7.96	7.97
Urban Areas:	7.47	7.57	7.64	7.52

The responses to making city school quality available in rural areas, i.e.: $\{\alpha^R, \beta^R\} = \{\alpha^C, \beta^C\}$, are quite informative since they show the limitations of a policy that we found quite effective in 1980. For the Brazilian economy of 2010, the results are much smaller. Naturally, to gather the benefits of such a policy some families would have moved back from urban to rural areas, which for many would entail a drastic curtailment of the labor market opportunities. Hence, the model indicates that the equilibrium reallocation of households would be just above 3 p.p. of the population. There would be some reshuffling within the slums, but with relatively minor implications for the average levels of education E^ℓ, and hence little impact on the education prospects of children growing up in formal cities and urban slums. As we explain further down below, for 2010, a more effective policy for Brazil would be making city school quality available in urban slums, i.e.: $\{\alpha^F, \beta^F\} = \{\alpha^C, \beta^C\}$.

Besides their size, the composition of the population in urban slums –as well as in rural areas and formal cities– is endogenously determined in equilibrium. Table 17 reports the cross-section distribution of education level attainment of the three different locations in the baseline and in the three counterfactual economies. The top panel reports the cases for Brazil 1980 and the bottom one for Brazil 2010.

Table 17: Cross-Section Distributions of Education: Baseline and Counterfactuals

Education Group	Baseline 1980 & 2010			City Housing Costs $\xi_0^c \times \frac{1}{2}$			Agricult. Productiv. $X^A \times \frac{1}{2}$			School Quality $\{\alpha^R, \beta^R\} = \{\alpha^C, \beta^C\}$		
I. Brazil, 1980												
	Rural	Slums	Cities	Rural	Slums	Cities	Rural	Slums	Cities	Rural	Slums	Cities
0	50.6	39.9	1.5	60.2	49.3	2.8	34.3	9.7	0.4	49.9	31.2	1.2
1-4	36.0	52.4	52.5	28.9	45.2	55.1	47.3	71.3	45.4	39.5	54.2	51.8
5-8	8.5	5.7	18.3	6.8	4.1	17.5	10.2	12.7	19.8	8.0	7.3	18.3
9-11	4.3	1.5	15.2	3.4	1.1	13.8	6.4	4.6	16.9	2.2	6.2	16.0
12+	0.7	0.5	12.5	0.7	0.3	10.8	1.8	1.8	17.5	0.5	1.1	12.7
II. Brazil, 2010												
	Rural	Slums	Cities	Rural	Slums	Cities	Rural	Slums	Cities	Rural	Slums	Cities
0	29.9	11.3	0.5	56.5	24.7	3.0	26.5	8.7	0.4	23.8	13.4	0.5
1-4	40.4	36.0	26.6	21.4	33.6	32.7	43.1	34.2	25.2	38.4	36.5	26.5
5-8	14.1	24.4	33.0	10.2	11.9	21.9	14.0	26.1	33.9	26.0	19.9	31.2
9-11	13.2	21.0	28.7	8.2	13.0	19.5	13.8	23.1	28.9	10.3	22.6	30.0
12+	2.4	7.3	11.2	3.7	16.8	22.8	2.6	7.9	11.6	1.6	7.7	11.8

The first three columns of Table 17 show the equilibrium cross-section distributions by regions generated by the baseline calibrated model for 1980 and 2010. As discussed above, they reproduce fairly well the location patterns observed in the data: Rural areas are mostly populated by the two lowest education groups, 0 and $1-4$. Urban slums are predominantly populated by those with $1-4$, but also from the two other lower-end groups. In particular, in 1980 they attracted many individuals with no schooling, while in 2010 slums were substantially populated by adults with $5-8$. Formal cities have a much larger shares of their population in the higher education groups. From 1980 to 2010 the education distribution in Brazil has markedly shifted upwards but the equilibrium ranking remains: formal cities dominate urban slums which in turn dominate rural areas.

Associated with the expansion of the formal cities and the contraction of the rural areas, lower housing costs would lead to a downward shift in the cross-section distribution of schooling attainments in all the regions. Table 17 (columns 5-7) shows that the contraction in the rural population would be mostly from those with higher education. Thus, not only do rural areas become smaller but also even more heavily populated by low-education individuals. Similarly, slums and formal cities would become much more intensively populated by lower-education individuals as more of them would enter the urban regions. A different pattern is associated with lower agricultural productivity. Here comparative advantage would push harder for those with lower non-agricultural skills to move to the rural areas, and thus both urban regions become more highly populated by higher education individuals. Interestingly, the school reform counterfactual seems to generate different reallocation patterns: while in 1980 the cross-section distribution would shift upwards in the slums, it would however remain relatively constant in 2010. For the latter year, the rural areas are the ones that would become relatively more highly populated by mid-level educated individuals, from 14% in the baseline to 26%.

5.2 Urban Slums: Stepping-Stones, Blockades and Shields

We now use our model to explore whether the option of living in slums has been a stepping-stone or a blockade for the human capital formation of individual households and Brazil as a whole. Since slums are endogenous, the proper question is: What would the equilibrium in the Brazilian economy have looked like under conditions that would lead to the eradication or reduction of urban slums? To answer this question we consider two counterfactual interventions. First, we consider the case in which urban slums are completely cracked-down, i.e. setting $\tau^F = 1$, and hence making living there impossible. Second, we reproduce while adding some new results, the previous experiment in which we consider an intervention that facilitates entry into formal cities by assuming that constructing a house there requires only half of the units of the N goods of the baseline case. These two counterfactual interventions are quite different from each other: the first eliminates one option and thus increases the cost of households to locate in urban locations; the second intervention does the opposite since reduces the cost of one option.

The general equilibrium responses of these counterfactual interventions reshape the labor market opportunities for adults and the education prospects for children, changing the allocation of the population across regions and employment by sectors. The reallocation of the population across locations reshapes the next-period cross-section distribution of education attainment levels because of two distinctive forces. First, the reassignment of households across locations directly changes the type $\{\alpha^{\ell}_{i,j}, \beta^{\ell}_{i,j}\}$ of schools for some children. Second, changes in the assignment of households across locations change the exposure effects E^{ℓ}_{t} which affect the educational outcomes of all the children in each location. For the different households, these two forces can offset or reinforce each other, depending on the counterfactual intervention.

Tables 18 and 19 compare the baseline results with the two counterfactuals for 1980 and 2010. Table 18 reports the aggregate consequences, i.e. for Brazil as a whole, and Table 19 reports the consequences for the households across education levels in terms of inter-generational mobility in education attainment.

Table 18: Aggregate Implications of Slum-Reducing Policies

Year	1980			2010		
Equilibrium Result	Baseline	$\tau^F_{1980} = 1$	$\xi^c_0 \times \frac{1}{2}$	Baseline	$\tau^F_{2010} = 1$	$\xi^c_0 \times \frac{1}{2}$
I. Aggregate Statistics						
Population, by Location						
Rural	32.95	41.28	28.30	17.98	21.72	15.82
Slums	11.64	0.00	6.47	19.06	0.00	16.02
Cities	55.40	58.72	65.23	62.96	78.28	68.16
Employment, by Sector:						
Agriculture	32.10	40.50	27.34	17.03	20.62	14.98
Non-agriculture	57.67	50.59	61.02	67.93	65.24	68.97
Services	10.23	8.91	11.64	15.04	14.13	16.05
Average Education, by Location						
Rural	2.28	2.11	1.85	4.02	3.80	2.81
Slums	2.29	–	1.88	6.16	–	5.74
Cities	6.41	6.30	6.02	7.87	7.69	8.01
II. Country's Cross-Section, 30 Years Later						
Population, by Schooling Years						
0	17.47	17.53	17.16	4.98	4.85	6.93
1-4	27.83	27.77	25.06	19.07	18.09	19.22
5-8	16.65	16.38	16.27	21.15	17.32	18.11
9-11	18.57	18.63	21.10	23.51	23.56	20.24
12+	19.48	19.68	20.41	31.29	36.18	35.50

Consider first the policy of cracking-down urban slums by setting $\tau^F = 1$, contained in columns 3 (for 1980) and 6 (for 2010) of Tables 18 and 19. Panel I of Table 18 shows that relative to their respective baselines, cracking-down slums would lead to expansions of the rural population and of agricultural employment. Thus, the option of living in slums seems to have enhanced Brazil's structural transformation and urbanization. The effects are much larger for 1980 than in 2010, which is very reasonable since at that time Brazil's productivity in agriculture was lower and its population was significantly less educated. In 1980, the main response is an increase in the rural population, from 33% to 41%, with a relatively minor expansion in formal cities. In 2010, the main response is a large increase in the population in formal cities, from 63% to 78%, with a much smaller expansion in the rural population.

Consider now the other policy of reducing urban slums by reducing city housing requirements by half, i.e. $\xi_0^c \times \frac{1}{2}$, contained in columns 4 (for 1980) and 7 (for 2010) of both tables. Panel I of Table 18 shows that this policy would lead to expansions in the total urban population while reducing the population in slums. As seen before in Table 18, the responses for 2010 are smaller than for 1980. In 1980, this policy would have cut almost half the slum population; in 2010 it would reduce it proportionally much less. The differences are due to the equilibrium increase in housing prices in the city across the two years, as we can see from the tables, and to the fact that in 2010 productivity in agriculture was relatively high when compared to 1980.

The consequences 30 years later of cracking-down slums 1980, i.e. by setting $\tau_{1980}^F = 1$, are surprisingly minor, but the same policy in 2010 would have more substantial effects. As shown by Panel II of Table 18, this policy in 1980 would lead to virtually the same cross-section distribution of education attainments in 2010 as in the baseline case. Yet, the elimination of slums in 2010 by setting $\tau_{2010}^F = 1$ would enhance the human capital formation of the country, increasing by 5 p.p. the share of Brazilians with more than 12 years of formal education in 2040, mostly in exchange for a lower share of Brazilians with only 5-8 years of formal education.

Interestingly, the intervention of reducing city housing costs, i.e. $\xi_0^c \times \frac{1}{2}$, would lead to more uneven effects. Implementing those policies in 1980 would have marginally increased the mass of individuals in the higher education groups in 2010. But implementing such a policy in 2010 would have increased polarization in the education attainment, leading to higher fractions of Brazilians at the extremes, 0 and with 12+ years of schooling As shown by Panel I of Table 18, the lower city housing costs would lead to a stronger fragmentation of the exposure effects E^ℓ as the respectively marginally more educated families leave from the rural areas to the slums, and from the slums to the cities.

Table 19: Slum-Reducing Policies Implications on Inter-generational Mobility

	1980-2010			2010-2040		
	Baseline	$\tau^F_{1980}=1$	$\xi^c_0 \times \frac{1}{2}$	Baseline	$\tau^F_{2010}=1$	$\xi^c_0 \times \frac{1}{2}$
Upward mobility: Brazil	55.29	55.44	57.66	60.90	65.60	63.94
0 yrs of school.	61.44	48.82	46.10	71.67	71.68	66.83
1-4 yrs of school.	51.09	54.63	60.17	72.32	69.61	67.23
5-8 yrs of school.	51.11	67.55	69.22	67.29	68.10	66.31
9-11 yrs of school.	37.70	47.84	46.92	62.04	54.55	48.96
Rural	37.62	35.21	35.11	54.30	51.12	46.53
Slums	36.38	-	36.37	37.88	-	48.30
Cities	69.78	69.66	69.40	69.76	69.61	71.66
Immobility:Brazil	37.79	37.90	36.59	30.89	28.59	34.98
0 yrs of school.	38.56	51.18	53.90	28.33	28.32	33.67
1-4 yrs of school.	41.82	35.02	31.21	22.34	26.20	27.85
5-8 yrs of school.	25.11	14.73	14.68	29.40	12.38	15.65
9-11 yrs of school.	32.88	37.22	37.48	23.76	35.40	39.02
12 or + yrs of school.	53.66	60.57	58.68	79.43	69.46	63.15
Rural	48.83	51.25	52.91	28.23	30.78	41.06
Slums	49.60	-	51.53	43.06	-	35.78
Cities	28.74	28.52	28.03	27.97	27.99	33.37
Downward mobility: Brazil	17.71	17.66	16.99	15.89	14.02	18.21
1-4 yrs of school.	7.09	10.35	8.62	5.34	4.19	4.92
5-8 yrs of school.	23.79	17.72	16.11	3.32	19.52	18.04
9-11 yrs of school.	29.42	14.95	15.60	14.20	10.05	12.02
12 or + yrs of school.	46.34	39.43	41.32	20.57	30.54	36.85
Rural	27.98	28.07	30.72	26.77	28.37	32.46
Slums	23.60	-	24.13	24.59	-	31.91
Cities	10.37	10.34	10.33	10.16	10.01	11.68

Table 19 reveals that counterfactual interventions would have substantial impacts on the degrees of intergenerational mobility across the different education groups. Our results indicate that often slums can simultaneously serve as stepping stones for some households and blockades for others. In both, 1980 and 2010, we find that households at the very bottom of the education distribution benefit from having the option of living in slums. For 2010, we also find that having the option of living in slums serves as a stepping-stone for households with middle levels of education. For those at the bottom, moving to a slum improves the quality of education, because for $e = 0$ the differences between both school types, $\left\{\alpha^R_{i,j}, \beta^R_{i,j}\right\}$ vs. $\left\{\alpha^F_{i,j}, \beta^F_{i,j}\right\}$, and exposure effect, and E^R vs. E^F, is more favorable in the slums. Eliminating the option of slums by setting $\tau^F = 1$ reduces the opportunities for those households to rear children with higher education. A countervailing force is that the equilibrium value of the peer effect E^R is higher when $\tau^F = 1$.

For all the other groups, the effects tend to move in the opposite direction. First, for higher e, the comparison between $\left\{\alpha^R_{i,j}, \beta^R_{i,j}\right\}$ vs. $\left\{\alpha^F_{i,j}, \beta^F_{i,j}\right\}$ turns unfavorable to slums. Moreover, for those at higher levels of education, living in the formal city is the dominant choice and thus the impact of these interventions is through the equilibrium configuration of the level of peer effects in the city, E^C. By allowing the fragmentation of the urban peer effects, slums tend to increase the equilibrium average value E^C and hence reinforce the education prospects of the children growing up in the formal city.

Underneath the rather small aggregate responses in 1980, the counterfactual exercises reveal very sizeable micro-level effects. Interestingly, the micro effects are larger for 1980 than for those of 2010, when we would have detected larger macro responses. Comparing the differences between the baseline in 1980 and the case of $\tau^F_{1980} = 1$, shows that the upward mobility of households with 0 years of schooling would have fallen dramatically, by almost 13 p.p., while the upward mobility of all the other education groups would have increased. Households in the $5-8$ and $9-11$ years of education would have exhibited the larger improvements without slums, as both their upward mobility would have increased and their downward mobility would have declined sharply, by more than 14 p.p. To be sure, the large gains for the lowest education group would have been more than offset by the losses of those in the higher levels. For 2010, the micro impacts of $\tau^F_{2010} = 1$ would have been significant.

Eliminating slums in 2010 would have more negatively impacted households with $5-8$ and with $9-11$ years of schooling, mostly by reducing upward mobility, from 62% to 56%, for the first group and by increasing downward mobility, from 3% to 20%, for the second. For these households, slums are a stepping-stone for their children. By eliminating them, this policy would push some of these households to the rural areas and, according to the model, this would reduce the expected education attainment of their children. The elimination of slums would also negatively impact households at the top end of the education distribution because their downward mobility would have increased from 21% to 31%. These households mostly inhabit formal cities, and for them slums are a shield from the lower education households. The elimination of slums would lead to a reduction in E^C and hence on the education prospects of their children.

Interestingly, the seemingly better-intentioned intervention of eradicating slums not by sheer force, i.e. $\tau^F = 1$, but by reducing housing costs in the formal cities can have more detrimental implications for upward mobility for those at the bottom of the distribution. Those results are in columns 4 and 7 for 1980 and 2010 of the tables 18 and 19, respectively. With the lower housing costs the formal cities expand mostly by attracting otherwise slum dwellers, and slums would attract otherwise rural dwellers. Because of selection, these reallocations would deplete the rural areas not only by reducing their population but also by reducing the average exposure E^R. As a result, the implementation of such policies in 1980 and 2010 would impact even more negatively the upward mobility of households with 0 years of education than the harsher policies of setting $\tau^F = 1$.

For households with $1-4$, the impact of the housing subsidy policies would be different in the two years. In 1980 it would be very beneficial as it would increase upward mobility because of households migrating from rural areas to slums or from slums to formal cities, but in 2010 the effects on upward mobility would be detrimental because at that time most of those households would be in the slums and they would be less likely to migrate to the formal city relative to the higher education households. For households at the upper end of the distribution, the effects of reducing slums by these policies would be even more detrimental. In this case, the expansion of the formal cities is even more substantial, but the additional force is an increase in housing cost in the city relative to skill prices that leads some of these households to the slums, despite the negative consequences for their children's education.

All in all, these exercises suggest that policies that restrict slums or expand access to formal cities can have a relatively limited macro impacts on the overall educational attainment in each region. However, In accordance to the stage of development of a country, these policies would lead to major distributional consequences, boosting households at the opposite ends of the distributions from which slums could be seen as stepping-stones (lower-end) or shields (upper-end), but impairing others for whom slums are blockades in their children's education. These countervailing forces are driven by the regional realignment of the peer effects, E^ℓ, which are a crucial component of the general equilibrium of the economy.

5.3 Improving Schools: Rural Areas or Urban Slums?

Driven by the countervailing responses on the peer effects E^{ℓ} across locations, the previous subsection found both limitations at the aggregate level and significant distributional disruptions of two natural policies aimed at reducing urban slums. In this section, we explore the implications of policies that change the fundamental qualities of schools in less advantageous locations. These exercises can be seen as natural alternatives or complementary to the socially and fiscally costly policies of cracking-down slums by force or reducing them by decreasing housing costs in the formal city.

Specifically, we explore the consequences of transplanting the estimated parameters $\{\alpha^{C}_{i,j}, \beta^{C}_{i,j}\}$ that govern the education attainment probabilities of children growing up in formal cities to either rural areas, urban slums, or to both and compare the implications of the resulting equilibria with the baseline for 1980 and 2010. As discussed above, the parameter estimates indicate that, for each parental education e and for the same level of E^{ℓ}, the city parameters $\{\alpha^{C}_{i,j}, \beta^{C}_{i,j}\}$ lead to better education prospects than either $\{\alpha^{R}_{i,j}, \beta^{R}_{i,j}\}$ or $\{\alpha^{F}_{i,j}, \beta^{F}_{i,j}\}$. Improving the schools in one or two regions would lead to reallocations of the population across the three types of locations, thus changing the equilibrium values of E^{ℓ}. We discuss in detail whether these realignments of E^{ℓ} reinforce or dampen the impact of the changes in $\{\alpha^{\ell}_{i,j}, \beta^{\ell}_{i,j}\}$.

Tables 20 and 21 report the results for 1980 and 2010, respectively. The first panel in the tables reports the impact of population allocation across locations and of employment across sectors. The second panel reports the resulting cross-section distribution for Brazil as a whole 30 years later. The second column reports the baseline results for the year of each table. The third column reports the resulting equilibrium outcomes when only the schools in slums are upgraded to those in the formal cities, i.e. $\{\alpha^{F}_{i,j}, \beta^{F}_{i,j}\} = \{\alpha^{C}_{i,j}, \beta^{C}_{i,j}\}$ The fourth column reports the resulting equilibrium outcomes when only the schools in rural areas are upgraded to those in the formal cities, i.e. $\{\alpha^{R}_{i,j}, \beta^{R}_{i,j}\} = \{\alpha^{C}_{i,j}, \beta^{C}_{i,j}\}$ Finally, the firth column reports the resulting equilibrium outcomes when the both schools in slums and rural areas are upgraded to those in the formal cities, i.e. $\{\alpha^{R}_{i,j}, \beta^{R}_{i,j}\} = \{\alpha^{F}_{i,j}, \beta^{F}_{i,j}\} = \{\alpha^{C}_{i,j}, \beta^{C}_{i,j}\}$.

Table 20: Implementing City Schools in the Rest of Brazil 1980

	Baseline	School Quality $\{\alpha^{\ell}_{i,j}, \beta^{\ell}_{i,j}\}$		
Variable	Calibration	Slums=Cities	Rural=Cities	Rural & Slums=Cities
I. Aggregate Statistics for the Economy in 1980				
Population, by Location				
Rural	32.95	28.81	39.52	35.39
Slums	11.64	24.41	5.47	17.25
Cities	55.40	46.78	55.01	47.36
Employment, by Sector:				
Agriculture	32.10	27.81	38.24	33.70
Non-agriculture	57.67	61.37	52.03	55.72
Services	10.23	10.82	9.73	10.58
II. Cross-Section Distribution of Education, Brazil as a whole 2010				
Schooling Group				
0	17.47	10.99	9.36	8.14
1-4	27.83	26.70	22.10	21.23
5-8	16.65	19.59	18.39	18.42
9-11	18.57	19.63	24.71	26.07
12+	19.48	23.10	25.45	26.15

For 1980, Table 20 shows that these policies would have substantial impacts on the economy of Brazil. On the one hand, improving the schools only in slums would have greatly increased the populations in the urban slums, from 11% to 24%. The expansion would have mostly come from a large reduction in the formal city population but also from a reduction in the rural population. This policy would have accelerated the structural transformation of Brazil, by moving employment away from agriculture. On the other hand, a policy of only improving the schools in rural areas would have greatly reduced the population in urban slums. In this case, most of the reduction in the slum population would have been accounted for by an increase in the rural population, as the size of formal cities would have remained essentially unchanged. Furthermore, this policy would slow-down the movement of employment away from agriculture. Finally, a policy of improving both sets of schools would lead to smaller changes but in the direction of reduced urbanization and structural transformation, but larger slums.

Table 21 also shows that all these school policy counterfactuals would have led to large improvements in Brazil's education attainment distribution. In particular, they would have decreased the illiterate population in Brazil and would have expanded the fraction of the population with 12 or more years of schooling. It is also important to notice that in 1980, the policy of improving rural schools would have dominated that of improving schools in the slums. Indeed, once rural schools have been upgraded, the marginal gain of also improving the schools in the slums would be relatively minor. Nonetheless, notice that improving schools in the slums would also be a powerful intervention. Even if it leads to drastically different paths in terms of urban slums, the two policies lead to improvements in the same direction for the Brazilian economy in 2010.

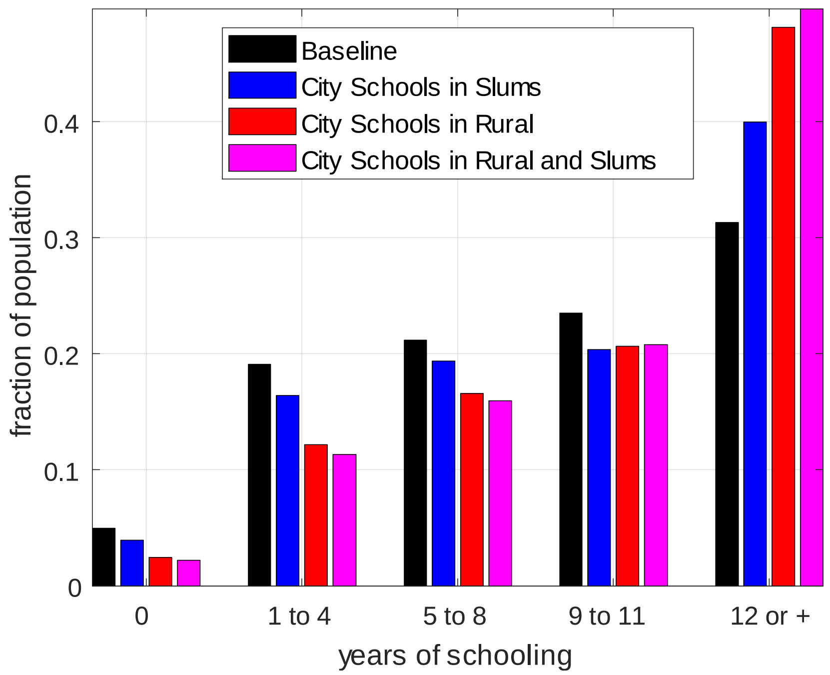
Table 21: Implementing City Schools in the Rest of Brazil 2010

	Baseline	School Quality $\{\alpha_{i,j}^{\ell}, \beta_{i,j}^{\ell}\}$		
Variable	Calibration	Slums=Cities	Rural=Cities	Rural & Slums=Cities
I. Aggregate Statistics for the Economy in 2010				
Population, by Location				
Rural	17.98	17.67	21.18	18.96
Slums	19.06	17.74	18.71	16.31
Cities	62.96	64.59	60.11	64.73
Employment, by Sector:				
Agriculture	17.03	16.68	19.85	17.68
Non-agriculture	67.93	68.10	65.09	67.15
Services	15.04	15.22	15.06	15.18
II. Cross-Section Distribution of Education, Brazil as a whole 2040				
Schooling Group				
0	4.98	4.43	4.44	3.82
1-4	19.07	16.60	15.67	13.79
5-8	21.15	16.91	19.36	15.96
9-11	23.51	25.63	28.38	29.19
12+	31.29	36.43	32.15	37.24

Table 22 reports the results for 2010, providing several interesting similarities and important differences with respect to the results for 1980. First of all, the impact of the same policies would have been much lower on structural transformation and overall urbanization of the country than in 1980. As with the other policies, in 2010 the responses to the changes in schooling qualities would have been much less on the rural-urban margin because of the higher levels of agricultural productivity and the education attainments in the country's population in that year. Notice however that all the interventions have the same direction as the corresponding cases for 1980.

Second, as in 1980, all the school interventions would lead to substantial improvements in terms of the cross-section distribution of education attainment for Brazil in 2040. Yet, notice that the impact would have been much less on the low end of the distribution and much more on the top end. Indeed, in all cases, there are minor declines in the fraction of the population with 0 years of schooling, while the improvements in the mass with 12 or more years is increased substantially in 3 of the 4 cases. Third, and most interestingly, the ranking between improving rural schools only vs. improving slums schools only is reverted in 2010 relative to 1980. The dominant policy in 2010 would be improving the schools in urban slums, which would lead to virtually the same decline in the fraction with 0 and a substantially higher increase in the fraction with 12+ years of education. Adding also improvements in the rural schools on top of the improved slums schools would have sizable marginal improvements for 2040 Brazilian human capital.

Figure 5: Brazil's Population in 2040: Alternative Policies in 1980 & 2010



We close this section with the results for the population of Brazil in 2040 of counterfactual school reforms that, starting in 1980, would have sustained the changes in school qualities $\left\{\alpha^{\ell}_{i,j}, \beta^{\ell}_{i,j}\right\}$ not only for 1980 but also for 2010. Figure 5 compares the baseline population distribution in 2040 (black bars) with the counterfactual populations resulting from improvements only in schools in slums (blue), improvements in rural schools only (red), and both rural and slum schools (magenta) Clearly, over the sixty years, any of the school policy intervention would have had very large benefits on the Brazilian population distribution of human capital and hence on the overall development of the country. Obviously, the largest improvements would be when schools are upgraded in both rural areas and slums[55]. However, much of those improvements would have been attained by improving the schools in the rural area, which, as discussed before, would have slowed down the urbanization and structural transformation of the country but would have also massively curtailed the emergence of slums in the country.

In sum, our results suggest that the low quality of schools in rural areas was one of the main factors leading up to the emergence of the slums and that the low quality of the schools in urban slums is a major force behind their persistence.

[55] After sixty years, average years of schooling would change from 9.2 years in the baseline economy to 11.3 in an economy where the education fundamental quality is the same as in the city for all three locations.

6 Conclusions

On the surface, the urbanization and structural transformation patterns in Brazil (and other developing countries) seem to follow the historical patterns of developed countries. Yet, beneath the massive rural-urban migration and employment reallocation to non-agricultural sectors, we uncovered a substantial growth in low-skill urban jobs and urban slums. In this article, on the basis of salient micro evidence, we construct a simple dynamic model in which the population distribution across locations and occupations, as well as the formation of human capital, are all endogenous. Following the evidence, there are substantial education advantages of cities over slums and of slums over rural areas. A key feature of the workings of slums is they grant access to working adults to the urban labor markets at large but restrict the human capital formation of children to inferior options. Despite those shortcomings, living in a slum is the preferred option for some low-skill households, in light of the high housing costs of the cities proper. We calibrate the model to the Brazilian data and examine different aspects of the formation and persistence of low-skill jobs and urban slums.

We argue that, more than a barrier, slums are a stepping-stone for low-skill households and for the country as a whole. To be sure, slums are stepping-stones, not bridges, as they are associated with dire living conditions. But for low-skill households, they enhance the labor market and human capital formation opportunities when compared to the countryside. Indeed, we find that cracking down on slums and secluding low-skill households in rural areas would slow down the acquisition of human capital in the low end of the distribution, inducing the formation of even larger slums in the future. Yet, when compared to the city proper, slums are a barrier in terms of human capital formation opportunities. In fact, we show that giving slum-dwelling children some access to schools in the city would foster their education attainment. On the aggregate, this change would eventually lead to larger cities and smaller slums, precisely because the country's labor force would be less concentrated in low-skill workers.

To emphasize the key general equilibrium aspects of rural-urban migration and sectoral transformation, our model is highly stylized, and we also look at the data from a very high level. We see three well-defined avenues for future work. First, we should go beyond the simple peer-effects human capital formation model and more closely explore the factors driving the underwhelming schooling outcomes in rural and poor urban areas. Accounting for location differences in peers, teachers, financing, and other inputs could suggest a wider scope for policy. Such an analysis should not be restricted to the micro aspects, since, as we have underlined in this paper, the macro implications of education policies can be as substantial as determining the skill composition of rural-urban migration and whether structural transformation is directed toward low- or high-skill urban occupations. For instance, high-quality schools in the countryside could prevent the formation of urban slums altogether. Second, it would be interesting to consider a multi-city or multi-neighborhood environment. As we have done here, such an analysis should incorporate urban slums as one of the residential options. For low-skilled households, such a richer setting could more finely capture the consumption and education trade-offs offered to low-skill households by the countryside, the different cities, and the slums. For high-skilled households, the setting could more finely capture the multiple schooling options offered by cities. In the same vein, a third avenue is to extend our one-house/two-goods/three-occupations model and consider richer models that can capture the impact of a fat tail in the income distribution on the demand for personal services and other low-skill urban jobs as a main driver for the formation of urban slums. All in all, those extensions deserve multiple papers on their own, and we view this paper as part of their foundation.

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A Data

The sample covers Brazil and the years 1950 to 2010. The series for real output, value-added shares and employment by sectors were taken from IPEADATA and Census data. We obtained value-added and output data from the IPEADATA database. In the case of Total GDP and Agriculture value added there are available series in reais of 2010 from 1947 to 2019, but for Personal Services (we used the "Serviços - Outros" series) there are only data in real terms from 1980 to 2019. We experimented with alternative deflators and methods to obtain the 1950-1980 series in real terms, and ended up multiplying total GDP by a series of "Serviços - Outros" as % of GDP.

Labor force was obtained from the 1950 to 2010 Census. Total and agriculture labor forces are easily available and their definition did not change in the period. As personal services labor force definitions in 1950 and 1960 are slightly different from subsequent years, it required minor adjustments. In 1960, for instance, there are two possible series, dependig on what occupations are considered and we opted for a broader definition. To obtain the "Non-agriculture" sector variables we subtracted from the Total GDP and Labor Force series the corresponding values from agriculture and personal services. Following the literature, the productivity series were constructed as the ratio between the real value added and the persons employed by each sector for the period 1950 to 2010.[56]

From the Brazilian census, we explore interesting characteristics and dynamics of the economy since 1950. The census is a meticulous survey of all households in the country, conducted every 10 years by the Brazilian Institute of Geography and Statistics (IBGE).[57] For the years 1991 and 2000, the census provides an interesting variable, telling us whether a household lives in a "subnormal agglomerate" which is defined as "a set of 51 or more housing units characterized by absence of a proper ownership title and at least one of the following aspects: (i) Irregular traffic routes or irregular size (shape) of land plot; (ii) Lack of essential public services such as garbage collection, sewage system, electricity and public lighting."

An alternative definition is the one used by UN Habitat, which defines "a slum household" as "a group of individuals living under the same roof and lacking one or more of the following conditions: (i) Access to improved water; (ii) Access to improved sanitation; (iii) Sufficient-living area; (iv) Durability of housing; (v) Security of tenure. Under this definition, the slum population in Brazil would be even larger because it could include smaller groups of slum households scattered across the urban areas. For more details about the underestimation of the number of slum dwellers in Brazil, see Cavalcanti and Da Mata (2014). Finally, the description of a slum is almost equivalent to that of very poor settlements. Thus, following the Brazilian literature, we use here slums and "subnormal agglomerate" interchangeably.

We make intensive use of the Favela Census,[58] conducted by the state government of Rio de Janeiro in 2010. As explained in the text, this census is a unique initiative of mapping and identifying the profile of residents who live in the three biggest slums in Rio: Alemão, Manguinhos and Rocinha.

The 1988 and 1996 surveys from the PNAD (Pesquisa Nacional por Amostra de Domicílio)[59] have a special supplement that includes questions about the parental education of the household head and spouse. This database allowed us to compute the transition probability for an entire country's rural and urban areas. We proxied slum households as those living in metropolitan areas with total income in the 35^{th} percentile or lower.

B The Early History of Brazilian Favelas

The origin of slums can be traced back to the Golden Law (Lei Áurea) that in 1888 abolished slavery in Brazil. This law lacked any policy for inserting former slaves into the labor market or for providing basic services (e.g., food, housing and health) and led to a large-scale migration of former plantation workers to the cities, in particular to Rio de Janeiro, the capital of Brazil during the years 1763 to 1960. These workers, unable to buy or rent formal housing, ended up living in tenements (cortiços) and in illegal areas in hills, caves, and swamps.

In 1889, a military coup overthrew the monarch Don Pedro II and established a republic backed by the landowning elites. During this time, Antonio Conselheiro, a peripatetic preacher, wandered the Brazilian backlands and preached against slavery and the Brazilian Republic and against the separation of Church and State. Conselheiro settled in Canudos, in Bahia, and established the village of Belo Monte with its own social system and division of labor based on common property and its own currency. Fearing the massive growth of the movement initiated in Belo Monte, in 1896, the republican government sent thousands of troops to the region, starting the War of Canudos (1896-1897), probably the biggest civil war in Brazil. Canudos was completed destroyed, and the soldiers reclaimed the territory.

[56] Note, however, as explained in Apendix D, that X^N and X^S were calibrated while X^A is constructed from the data.

[57] See *www.ibge.gov.br/english/.*

[58] For more details see *www.emop.rj.gov.br/trabalho-tecnico-social/censos-comunitarios.*

[59] National Household Survey conducted every year in Brazil since 1976.

The victorious veterans returned to Rio de Janeiro to claim the land grants promised by the government. While waiting, they settled on a hillside alongside the former slaves and street vendors already camping there. The soldiers were never able to gain the lands promised by the government and gradually built their own shacks to replace their tents. The Canudos veterans named the hillside Morro da Favela, as the bushes there were reminiscent of the favela plant (Cnidoscolus quercifolius) found in Canudos. This first favela was later called Morro da Providência, and forever after the term favela has been used to refer to squatter settlements, shantytowns, and all types of irregular settlements, which in Brazil typically settle allong the hillsides (such as Rocinha and Complexo de Alemao) and in the lowlands of Brazilian cities.

During the years 1902 and 1906, the mayor of Rio de Janeiro aggressively focused on the sanitation and planning of the city, and to achieve his goals, favelas, cortiços, and shelters were destroyed. However, Morro da Favela remained untouchable. After that failed cleanup policy, the number of squatter settlements increased from around 100 in 1906 to around 1,500 in 1933, with a population close to 10,000. Since the early 20^{th} century, we observe the first waves of rural-urban migration and the emergence of the first slums in Rio de Janeiro, but it was only after World War II that the process of urbanization and the formation of slums became a national and widespread phenomenon.

Although the term, favela had been commonly used as a generic term for any squatter settlements, the first legal recognition of favelas was in late 1930, when the Building Code of 1937 prohibited the building of new favelas and banned the expansion of the existing ones, categorizing them as an urban aberration. See Pearlman (2010) and Pino (1997) for a richer account of the historical aspects of slums in Brazil and engaging details of the circumstances, decisions, and outcomes of the households involved.

C Estimating the Labor Market Skills Distributions

Following Heckman and Sedlacek (1985) and Heckman and Honore (1989), we assume that the routine and non-routine skills of workers are lognormally conditional on the workers' education. Thus, for each $e \in E = \{e_1, e_3, e_3, e_4, e_5\}$, the ability of workers is characterized by the means $(\bar{\mu}^r, \bar{\mu}^n)$, variances $(\sigma_{rr}, \sigma_{nn})$, and covariance σ_{rn}. Without the risk of confusion, in what follows we will keep implicit the dependence of these parameters on the schooling level e.

Skill prices, (w^r, w^n), are common for all workers. Each worker chooses the occupation that maximizes their income. Thus, either $w^r z_r$ or $w^n z_n$ is observed if they are, respectively, the highest and lowest value. Define:

$$
\begin{aligned}
c_r &\equiv \frac{\bar{\mu}^r - \bar{\mu}^n}{\sigma^*},\ c_n \equiv -c_r, \\
\sigma^* &\equiv \sqrt[2]{\sigma_{rr} + \sigma_{nn} - 2\sigma_{rn}}, \\
\rho_r &\equiv \frac{\sigma_{rr} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{rr}}}, \\
\rho_n &\equiv \frac{\sigma_{nn} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{nn}}},
\end{aligned}
$$

and

$$\lambda(c) \equiv \frac{\phi(c)}{\Phi(c)},$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are, respectively, the probability density function and the cumulative density function of a standard normal distribution.

Then, as shown by Heckman and Sedlacek (1985), the observed log-earnings must satisfy

$$
\begin{aligned}
E[\ln y^r | \ln y^r > \ln y^n] &= \underbrace{\bar{\mu}^r}_{\ln w^r + \mu^r} + \left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^*}\right)\lambda(c_r), \\
E[\ln y^n | \ln y^n > \ln y^r] &= \underbrace{\bar{\mu}^n}_{\ln w^n + \mu^n} + \left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^*}\right)\lambda(c_n), \\
var[\ln y^r | \ln y^r > \ln y^n] &= \sigma_{rr}\left\{\rho_r^2\left[1 - c_r\lambda(c_r) - [\lambda(c_r)]^2\right] + \left(1 - \rho_r^2\right)\right\}, \\
var[\ln y^n | \ln y^n > \ln y^r] &= \sigma_{nn}\left\{\rho_n^2\left[1 - c_n\lambda(c_n) - [\lambda(c_n)]^2\right] + \left(1 - \rho_n^2\right)\right\}.
\end{aligned}
$$

Moreover, the fraction f^r of workers in routine occupations must satisfy

$$f^r = \Phi(c_r).$$

Then, denoting by $\bar{m}_y^r \equiv E\left[\ln y^r | \ln y^r > \ln y^n\right]$, $\bar{m}_y^n \equiv E\left[\ln y^n | \ln y^n > \ln y^r\right]$, and $\bar{S}_y^r \equiv var\left[\ln y^r | \ln y^r > \ln y^n\right]$, $\bar{S}_y^n \equiv var\left[\ln y^n | \ln y^n > \ln y^r\right]$ as observed in the data, and given $c_r = \Phi^{-1}\left(f^r\right)$, $c_n = -c_r$, we have the following system of equations:

$$
\begin{aligned}
f^r &= \Phi\left(\frac{\bar{\mu}^r - \bar{\mu}^n}{\sigma^*}\right), \\
\bar{m}_y^r &= \bar{\mu}^r + \left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^*}\right)\lambda\left(c_r\right), \\
\bar{m}_y^n &= \bar{\mu}^n + \left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^*}\right)\lambda\left(c_n\right), \\
\bar{S}_y^r &= \sigma_{rr}\left\{\left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{rr}}}\right)^2\left[1 - c_r\lambda\left(c_r\right) - \left[\lambda\left(c_r\right)\right]^2\right] + \left[1 - \left(\frac{\sigma_{rr} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{rr}}}\right)^2\right]\right\}, \\
\bar{S}_y^n &= \sigma_{nn}\left\{\left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{nn}}}\right)^2\left[1 - c_n\lambda\left(c_n\right) - \left[\lambda\left(c_n\right)\right]^2\right] + \left[1 - \left(\frac{\sigma_{nn} - \sigma_{rn}}{\sigma^* \sqrt[2]{\sigma_{nn}}}\right)^2\right]\right\}.
\end{aligned}
$$

This is a system of five equations on the five unknowns $\{\bar{\mu}^r, \bar{\mu}^n, \sigma_{rr}, \sigma_{nn}, \sigma^*\}$, which we solve numerically for each $e \in E = \{e_1, e_3, e_3, e_4, e_5\}$.

D Sector Productivity and Factor Shares

To estimate the productivity of the different sectors of the economy we proceded in two steps. In the case of agriculture, the parameter X^A is directly observed in the data, as the ratio between sector output and labor force. The output data is from the IPEADATA database and are available from 1947 to 2019 in real terms. Labor force was obtained from the 1950 to 2010 Census. In this way we got X^A values for 1980 and 2010.

The second step was to calibrate X^N and X^S. As the production functions of Personal Services and the Non-Agriculture sectors use routine labor, in the first case, and routine and non-routine labor in the second, there is not a correspondence between the labor market data and the model. In this case we calibrated the productivity of these sectors, for 1980 and 2010, so that their share in the total output in the model match the data as closely as possible. To calculate these shares in the data we used the "Serviços - Outros" value-added series for Personal Services while Non-Agriculture value-added was obtained as the dfference between total value-added and Agriculture and Personal Services value-added. All these series - in real terms - are from the IPEADATA database.

In our model, the production of agricultural goods is entirely based on unskilled labor and the production of personal services is entirely based on routine skills. The production function of the non-agricultural good N is a Cobb-Douglas combining both routine and non-routine occupations. To estimate the factor shares of these two types of skills, we classified the different occupations into routine/non-cognitive and non-routine/cognitive. For each broad occupation group in the Brazilian Census 1980, Table D1 below contains the breakdown of the occupations within that group that are classified as routine and non-routine, as well as those not defined.

Table D1: Number of routine and non routine suboccupations in Census occupations

Census Occupations	# routine	# non-rout	# not def.	# agricult.	# total
Employers	2	14	0	0	16
Directors & chiefs in public administration	0	0	2	0	2
Directors & managers in private sector	0	11	0	0	11
Bureaucratic functions	13	0	0	0	13
Engineers, architects & auxiliary occup.	3	4	0	0	7
Chemicals, physicists & auxiliary occup.	3	5	0	0	8
Agronomists, biologists, veterinarians	0	4	0	0	4
Doctors, dentists, nurses & auxiliary occup.	8	4	0	0	12
Mathemat., statisticians, systems analyst	0	3	0	0	3
Economists, accountants & auxiliary occup.	4	3	0	0	7
Social scientists	0	5	0	0	5
Teachers & auxiliary occup.	2	9	0	0	11
Lawyers, judges & auxiliary occup.	3	4	0	0	7
Priests	0	1	0	0	1
Artists & auxiliary occup.	3	10	0	0	13
Other technical & scientific occup.	0	3	0	0	3
Agriculture workers, hunters, fishermen	0	0	0	13	13
Extraction workers, machine operators	7	0	0	0	7
Manufacturing industry workers	125	0	1	0	126
Occupations in retail and wholesale	15	4	3	0	22
Occupations in transport and communic.	25	2	0	0	27
Occupations in personal services	26	3	4	0	33
Occupations in national defense	0	0	9	0	9
Other occupations	16	0	2	0	18

We compute the income share of routine skills as the ratio of all the labor income of those workers in the routine occupations relative to the total.

E Housing Price Functions

In the estimations of the housing price function, we used data from the 1991 census at the household level. Rent information from the census is the only source of data on housing costs that is comparable between the different locations, which we use as a proxy for housing costs.[60] We obtain the rent costs $P_i^{h,\ell}$ paid for all $i = 1, ..., N^\ell$ households living in location $\ell \in \{\text{slums, cities}\}$. For each household, we record the size of the location s_i^ℓ in which the individual lived, normalized by the mean sample size, and other controls T_i^ℓ (individual income, access to sanitation, house density, etc.).

We used the OLS method in all regressions but we also run IV regressions for a sub-sample of individuals and locations for which we had data. We run a simple log-linear regression on a constant, s^ℓ and T_j^ℓ: $\log(P_i^{h,\ell}) = a_\ell + \xi_1^\ell \log\left(1 + s^\ell\right) + \delta^\ell T_j^\ell + \varepsilon_i^\ell$; but also $\log(P_i^{h,\ell}) = a_\ell + \xi_1^\ell \log\left(s^\ell\right) + \delta^\ell T_j^\ell + \varepsilon_i^\ell$ for robustness, which led to similar results. In the main group of estimations we ran separated regressions for individuals living in slums and individuals living outside slums. For robustness we restricted the sample, in some regressions, to a specific type of house (e.g., two bedroom apartments) as a way to homogenize the sample, but results were not too different.

Most estimations we know in the literature - e.g., Saiz (1990), Malpezzi and Maclennan (2001), Da Mata et al. (2007) - employ data at metropolitan or city level, so results are not directly comparable but as we will see they are close to previous estimations. As we did not have the same type of information for other census, we run cross-section estimations, another difference from the literature that employ mostly panel techniques.

In the table below we present regressions of the benchmark case (when regressors enter as $log(1 + size)$):

[60] The 1991 Census is the only one with information on both slums and rents.

Table E1: Regressions for the Housing Price

	slums			Formal City		
	1	2	3	4	5	6
intercept	0.34	0.39	0.43	0.38	0.44	0.46
	(0.02)	(0.01)	(0.03)	(0.003)	(0.002)	(0.002)
size	0.23	0.33	0.25	0.30	0.49	0.54
	(0.02)	(0.02)	(0.04)	(0.002)	(0.01)	(0.003)
income	0.83			1.13		
	(0.02)			(0.003)		
density	-0.48			-0.63		
	(0.03)			(0.003)		
sample	all	all	2 bedrooms	all	all	2 bedrooms
R^2	0.17	0.03	0.03	0.37	0.09	0.11
F stat.	728	282	2747	10560	5380	44

Source: Brazilian Census (1991)

Notes: Values in parenthesis are standard errors.

We used estimation values from models one and four in the calibration of the model. However, parameter values do not change considerably when we drop (or change) controls or use only rents of two bedroom apartments as the dependent variable. The inverse elasticity for city, in these two cases imply housing elasticities from 2 and 3. These values are in the interval of previous estimations. Moreover, the implied housing price elasticities in slums are larger than those of formal city, which makes economic sense, and for the same location size, estimations imply that prices at slums are smaller than those in the formal city. When we used log(size) instead of log(1+size) in the regressions, the estimated inverse elasticity reduced to less than half the figures above. The implied housing price elasticities in this case, from 7 to 12, are in the upper end of previous estimations of the literature (e.g., Malpezzi. and Maclennan (2001)).

We also use instrumental variable methods to estimate housing (inverse) elasticities. We used as an exogenous instrument the ratio of undevelopable land (bodies of water and steep terrains) in a given city, which was obtained from Guedes et al. (2023). Unfortunately, the data was only available to individuals living in cities in the Rio de Janeiro State, so results are not directly comparable with those above, but we reran the mains OLS regressions restricting the sample to Rio de Janeiro. In this case the estimated inverse elasticities for slums and city were, respectively, 0.39 and 0.42, higher but not far from the OLS benchmark estimations. In the main IV estimation, following equations 1 and 4 above, the estimated inverse elasticities were 0.38, in the case of slums, and 0.46 in the case of cities proper. The fact that regressions with OLS and IV methodologies deliver similar results - estimated inverse elasticities were very close - add further confidence in the OLS results that were used in the main calibration.

F Demand For Goods and Indirect Utility

Preference of Households for goods can be written simply as:

$$u\left(c^A, c^N, c^S\right) = \alpha_A \ln\left(c^A - \bar{c}^A\right) + \alpha_N \ln\left(c^N\right) + \alpha_S \ln\left(c^S + \bar{c}^S\right),$$

where $\sum_{i=\{A,N,S\}} \alpha_i = 1$ and $\bar{c}^A > 0 < \bar{c}^S$.

Consider the maximization problem of a household in a given location. The Lagrangean is:

$$L = \max_{c^A, c^N, c^S} \left\{\alpha_A \ln\left(c^A - \bar{c}^A\right) + \alpha_N \ln\left(c^N\right) + \alpha_S \ln\left(c^S + \bar{c}^S\right) + \lambda\left[y - p^{H,\ell} - \left(p^A c^A + p^N c^N + p^S c^S\right)\right]\ \right\}.$$

Therefore, consider the first order conditions:

$$\begin{aligned}
[c_A] &: \quad \frac{\alpha_A}{c^A - \bar{c}^A} = \lambda p^A; \\
[c_N] &: \quad \frac{\alpha_N}{c^N} = \lambda p^N; \\
[c_S] &: \quad \frac{\alpha_S}{c^S + \bar{c}^S} \leq \lambda p^S,\ c^S \geq 0 \text{ and at least one with equality.}
\end{aligned}$$

I. Consider first the case in which $c^S = 0$. Then, using $p^A = 1$, we get

$$
\begin{aligned}
c^N &= \frac{\alpha_N}{\alpha_A p^N}\left(c^A - \bar{c}^A\right) \text{ and} \\
y - p^{H,\ell} &= c^A + p^N c^N.
\end{aligned}
$$

Then

$$
\begin{aligned}
y - p^{H,\ell} + \frac{\alpha_N}{\alpha_A}\bar{c}^A &= \left(\frac{\alpha_A + \alpha_N}{\alpha_A}\right) c^A \implies \\
\frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} + \frac{\alpha_N}{\alpha_A}\bar{c}^A\right) &= c^A.
\end{aligned}
$$

Then:

$$
\begin{aligned}
c^A &= \frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} + \frac{\alpha_N}{\alpha_A}\bar{c}^A + \frac{\alpha_A + \alpha_N}{\alpha_A}\bar{c}^A - \frac{\alpha_A + \alpha_N}{\alpha_A}\bar{c}^A\right), \\
&= \bar{c}^A + \frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} + \frac{\alpha_N}{\alpha_A}\bar{c}^A - \frac{\alpha_A + \alpha_N}{\alpha_A}\bar{c}^A\right), \\
&= \bar{c}^A + \frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} - \bar{c}^A\right).
\end{aligned}
$$

For N, then:

$$
\begin{aligned}
c^N &= \frac{\alpha_N}{\alpha_A p^N}\left(c^A - \bar{c}^A\right), \\
&= \frac{\alpha_N}{\alpha_A p^N}\left(\bar{c}^A + \frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} - \bar{c}^A\right) - \bar{c}^A\right), \\
&= \frac{\alpha_N}{\alpha_A + \alpha_N}\left(\frac{1}{p^N}\right)\left(y - p^{H,\ell} - \bar{c}^A\right).
\end{aligned}
$$

In sum, for $y < \bar{y}^\ell$ the demand becomes:

$$
\begin{aligned}
c^A &= \bar{c}^A + \frac{\alpha_A}{\alpha_A + \alpha_N}\left(y - p^{H,\ell} - \bar{c}^A\right), \\
c^N &= \frac{\alpha_N}{\alpha_A + \alpha_N}\left(\frac{1}{p^N}\right)\left(y - p^{H,\ell} - \bar{c}^A\right), \\
c^S &= 0.
\end{aligned}
$$

II. Now consider the case in which $c^S > 0$. Then, the more traditional case holds

$$
\begin{aligned}
c^A &= \bar{c}^A + \alpha_A\left(y + p_t^{S,\ell}\bar{c}^S - p^{H,\ell} - \bar{c}^A\right), \\
c^N &= \alpha_N\left(\frac{1}{p^N}\right)\left(y + p_t^{S,\ell}\bar{c}^S - p^{H,\ell} - \bar{c}^A\right), \\
c^S &= -\bar{c}^S + \alpha_S\left(\frac{1}{p^{S,\ell}}\right)\left(y + p_t^{S,\ell}\bar{c}^S - p^{H,\ell} - \bar{c}^A\right).
\end{aligned}
$$

Now, to determine the threshold level $\bar{y}^\ell$, simply solve for $c^S = 0$ and obtain:

$$
\bar{y}^\ell = p^{S,\ell}\bar{c}^S\left(\frac{1-\alpha_S}{\alpha_S}\right) + p^{H,\ell} + \bar{c}^A.
$$

In sum, the demand system becomes:

$$
c^{A,\ell}(y) = \begin{cases} \bar{c}^A + \frac{\alpha_A}{\alpha_A+\alpha_N}\left(y - p^{H,\ell} - \bar{c}^A\right), & \text{if } y < \bar{y}_t^\ell\left(\mathbf{p_t^\ell}\right) = \frac{(1-\alpha_S)p^{S,\ell}\bar{c}^S}{\alpha_S} + p^{H,\ell} + \bar{c}^A; \\ \bar{c}^A + \alpha_A\left(y - p^{H,\ell} + p_t^{S,\ell}\bar{c}^S - \bar{c}^A\right), & \text{otherwise.} \end{cases}
$$

$$
c^{N,\ell}(y) = \begin{cases} \frac{\alpha_N}{\alpha_A+\alpha_N}\left(\frac{1}{p^N}\right)\left(y - p^{H,\ell} - \bar{c}^A\right), & \text{if } y < \bar{y}_t^\ell\left(\mathbf{p_t^\ell}\right) = \frac{(1-\alpha_S)p^{S,\ell}\bar{c}^S}{\alpha_S} + p^{H,\ell} + \bar{c}^A; \\ \alpha_N\left(\frac{1}{p^N}\right)\left(y + p_t^{S,\ell}\bar{c}^S - p^{H,\ell} - \bar{c}^A\right), & \text{otherwise.} \end{cases}
$$

$$
c^{S,\ell}(y) = \begin{cases} 0, & \text{if } y < \bar{y}_t^\ell\left(\mathbf{p_t^\ell}\right) = \frac{(1-\alpha_S)p^{S,\ell}\bar{c}^S}{\alpha_S} + p^{H,\ell} + \bar{c}^A; \\ -\bar{c}^S + \alpha_S\left(\frac{1}{p^{S,\ell}}\right)\left(y + p_t^{S,\ell}\bar{c}^S - p^{H,\ell} - \bar{c}^A\right), & \text{otherwise.} \end{cases}
$$

The indirect utility function from consumption:

$$\begin{aligned} v\left(y, \mathbf{p}_{\mathbf{t}}^{\ell}\right) &= \frac{\left[u\left(c^{A,\ell}\left(y\right), c^{N,\ell}\left(y\right), c^{S,\ell}\left(y\right)\right)\right]^{1-\sigma}}{1-\sigma}, \\ &= \frac{\left\{\left[c^{A,\ell}\left(y\right)-\bar{c}^{A}\right]^{\alpha_A}\left[c^{N,\ell}\left(y\right)\right]^{\alpha_N}\left[c^{S,\ell}\left(y\right)+\bar{c}^{S}\right]^{\alpha_S}\right\}^{1-\sigma}}{1-\sigma}. \end{aligned}$$

For $y < \bar{y}_t^{\ell}\left(\mathbf{p}_{\mathbf{t}}^{\ell}\right)$, then:

$$\begin{aligned} v\left(y, \mathbf{p}_{\mathbf{t}}^{\ell}\right) &= \frac{\left\{\left[c^{A,\ell}\left(y\right)-\bar{c}^{A}\right]^{\alpha_A}\left[c^{N,\ell}\left(y\right)\right]^{\alpha_N}\left[c^{S,\ell}\left(y\right)+\bar{c}^{S}\right]^{\alpha_S}\right\}^{1-\sigma}}{1-\sigma}, \\ &= \frac{\left\{\left[\frac{\alpha_A}{\alpha_A+\alpha_N}\left(y-p^{H,\ell}-\bar{c}^{A}\right)\right]^{\alpha_A}\left[\frac{\alpha_N}{\alpha_A+\alpha_N}\left(\frac{1}{p^N}\right)\left(y-p^{H,\ell}-\bar{c}^{A}\right)\right]^{\alpha_N}\left[\bar{c}^{S}\right]^{\alpha_S}\right\}^{1-\sigma}}{1-\sigma}, \\ &= \frac{\left[\frac{(\alpha_A)^{\alpha_A}(\alpha_N)^{\alpha_N}\left[\bar{c}^{S}\right]^{\alpha_S}}{\left[(\alpha_A+\alpha_N)^{\alpha_A+\alpha_N}\right]\cdot(p^N)^{\alpha_N}}\cdot\left(y-p^{H,\ell}-\bar{c}^{A}\right)^{\alpha_A+\alpha_N}\right]^{1-\sigma}}{1-\sigma}. \end{aligned}$$

For $y > \bar{y}_t^{\ell}\left(\mathbf{p}_{\mathbf{t}}^{\ell}\right)$, then:

$$\begin{aligned} v\left(y, \mathbf{p}_{\mathbf{t}}^{\ell}\right) &= \frac{\left\{\left[\alpha_A\left(y-p^{H,\ell}+p_t^{S,\ell}\bar{c}^{S}-\bar{c}^{A}\right)\right]^{\alpha_A}\cdot\left[\alpha_N\left(\frac{1}{p^N}\right)\left(y+p_t^{S,\ell}\bar{c}^{S}-p^{H,\ell}-\bar{c}^{A}\right)\right]^{\alpha_N}\cdot}{1-\sigma} \\ &\quad \frac{\cdot\left[\alpha_S\left(\frac{1}{p^{S,\ell}}\right)\left(y+p_t^{S,\ell}\bar{c}^{S}-p^{H,\ell}-\bar{c}^{A}\right)\right]^{\alpha_S}\right\}^{1-\sigma}}{1-\sigma} \\ &= \frac{\left\{\frac{[\alpha_A]^{\alpha_A}[\alpha_N]^{\alpha_N}[\alpha_S]^{\alpha_S}}{(p^N)^{\alpha_N}(p^{S,\ell})^{\alpha_S}}\left(y-p^{H,\ell}+p_t^{S,\ell}\bar{c}^{S}-\bar{c}^{A}\right)\right\}^{1-\sigma}}{1-\sigma}. \end{aligned}$$

In sum, the households utility over consumption of goods is given by:

$$v^{\ell}\left(y, \mathbf{p}_{\mathbf{t}}^{\ell}\right) = \begin{cases} -\infty & \text{if } y \leq p^{H,\ell}+\bar{c}^{A}; \\ \frac{\left[\frac{(\alpha_A)^{\alpha_A}(\alpha_N)^{\alpha_N}\left[\bar{c}^{S}\right]^{\alpha_S}}{\left[(\alpha_A+\alpha_N)^{\alpha_A+\alpha_N}\right]\cdot(p^N)^{\alpha_N}}\cdot\left(y-p^{H,\ell}-\bar{c}^{A}\right)^{\alpha_A+\alpha_N}\right]^{1-\sigma}}{1-\sigma}, & \text{if } p^{H,\ell}+\bar{c}^{A} < y < \bar{y}_t^{\ell}\left(\mathbf{p}_{\mathbf{t}}^{\ell}\right); \\ \frac{\left\{\frac{[\alpha_A]^{\alpha_A}[\alpha_N]^{\alpha_N}[\alpha_S]^{\alpha_S}}{(p^N)^{\alpha_N}(p^{S,\ell})^{\alpha_S}}\left(y-p^{H,\ell}+p_t^{S,\ell}\bar{c}^{S}-\bar{c}^{A}\right)\right\}^{1-\sigma}}{1-\sigma}, & \text{if } y \geq \bar{y}_t^{\ell}\left(\mathbf{p}_{\mathbf{t}}^{\ell}\right). \end{cases}$$

G Distant Poor Neighborhoods

In this section we add to our framework a fourth possible location choice: the distant poor neighborhoods (DPN), which are a common feature of the urbanization pattern of Brazil and many developing countries. The question we address here is why some households choose to live in slums (absence of a proper ownership title but located closer to downtown and to the job opportunities) and others prefer to live in distant poor neighborhoods (access to a proper ownership title but located far away from downtown and to the job opportunities).

What characterizes the DPN locational choice is, in the one hand, a "transportation" cost, τ_P, measured in terms of working hours lost commuting to the job location. In the other hand, there is no utility loss of living in DPN, as oppose to slums. Moreover, it is assumed that the DPN share some features with the slums. The social mobility in terms of education, i.e., the parameters governing the intergenerational mobility in skills formation, are the same in both locations. Since we assumed in the main model that the educational transition probabilities to households living in slums were from those in the 35^{th} percentile income distribution, considering the same for distant poor neighborhoods it is not too far from reality. It is also assumed that the parameters that determine the housing costs are the same, or as close as possible, in slums and distant poor neighborhoods. For all other parameters of the model, we use the same values from the main framework and calibration.

When a household decides now where to live, he/she faces the following location decision:

$$V_t\left(e, z, \eta^{\ell}\right) = \max\left\{V_t^R, V_t^F, V_t^C, V_t^P\right\},$$

where P stands for distant poor neighborhood. The key difference is that while the value function of the slum option is still given by:

$$V_t^F = \frac{\left[c_t\left(1-\tau_t^F\right)\right]^{1-\gamma}}{1-\gamma} + \beta\frac{\left[\mathbb{E}\left(e_{t+1}|\, e, E^F\right)\right]^{1-\gamma_e}}{1-\gamma_e} + \eta^F,$$

that of the PDN is the same as in the city proper

$$V_t^P = \frac{\left[c_t\right]^{1-\gamma}}{1-\gamma} + \beta\frac{\left[\mathbb{E}\left(e_{t+1}|\, e, E^P\right)\right]^{1-\gamma_e}}{1-\gamma_e} + \eta^P,$$

but the choice of occupation is now given by

$$y_t^U\left(z_r,\, z_n\right) = \max\left\{w_t^{r,U} z_r\left(1-\mathbf{1}_{\{l=P\}}\tau_P\right),\, w_t^n z_n\left(1-\mathbf{1}_{\{l=P\}}\tau_P\right)\right\}.$$

We choose the value of τ_P, 0.05, to match the share of the population living in distant poor neighborhoods of Rio de Janeiro[61]. Table G1 presents some key moments coming from the data and from the extended model. We consider the calibrated extended model to be close enough to the data, with the exception of schooling in the rural areas, which are now too high. But the match of population shares in each location is now slightly better than in the benchmark model

Table G1: The Calibration of the Extended Model and Observed Data for Brazil

	1980	
Variable	Data	Model
Population: (%)		
Slum: σ_t^F	10.69	10.98
PDN: σ_t^P	27.32	26.57
City: σ_t^C	33.25	36.21
Rural areas: σ_t^A	28.72	26.24
Personal Services: (%)		
Labor Share : L_t^S	12.28	12.39
Output Share: Y_t^S/Y	11.28	10.41
Average Schooling: (years)		
Rural Areas: $E\left(z'\|Z_t^R\right)$	1.96	4.28
Urban Slums: $E\left(z'\|Z_t^F\right)$	NA	4.75
PDN: $E\left(z'\|Z_t^P\right)$	NA	6.00
Cities, Proper: $E\left(z'\|Z_t^C\right)$	NA	7.64
Urban Areas: $E\left(z'\|Z_t^U\right)$	5.43	6.62

We run two counterfactual simulations. In the first exercise we increased transportation cost to 0.7 [62] to study how population distribution across the four possible locations changes when commuting cost to PDN is extremely high. Table G2 presents the results for some key moments:

Table G2: Higher commuting cost

Variable	Benchmark	$\tau_P = 0.7$
Population: (%)		
Slum	10.98	16.83
PDN	26.57	8.30
City	36.21	46.95
Rural areas	26.24	27.92
Personal Services: (%)		
Labor Share	12.39	10.82
Output Share	10.41	9.19

[61] We considered as distant poor neighborhoods all the cities in the metropolitan region of Rio de Janeiro which are within a maximum radius of 70 km from the city center of Rio de Janeiro and whose average household income is between the 0 and 35^{th} percentile of the income distribution of those households who live in the city of Rio de Janeiro. We did this same exercise for the other eight Brazilian metropolitan regions in 1980 (Sao Paulo, Belo Horizonte, Belem, Salvador, Recife, Fortaleza, Curitiba and Porto Alegre) and the percentage of urban population living in distant poor neighborhoods ranges from around 20% to 30%. Therefore, we considered as a benchmark to our model the numbers coming from the metropolitan region of Rio de Janeiro as representative to Brazil as a whole.

[62] For values above 0.73, the program does not converge numerically.

Location decisions change dramatically when commuting costs increase. Slums experience the larger proportional increase in population, that jumps by 53.3%, from 10.9% to 16.8% of the total. A large share of the population that with $\tau_P = 0.05$ paid for transportation, living distant from the job market, would now rather suffer the welfare loss of living in the slums than lose 70% of their time commuting. The city proper population increase by 29%, to 46.9% of the total, as it is now worth, for richer individuals, paying the higher cost of living there. The reallocation to the rural area is small, its population increase by only 1.7 percentage point. We can conclude from this result that part of the slum size can be explained by transportation costs to distant neighborhoods: the higher τ_P, the larger the share of the population living in slums.

In the second experiment we repeat the counterfactual exercise in which slums are closed down, now in a world with DPN. We do this by imposing that the linear utility cost of living in slums goes to one ($\tau_{0,F} = 1$) Results are presented in Table G3:

Table G3: closing down slums

Variable	Benchmark	$\tau_{0,F} = 1$
Population (%)		
Slum	10.98	0.00
PDN	26.57	29.12
City	36.21	41.96
Rural areas	26.27	28.92
Personal Services (%)		
Labor Share	12.39	12.28
Output Share	10.41	10,83

When slums were closed down, PDN population increases by 9.6%, that of rural area by 10.5% and that in the city proper by 15.9%. Having now an alternative location to the rural areas, a large number of slums residents move to PDN - that now represents 29% of the total population - rather than to rural areas. In the benchmark case without PDN, rural population jumps to 41.3% of the total when slums are closed, but now it is considerably less, 28.9%. With the alternative of living in a PDN, closing the favelas now does not hinder the structural transformation process as much as it did before in the main model. It should also be noted that some wealthier individuals would rather move to cities, paying a higher cost of housing but having access to better education, than return to rural areas or lose part of their time commuting to the PDN.

H Measuring Intergenerational Education Mobility

Given our five education groups, we define:

- Upward Mobility (UM): Fraction of children attaining higher education groups than parents;
- Immobility (IM): Fraction of children that attaininin the the same group as their parents;
- Downward Mobility (DM): Fraction of children attaining lower education groups than parents.

We use these measures to evaluate the fit of the calibrated model and also the social mobility impacts of the policy experiments. We define these measures for the population of Brazil as a whole, for the populations in each of the three different types of locations (rural, slums, and formal cities) and for the population of households at each level of education. Thus, upward mobility is zero for households with 12+ years of schooling and downward mobility is zero for those with 0 years of schooling.

Recall that $\mu^{\ell}_{j,t}$ is the mass of adult individuals at time t, with education $e = e_j$ living in location ℓ and that $P^{\ell}_{i,j}$ is the fractions of their children of attaining education i in the bin e_i. Then, we define the following

- By Location:
  - Upward Mobility in each Location ℓ:

$$UM^{\ell}_t = \frac{\sum_{j=1}^{J-1} \mu^{\ell}_{j,t} \sum_{i=j+1}^{J} P^{\ell}_{i,j}}{\sum_{j=1}^{J-1} \mu^{\ell}_{j,t}}.$$

– Downward Mobility in each Location ℓ:

$$DM_t^\ell = \frac{\sum_{j=2}^{J} \mu_{j,t}^\ell \sum_{i=1}^{j-1} P_{i,j}^\ell}{\sum_{j=2}^{J} \mu_{j,t}^\ell}.$$

– Immobility in each Location ℓ:

$$IM_t^\ell = \frac{\sum_{j=1}^{J} \mu_{j,t}^\ell P_{j,j}^\ell}{\sum_{j=1}^{J} \mu_{j,t}^\ell}.$$

- For Brazil as a Whole:

  – Upward Mobility:

$$UM_t^{\mathrm{BRA}} = \frac{\sum_{\ell=\{R,F,C\}} \sum_{j=1}^{J-1} \mu_{j,t}^\ell \sum_{i=j+1}^{J} P_{i,j}^\ell}{\sum_{\ell=\{R,F,C\}} \sum_{j=1}^{J-1} \mu_{j,t}^\ell}.$$

  – Downward Mobility:

$$DM_t^{\mathrm{BRA}} = \frac{\sum_{\ell=\{R,F,C\}} \sum_{j=2}^{J} \mu_{j,t}^\ell \sum_{i=1}^{j-1} P_{i,j}^\ell}{\sum_{\ell=\{R,F,C\}} \sum_{j=2}^{J} \mu_{j,t}^\ell}.$$

  – Immobility:

$$IM_t^{\mathrm{BRA}} = \sum_{\ell=\{R,F,C\}} \sum_{j=1}^{J} \mu_{j,t}^\ell P_{j,j}^\ell.$$

  The last formula gets simplified because $\sum_{\ell=\{R,F,C\}} \sum_{j=1}^{J} \mu_{j,t}^\ell P_{j,j}^\ell = 1$.

- By Education level j, for Brazil as a whole:

  – Upward Mobility: for $j = 1, ..., J-1$

$$UM_{j,t}^{\mathrm{BRA}} = \frac{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell \left(\sum_{i=j+1}^{J} P_{ij}^\ell\right)}{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell},$$

  – Downward Mobility: for $j = 2, ..., J$

$$DM_{j,t}^{\mathrm{BRA}} = \frac{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell \left(\sum_{i=1}^{j-1} P_{ij}^\ell\right)}{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell},$$

  – Immobility: for $j = 1, ...J$

$$IM_{j,t}^{\mathrm{BRA}} = \frac{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell P_{jj}^\ell}{\sum_{\ell=\{R,F,C\}} \mu_{j,t}^\ell}.$$