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Philippe Bocquier
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Frédéric Docquier
LISER, University of Luxembourg and IZA

Narcisse Cha'ngom
LISER and University of Luxembourg

Joël Machado
LISER and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

The Within-Country Distribution of Brain Drain and Brain Gain Effects: A Case Study on Senegal*

Existing empirical literature provides converging evidence that selective emigration enhances human capital accumulation in the world's poorest countries. However, the within-country distribution of such brain gain effects has received limited attention. Focusing on Senegal, we provide evidence that the *brain gain* mechanism primarily benefits the wealthiest regions that are internationally connected and have better access to education. Conversely, human capital responses are negligible in regions lacking international connectivity, and even negative in better connected regions with inadequate educational opportunities. These results extend to internal migration, implying that highly vulnerable populations are trapped in the least developed areas.

JEL Classification: J24, J61, O15, R23, E24

Keywords: human capital, migration, selection, brain drain, brain gain, Senegal

Corresponding author:
Joël Machado
Luxembourg Institute of Socio-Economic Research
Maison des Sciences Humaines
11, Porte des Sciences
L-4366 Esch-sur-Alzette / Belval
Luxembourg
E-mail: joel.machado@liser.lu

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1 Introduction

International migration is a selective process and the question of how it affects (post-migration) human capital accumulation in the place of origin is of prime importance for economic development. Focusing on the world's poorest countries (i.e. low-income and lower-middle income countries), several case studies and cross-country analyses evidence that selective emigration to wealthier countries actually contributes to the growth of domestic human capital, transforming what is frequently referred to as *brain drain* into a *brain gain*. This phenomenon occurs primarily because the prospects of emigration to wealthier nations create stronger incentives for individuals to invest in education and enhance their human capital even before they migrate. This *incentive effect* dominates the pure *composition effect* – the fact that the propensity to emigrate increases with the level of education – in most of the world's poorest countries. Despite substantial variations in exposure to international migration across different regions, as demonstrated in studies such as Batista et al. (2012) on Cape Verde, Abarcar and Theoharides (2021) on the Philippines, Dinkelman and Mariotti (2016) on Malawi, or McKenzie and Rapoport (2011) and Caballero et al. (2021) on Mexico, there has been limited consideration of how these human capital responses are distributed within these countries.

This paper focuses on Senegal and explores how international and internal migration exposure impacts human capital and welfare disparities among regions. Senegal presents an intriguing case study. The country has shifted from a traditional country of destination in the Western Africa region to a country of emigration.[1] Furthermore, internal migration has significantly increased since the late 1990s, driven by factors like underemployment, urbanization, and natural resource degradation, among others (Ba et al., 2017). Our analysis relies on data from the 2013 Senegalese census, which offers extensive information regarding households' exposure to both international and internal migration. We employ this data to calibrate a Random Utility Model (RUM) that simultaneously considers education and migration decisions across the country's 45 *départements*. The model's parameterization is designed to precisely match existing data and relevant elasticities identified in previous empirical studies. Using this model, we aim to identify populations that lack international and internal connectivity, quantify the impact of mobility exposure on welfare, and assess disparities in high-level human capital across regions, as measured by the proportion of college graduates in the regional labor force.

While there is a growing body of evidence supporting the idea that selective emigration to wealthier countries enhances the accumulation of high-level human capital in the majority of low-income and lower-middle income nations, our research reveals that this

[1] See https://www.iom.int/countries/senegal.

selective emigration benefits the country as a whole, with significant advantages accruing to the wealthiest regions that are well-connected internationally and have better educational access. The gains in welfare resulting from international mobility are constrained by the fact that highly vulnerable and marginalized populations often lack the resources to migrate or access quality education, mainly due to enduring economic underdevelopment. Hence, international emigration exacerbates disparities in both human capital accumulation and welfare between the wealthiest and the poorest regions.

We also observe that internal labor mobility from less affluent to more prosperous regions can mitigate some of these disparities. However, the poorest regions within the country also suffer from limited internal connectivity and, therefore, derive little benefit from opportunities for inter-departmental migration. Consequently, the *brain gain* observed at the national level is primarily driven by net human capital gains experienced by the wealthiest *départements* located in the Dakar region (including Pikine, Guédiawaye, Ruffisque, and Dakar itself) and the surrounding areas in the Thiès and Diourbel regions. The response in human capital to international migration is negligible in *départements* lacking international connectivity and may even be negative in *départements* that are better connected but still face challenges related to educational access. Overall, the Dakar region enjoys a "double dividend" due to both the incentives created by selective international migration prospects and the influx of human capital from other parts of the country.

Our paper speaks to the literature on human capital, migration and economic development. First, it is widely acknowledged that human capital accumulation, economic growth and welfare are closely interrelated. Empirical research consistently demonstrates that the impact of human capital on economic growth is more pronounced when human capital is not just measured as the average years of schooling or literacy rates, but with more exclusive and elitist metrics such as the average stock of cognitive skills or knowledge capital. Notably, scholars such as Hanushek and Woesmann (2008, 2021) propose the use of international measures of math and science skills as proxies for knowledge capital. Similarly, the consideration of upper-tail human capital, represented by the proportion of tertiary-educated workers, has gained importance in studies examining historical events like the industrial revolution (e.g. Mokyr, 2005, Mokyr and Voth, 2009, Squicciarini and Voigtländer, 2015) as well as in contemporary analyses of developing countries (e.g. Castelló-Climent and Mukhopadhyay, 2013). Our paper extends this existing literature by constructing a model that explores the factors influencing disparities in upper-tail human capital among regions within a developing country.

Second, we contribute to the theoretical literature on brain drain, pre-migration human capital formation, and post-migration human capital accumulation. This literature

emphasizes the role of increased returns to education, facilitated by the option of selective emigration, in stimulating human capital growth. The founding *brain gain* study is Mountford (1997), building upon his 1995 working paper. It has since been explored by other scholars such as Stark et al. (1997), Vidal (1998) or Beine et al. (2001), and has expanded in various directions. Drawing from the quantity-quality trade-off model of fertility, Mountford and Rapoport (2011) investigate how selective emigration affects fertility responses in both sending and receiving countries and its global inequality implications.[2] Furthermore, besides the anticipation of higher returns, the emigration option can serve as a protective mechanism, incentivizing a shift in investments from less mobile (physical) capital to more mobile human capital in situations where economic uncertainty is pronounced in the origin countries (Katz and Rapoport, 2005). Compared with these studies, our model integrates endogenous decisions regarding education and emigration within a multi-region context, encompassing many origin and destination regions. However, it abstracts from considerations of economic uncertainty and dynamic implications.

Third, we contribute to the empirical *brain gain* literature. Identifying the causal effect of selective emigration on human capital accumulation is a complex task due to the endogenous nature of skill-specific emigration rates. Cross-country regressions with instrumental-variable techniques show that selective migration tends to enhance both education and the subsequent accumulation of human capital in developing countries (Beine et al., 2001, 2008, 2010). This effect is particularly pronounced when focusing on the world's poorest nations, specifically low-income and lower-middle income countries, as confirmed by Cha'Ngom et al. (2023). Case studies leveraging quasi-experimental settings find compelling evidence that shocks affecting skill-specific emigration prospects lead to heightened levels of human capital several years down the line – see Shrestha (2017) on Nepal, Abarcar and Theoharides (2021) on the Philippines, Khanna and Morales (2021) on India, and Chand and Clemens (2023) on the Fiji. Similarly, research examining persistent spatial disparities in emigration exposure between regions yields similar results (Batista et al., 2012, Theoharides, 2018).[3] In a related vein, Mobarak et al. (2023) explores the unique case of a government lottery that randomly allocated visas to Bangladeshis for low-skilled temporary labor contracts in Malaysia. Their findings emphasize a notable increase in pre-departure investments, with a distinct focus on skills, partly driven by Malaysia's specific labor market requirements; these investments, however, generate low

[2] Mountford and Rapoport (2016) utilizes the same framework to examine the potential impact of migration policies on demographic transitions in Africa.

[3] Other mechanisms of transmission have been identified in the literature, such as remittances (Clemens and Tiongson, 2017, Dinkelman et al., 2021, Dinkelman and Mariotti, 2016, Khanna et al., 2022), parental absence (Antman, 2011, Gibson et al., 2011) or transfer of education norms (Fernández Sánchez, 2022), but are less directly related to the selective structure of emigration flows.

or negligible returns in the domestic labor market.

In contrast to these studies, we adopt an alternative micro-founded approach that concurrently models migration and education decisions, considering regional characteristics as crucial determinants. Our primary focus is on understanding the responses within a country to selective emigration. It is well-documented that low-income and lower-middle income countries exhibit significant regional disparities in human capital accumulation. For instance, Gollin et al. (2014) and Vollrath (2009) highlight substantial variations in the urban/rural ratio of years of schooling, ranging from 2.0 to 1.5 in poorer nations. Moreover, various case studies underscore the considerable discrepancies in exposure to selective migration across regions within developing countries (Abarcar and Theoharides, 2021, Batista et al., 2012, Theoharides, 2018). Given this substantial heterogeneity in both international connectivity and access to education across regions, our investigation centers on whether selective migration flows within Senegalese regions amplify or mitigate regional disparities in human capital.

Lastly, our contribution extends to the literature addressing the intersection of internal migration and education decisions. Notably, Bryan et al. (2014) employ randomized controlled trials to investigate the impact of rural-to-urban migration during the lean season in rural Bangladesh. Their findings reveal a significant increase in household expenditure on children's education when a migrant is present in the household. Building on the same context, Lagakos et al. (2023) develop a dynamic incomplete-markets model that portrays seasonal migration as an insurance mechanism benefiting vulnerable households with limited assets and financial constraints. Furthermore, research by Meghir et al. (2022) demonstrates that temporary migration subsidies in the Bangladeshi context can generate spillover effects, enhancing risk sharing within the migrant's village and extending beyond the benefiting household. Other contributions delve into the effects of China's Hukou system, with studies by Pan (2017) and de Brauw and Giles (2017) revealing that negatively selected migration diminishes the likelihood of transitioning from middle to high school in rural areas. Additionally, related studies explore how improvements in connectivity within economically disadvantaged regions impact education choices in both developed and developing countries.[4] Our micro-founded model offers a relevant framework for comparing the effects of international and internal movements on human capital disparities among regions within Senegal.

The remainder of this paper is structured as follows. Section 2 provides an overview of our data sources and offers insights into the regional disparities concerning exposure

[4]See Cucu (2019) on decisions to acquire college education after the development of the U.S. Interstate Highway System in the 1950s, or Aggarwal (2018) on the differential impact of the timing and placement of paved roads on education of teenaged and younger children in Indian villages.

to both international and internal migration within Senegal. Section 3 presents our Random Utility Model (RUM), which simultaneously incorporates mobility and education decisions. We then parameterize the model to fit the available data and empirical estimates drawn from existing literature. Section 4 presents the quantitative findings of our analysis. Finally, Section 5 offers concluding remarks and summarizes our contributions..

2 Context, Data and Facts

Context. – Migration patterns from Senegalese regions result from a combination of historical events and the changing demographic landscape, notably the growing prominence of the Dakar region. In the early 20th century, the first Senegalese migrants comprised sailors, traders, and demobilized soldiers.[5] Sailors were driven to depart due to the decline in traffic on the Senegal River, often finding employment in the merchant navy and the French war navy (Robin, 2000). However, significant international emigration did not truly emerge until the 1960s, spurred by the establishment of recruitment centers in Senegal by the French *Office National de l'Immigration*, in collaboration with French companies and supported by the French Ministry of Labor and Population. This move was prompted by a labor demand surge in the French automobile industry. They recruited extensively from the Senegal River valley, the Tambacounda region, and Casamance, including all *départements* located south of the Gambia. During this period, rural Senegal was grappling with a series of droughts (Robin, 1996).

In terms of African destinations, Senegalese migrant farmers and traders were drawn to countries like Ivory Coast and Ghana, which were experiencing economic success. These migrants also sought opportunities in Gabon, Zaire, and Cameroon. However, the crisis in groundnut cultivation, compounded by successive droughts from the 1970s onwards, led to a significant increase in international emigration towards Europe. Until the 1980s, a majority of these migrants originated from the Senegal River valley and increasingly settled in France, despite the formal end of immigration programs in 1974. France's immigration policy in 1975 and 1976 shifted traditional labor immigration, predominantly composed of single men, towards family immigration (Robin, 2000).

Since the 1980s, the capital, Dakar, has become a significant hub for international emigration, particularly due to its rising share in the national population. Although there has been a gradual increase in the proportion of young adults in Dakar who have taken some initial steps toward international emigration (reaching one-third during 2000-2008), their actual likelihood of emigrating from Dakar remained relatively stable until

[5]For a comprehensive review of the history of international migration in Senegal, see Lessault and Flahaux (2013).

the late 2000s, at around one in ten young adults (Beauchemin et al., 2020, Lessault and Flahaux, 2013). Starting in the 1990s, Senegalese emigration dynamics were also influenced by emigration from the Diourbel, Thiès, and Louga regions (formerly known as Baol, Cayor, and Djambour). African destinations gradually declined to the benefit of a more diversified range of high-income and transit countries.[6] Senegalese emigration to the United States dates back to the early 1980s and reflects this shift away from Africa. Additionally, two new destinations, Italy and Spain, gained prominence (Robin, 1996).

Data sources. – Our dataset is derived from the 2013 Senegalese census, which encompasses the entire population, totaling approximately 13.2 million individuals. This dataset is comprehensive and includes a wealth of individual-level attributes, such as age, educational attainment, birthplace, and current residence, among others. Our analysis specifically focuses on individuals aged 15 and older, categorizing them into two skill groups: college graduates (comprising individuals with tertiary/higher education degrees) and the less educated. In doing so, our primary emphasis lies on the accumulation of upper-tail human capital, a crucial factor in modeling disparities in growth and productivity across countries and time periods (Castelló-Climent and Mukhopadhyay, 2013, Mokyr and Voth, 2009).

Senegal's administrative structure comprises four levels of divisions: 14 *régions*, 45 *départements*, 133 *arrondissements*, and 548 *communes* or municipalities. Our quantitative analysis in Section 4 is conducted at the *département* level. This choice is primarily driven by the availability of income data stratified by education level and its relevance in formalizing residential mobility between administrative units, as well as spatial disparities in access to tertiary education. It is worth noting that commuting flows between *départements* are generally limited, with the exception of the Dakar region, where *départements* tend to be smaller in size, and the transportation infrastructure is more developed.

The Senegalese census offers a crucial feature by providing comprehensive information regarding households' migratory backgrounds and exposure to international migration. This is achieved through two key elements:

- *Measurement of Internal Migration*: The census includes detailed inquiries about each respondent's department of birth. By comparing birthplaces and current residences, we can precisely gauge the stock of internal migrants between *départements* over the course of their lives. We adopt the concept of lifetime migration, considering individuals who live in a *département* different from their birth *département*.

[6] Notably, trans-Saharan migrations were reactivated, with Morocco emerging as a significant transit country.

This approach views migration as a life-course trajectory, focusing on individuals' long-term location choices. As of 2013, Senegal had 1,546,378 internal migrants, constituting approximately 24.1% of the working-age population. Among these, 471,527 internal migrants had relocated within the last five years. Notably, this group includes 106,747 college graduates, making up roughly 47.2% of the college-educated working-age Senegalese population.

- *Tracking International Emigration*: The census features questions about household members who have left the country in the past five years. This information allows us to compile data on migration flows, categorized by place of residence, destination country, and education level. Between 2008 and 2013, the census recorded 150,370 international emigrants of working age, with 11.1% being college graduates. We utilize this data on emigrant flows to estimate the composition of the stock of international Senegalese migrants by *départements* of origin. More specifically, we use the five-year migration flows to calculate the skill-specific proportions of emigrants to OECD countries by department of origin. Then, we apply these proportions to the total stock of Senegalese migrants residing in an OECD member state in 2015. Data on immigration to OECD countries are sourced from Arslan et al. (2015), which provides insights into the characteristics of 311,066 Senegalese migrants.

For reference, Table 5.1 in the appendix contains the country codes utilized throughout this paper, along with descriptive statistics regarding the population structure for the 45 Senegalese *départements*.

Stylized facts. – The 2013 census enables us to approximate the skill-specific stocks of lifetime internal and international migrants, categorized by *département* of origin and *département* or country of destination. Aggregating dyadic mobility at the *région* level, Figure 1 illustrates the lifetime movements of international (top panel) and internal (bottom panel) migrants, with a focus on college graduates in panels (a) and (c) and the less educated in panels (b) and (d).

The pivotal role of Dakar as a primary source of international migrants and a major destination for internal movers is prominently depicted. This is particularly pronounced among college-educated migrants. A substantial majority of highly skilled international migrants originate from the Dakar region, closely followed by the neighboring Thiès region, and they predominantly reside in OECD member states. In the realm of internal migration, Dakar emerges as the predominant destination, drawing migrants from across the country. For both college-educated international and internal migration, the largest *régions* of origin include Thiès, Saint-Louis, Ziguinchor, Diourbel, Kaolack, and Fatick.

Turning our attention to less educated migrants, the Dakar region remains the primary region of origin. However, owing to the persistence of historical migration routes used by Senegalese sailors, traders, and soldiers in the early 20th century, other traditional regions of emigration, such as Matam, Tambacounda, and Saint-Louis along the Senegal River, contribute significantly to the total stock of international migrants. Concerning low-skilled internal migrants, Dakar hosts 349,610 of them, while Thiès and Diourbel are also attractive regions, collectively attracting 377,275 movers.

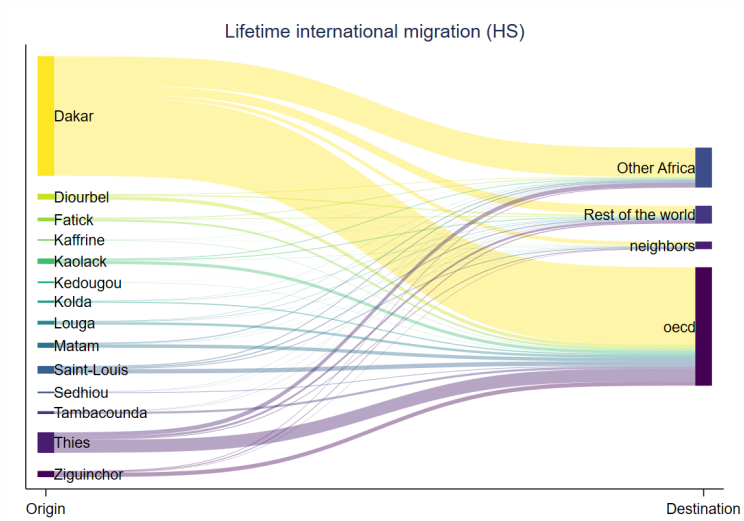
These disparities in the magnitude of lifetime movements are partially attributed to variations in native population size among regions. Notably, the four *départements* of the Dakar region (Dakar, Rufisque, Pikine, and Guédiawaye) constitute 18% of the Senegalese adult population but account for 45% of the college-educated population. To better illustrate the diversity in exposure to international and internal movements, we rely on skill-specific emigration rates, which define the emigration stock as a percentage of the corresponding native population. The spatial distribution of these emigration rates reflects discrepancies in the international and internal connectivity of high- and low-skilled populations. Figure 2 maps these disparities in connectivity between *départements*.

Regarding international migration (top panels), the highest emigration rates for college-educated individuals are observed in five *départements*: Dakar, Guédiawaye, Pikine, Rufisque (all within the Dakar region), and Kanel (in the Matam region). Moderate emigration rates are also noted in the less affluent *départements* of Mbacké, Matam, Goudiry, and Bakel. Other regions exhibit limited international connectivity. For less-educated individuals, the highest emigration rates are observed in the same *départements* and in the Senegal River regions bordering Mali and Mauritania, which still maintain relatively strong international connections. Nevertheless, these rates are considerably lower than those for college-educated individuals.

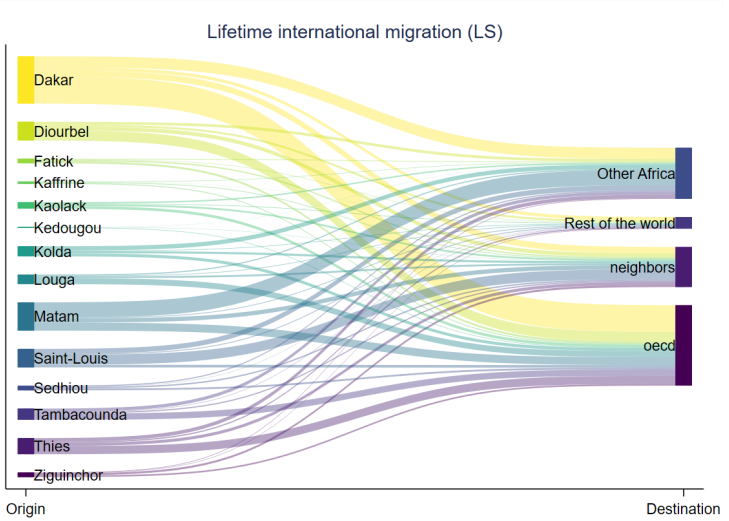
Shifting our focus to internal movements (bottom panels), the distribution of high-skilled emigration rates is more evenly spread across the country, although the eastern *départements* exhibit lower internal connectivity, in contrast to international migration patterns. The *département* of Salémata, in the Kédougou region, stands out with high emigration rates. Conversely, the distribution of emigration rates for low-skilled individuals suggests a lack of internal connectivity in many *départements*. Except for Salémata, distance from Dakar appears to be a reliable predictor of this isolation.

Figure 1: Stock of international and internal migrants by education level, *département* of origin and destination

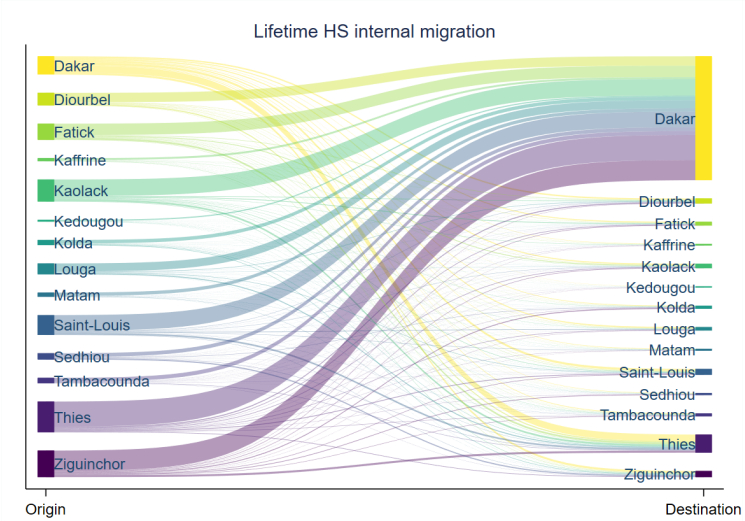
(a) International – College graduates



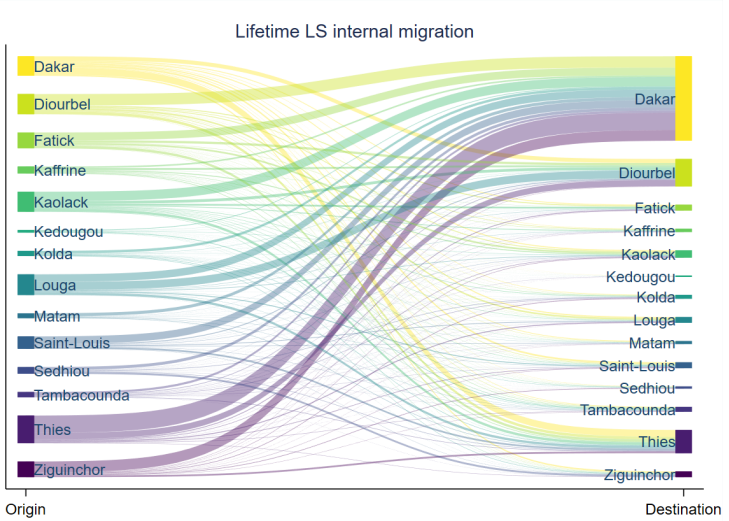
(b) International – Less educated



(c) Internal – College graduates



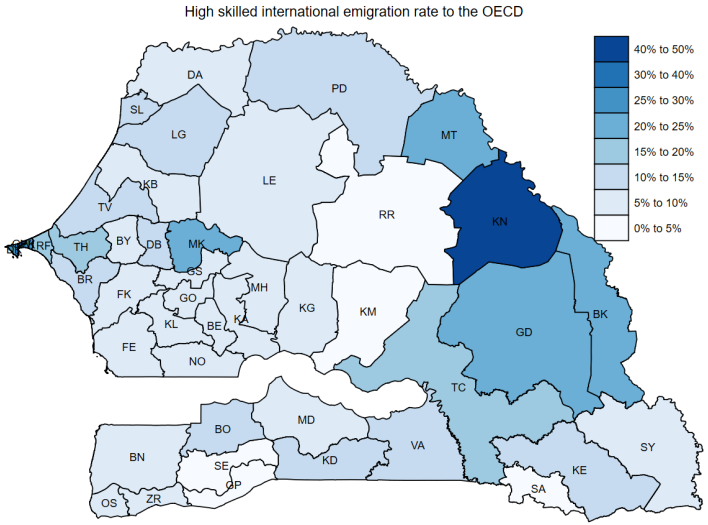
(d) Internal – Less educated



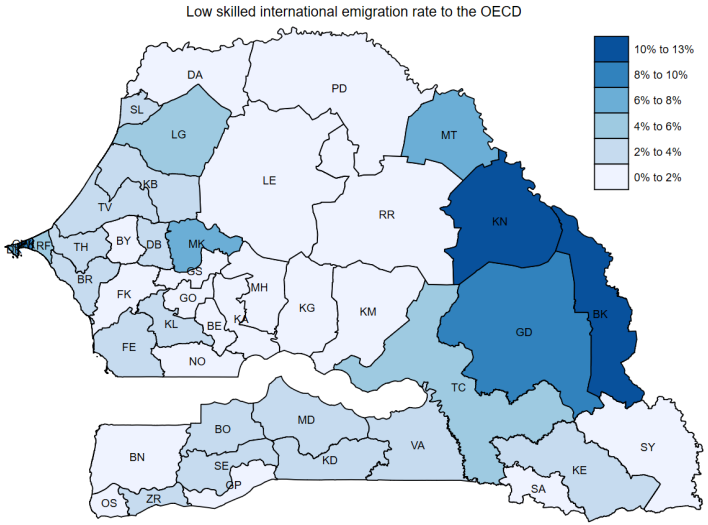
Note: Authors' computations based on 2013 Senegalese census data.

Figure 2: International and internal emigration rates by education level and *département* of origin

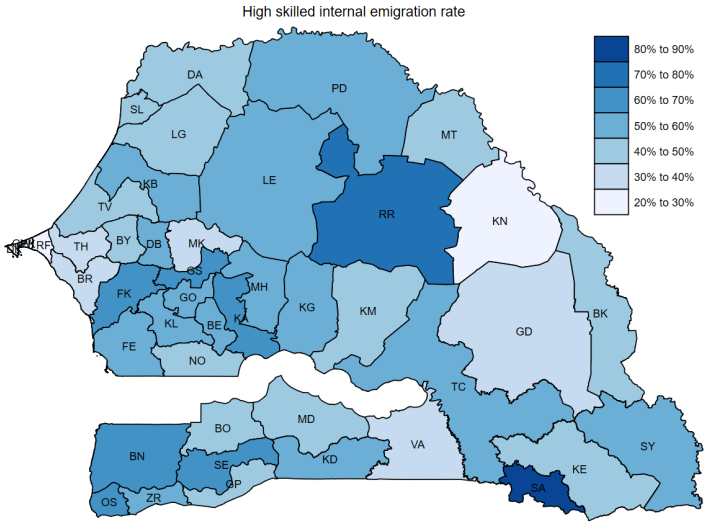
(a) College graduates



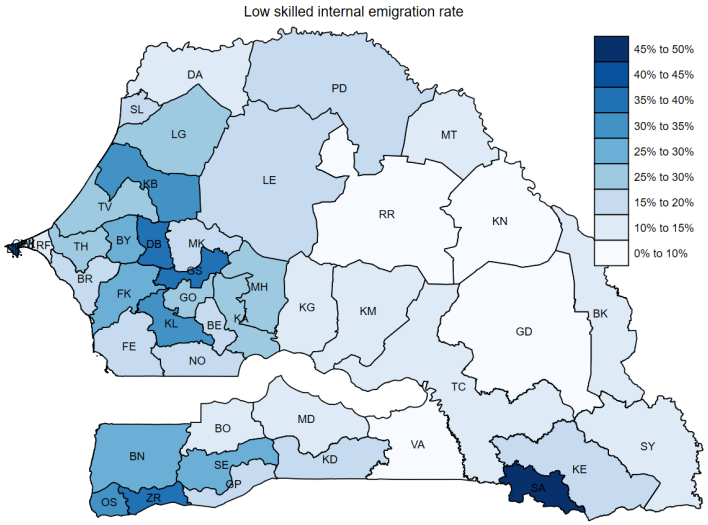
(b) Less educated



(c) College graduates



(d) Less educated



Note: Authors' computations based on 2013 Senegalese census data. We use skill-specific bandwiths for exposition purpose.

3 Model

To investigate the impact of international and internal mobility on human capital disparities in Senegal, we develop and parameterize a model that jointly endogenizes the fraction H_i of the (native) population from each *départements* i who choose to acquire college education (referred to as pre-migration, human capital formation), the share of individuals with specific skills opting to migrate to various destinations, both within Senegal and abroad ($m_{ij,s}$), and the proportion of college graduates within the regional workforce (h_i), which we term post-migration, human capital accumulation. Individuals can choose between two skill types $s = (h, l)$, with $s = h$ for college graduates and $s = l$ for the less-educated. The set of potential locations $\mathbb{J}$ encompasses a subset J of internal destinations (the departments within Senegal, $j = 1, ..., J$), as well as another subset J^* comprising foreign destinations ($j = J + 1, ..., J + F$). Our model factors in region-specific variables influencing mobility patterns, including migration costs, income disparities between easily accessible regions and foreign countries, and access to education, which considers factors like educational policy and individual ability distribution.

Our model inevitably leaves out a number of relevant factors related to migration decisions, human capital accumulation and economic development. First, unlike other studies (Delogu et al., 2018, Mountford and Rapoport, 2011, 2016), our static model focuses on how selective migration impacts the education choices made by a given cohort throughout their active years but does not delve into fertility decisions and their effect on Senegal's population dynamics. Second, we abstract from general equilibrium effects and assume that wages specific to skill levels remain constant. In a purely competitive labor market model with a constant population structure, selective migration could typically raise the skill premium at the origin while reducing it at the destination, ultimately decreasing the equilibrium level of selection. However, this is not necessarily the case in our model as human capital formation is endogenous. In addition, given our model's time frame of around 30 years (equivalent to a cohort's lifetime) and the ability of firms to internalize these effects, skill-biased technological changes are likely to offset any marginal productivity effects (see Acemoglu, 2002, Delogu et al., 2018, Monras, 2020). In our quantitative analysis, skill-specific wages are assumed to remain unaffected.

RUM structure. – Migration and education decisions are modeled as outcomes of a Random Utility Model (RUM) with two sources of heterogeneity between individuals (as in Cha'Ngom et al., 2023, Delogu et al., 2018) – in the ability to acquire higher education and in preferences for various destinations. The utility of an individual λ born in region

i, choosing education type-s and moving to a destination j is given by:

$$U_{ij,s}^{\lambda} = \left[\ln \omega_i^{\lambda} + \ln\left(1 - \frac{e_s^{\lambda}}{G_i}\right)\right] + \left[\ln w_{j,s} + \ln\left(1 - c_{ij,s}\right) + \varepsilon_{ij,s}^{\lambda}\right], \tag{1}$$

where the first term in brackets denotes the *pre-migration utility*, which depends on the income of individual λ (ω_i^{λ}), the heterogeneous effort required to acquire college education (e_h^{λ}), and a scale factor that proxies the mean access to education in region i (G_i).[7] No effort is required if the individual does not acquire higher education (i.e. $e_l^{\lambda} = 0$). The individual cost to acquire higher education e_h^{λ} is distributed on $[0, 1]$ according to the following cumulative distribution function: $F_2(e_h) = e_h^{z+1}$, where $z \in \mathbb{R}^+$ is a parameter governing the slope of the density function and the elasticity of human capital to the expected return to higher education. If $z = 0$, F_2 is the uniform distribution; the greater z, the lower the fraction of individuals with low education costs (i.e. z is a proxy for the scarcity of talent).

The second term in brackets denotes the *post-migration utility*, which depends on the average income at destination ($w_{j,s}$), the average level of mobility costs ($c_{ij,s}$), and a random component ($\varepsilon_{ij,s}^{\lambda}$) that captures heterogeneity between individuals in preferences, in moving costs, in the ability to value work-related skills and experience in a different location, etc. As is standard in the literature dealing with migration, we assume that the random component of utility $\varepsilon_{ij,s}^{\lambda}$ follows a Type I Extreme Value distribution with a dispersion parameter μ. As discussed below, the inverse of this parameter is the elasticity of dyadic migration to the income differential between origin and destination countries, and is a substitute for the elasticity of utility to income. In this setting, location decisions are governed by a multinomial logit expression.

Timing and expected utility. – The timing of decisions reflects the availability of information about the two random components of utility. In the first stage, individuals make higher education decisions before discovering their migration type, $\varepsilon_{ij,s}^{\lambda}$, but they know its distribution. Assuming perfect expectations about $w_{j,s}$ and $c_{ij,s}$, each individual decides to acquire higher education if the expected utility gain from being educated exceeds the cost. Given the distributional assumptions on ε, the expected level of maximum utility of type-s individuals born in department i is given by (McFadden, 1974):

$$\mathbb{E}\left(U_{i,s}^{\lambda}\right) = \left[\ln \omega_i^{\lambda} + \ln\left(1 - \frac{e_s^{\lambda}}{G_i}\right)\right] + \ln \sum_{j=1}^{\mathbb{J}} \left(w_{j,s}\right)^{1/\mu} \left(1 - c_{ij,s}\right)^{1/\mu}, \tag{2}$$

where the first (pre-migration) term is known by the individual when making education decisions, while the second term is the unconditional expected value of maximum utility

[7] This scale variable G_i can be seen as a weighted average of access to domestic and foreign education.

in the post-migration period, also termed log-sum or inclusive value of the underlying multinomial logit model.

The latter term includes the utility in the home location ($i \in \mathbb{J}$). Hence, for individuals born in department i, the expected value of post-migration maximum utility (i.e. the second term in Eq. (2)) can be rewritten as:

$$\Omega_{i,s} = \ln\left[(w_{i,s})^{1/\mu} + (W_{i,s})^{1/\mu} + (W^*_{i,s})^{1/\mu}\right], \tag{3}$$

where $(W_{i,s})^{1/\mu} \equiv \sum_{j\in J\setminus\{i\}}(w_{j,s})^{1/\mu}(1-c_{ij,s})^{1/\mu}$ is the expected utility component related to internal mobility prospects, and $(W^*_{i,s})^{1/\mu} \equiv \sum_{j\in J^*}(w_{j,s})^{1/\mu}(1-c_{ij,s})^{1/\mu}$ is the component related to international mobility prospects for type-s individuals. In a no-migration economy (NM), these two terms are nil, implying that $\Omega^{NM}_{i,s} \equiv (1/\mu)\ln w_{i,s}$.[8] In a context with mobility, the influence of internal and international mobility prospects is large if the levels of $W_{i,s}$ and $W^*_{i,s}$ are high in comparison with $w_{i,s}$. This is the case when wages in alternative destinations are high, and moving costs are low. The level of $\Omega_{i,s}$ is a proxy for the average welfare of type-s individuals born in i, as argued below.

In the second stage, after the education decision is implemented, individuals discover their migration type, $\varepsilon^{\lambda}_{ij,s}$, and decide where to emigrate, or to stay in their home country. Given heterogeneous preferences, the dyadic emigration rate from department i to destination j is defined as:

$$m_{ij,s} = \mathbb{P}\left[\ln w_{j,s} + \ln(1-c_{ij,s}) + \varepsilon_{ij,s} = \max_{k\in\mathbb{J}} \ln w_{k,s} + \ln(1-c_{ik,s}) + \varepsilon_{ik,s}\right].$$

Assuming regional characteristics ($w_{i,s}$ and G_i) and dyadic mobility costs ($c_{ij,s}$) are exogenous, we characterize below the solution for the three variables of interest (H_i, $m_{ij,s}$, and h_i).

Human capital formation (H_i). – For individual λ investing in college education is optimal when $\mathbb{E}\left(U^{\lambda}_{i,h}\right) \geq \mathbb{E}\left(U^{\lambda}_{i,l}\right)$. Given Eq. (2), this condition holds if the cost of acquiring higher education is not too large:

$$e^{\lambda}_h \leq G_i\left[\frac{\Lambda_i - 1}{\Lambda_i}\right], \tag{4}$$

where Λ_i is the expected "return" to higher education accounting for wage rates in all possible destinations, weighted by their accessibility. It can be expressed as:

$$\Lambda_i \equiv \frac{\exp(\Omega_{i,h})}{\exp(\Omega_{i,l})} \equiv \frac{(w_{i,h})^{1/\mu} + (W_{i,h})^{1/\mu} + (W^*_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu} + (W_{i,l})^{1/\mu} + (W^*_{i,l})^{1/\mu}}, \tag{5}$$

[8] This highlights that $1/\mu$ determines the elasticity of utility to income.

where the key variables $W_{i,s}$ and $W^*_{i,s}$ $\forall s$ capture the components of Λ_i driven by internal and international mobility. In a no-migration economy, the return to higher education is determined by the ratio of local wage rates ($\Lambda_i \equiv (w_{i,h}/w_{i,l})^{1/\mu}$). In an economy open to emigration, the expected return to higher education increases (resp. decreases) with wage rates, and accessibility to all alternative destinations for the highly educated (resp. less educated).

Given our distributional assumptions on e^{λ}, it follows that:

$$H_i = G_i^{1+z} \left[\frac{\Lambda_i - 1}{\Lambda_i} \right]^{1+z}. \tag{6}$$

Hence, the model has desired properties in line with the existing literature. Migration opportunities stimulate pre-migration human capital formation, H_i, if the education premium is greater in alternative destinations than in the region of birth (i.e. $\frac{W_{i,h}}{W_{i,l}}$ or $\frac{W^*_{i,h}}{W^*_{i,l}}$ are greater than $\frac{w_{i,h}}{w_{i,l}}$), in line with Mountford (1997), Stark et al. (1997), Vidal (1998), Beine et al. (2001, 2008). In addition, the greater G_i, the more a rise in skill premium in alternative destinations stimulates H_i, in line with Stark and Wang (2002) and Djajić et al. (2019).

Internal and international mobility. – Once the education decision has been made, individuals discover their migration type, $\varepsilon^{\lambda}_{ij,s}$, and make the choice between emigrating to another location or remaining in their home country. Assuming a Type I Extreme Value distribution, the likelihood that a type-s individual born in region i relocates to destination j is determined by the multinomial logit expression:

$$m_{ij,s} = \frac{(w_{j,s})^{1/\mu}(1 - c_{ij,s})^{1/\mu}}{(w_{i,s})^{1/\mu} + (W_{i,s})^{1/\mu} + (W^*_{i,s})^{1/\mu}},$$

which implies that internal and international emigration rates for type-s individuals from department i are given by

$$m_{i,s} = \sum_{j \in J \setminus \{i\}} m_{ij,s} = \frac{(W_{i,s})^{1/\mu}}{(w_{i,s})^{1/\mu} + (W_{i,s})^{1/\mu} + (W^*_{i,s})^{1/\mu}}$$

$$m^*_{i,s} = \sum_{j \in J^*} m_{ij,s} = \frac{(W^*_{i,s})^{1/\mu}}{(w_{i,s})^{1/\mu} + (W_{i,s})^{1/\mu} + (W^*_{i,s})^{1/\mu}}.$$

The ratios of these emigration rates determine the level of positive selection observed in internal mobility ($\rho_i \equiv \frac{m_{i,h}}{m_{i,l}}$, which increases with $\frac{W_{i,h}}{W_{i,l}}$) and international migration ($\rho^*_i \equiv \frac{m^*_{i,h}}{m^*_{i,l}}$, which increases with $\frac{W^*_{i,h}}{W^*_{i,l}}$).

Once again, the model exhibits desired properties consistent with empirical findings. The greater $W_{i,s}$ or $W^*_{i,s}$, the greater skill-specific emigration rates, $m_{i,s}$ or $m^*_{i,s}$. The

greater $\frac{W_{i,h}}{W_{i,l}}$ or $\frac{W^*_{i,h}}{W^*_{i,l}}$, the greater the selection ratio, ρ_i or ρ^*_i, in line with Grogger and Hanson (2011), Belot and Hatton (2012) and Kerr et al. (2016). Furthermore, in accordance with Cha'Ngom et al. (2023), mobility-driven expected utility shocks ($\Delta W_{i,s}$ or $\Delta W^*_{i,s}$) induce a positive correlation between human capital formation (H_i) and the ratio of emigration rates (ρ_i or ρ^*_i). For example, shocks that increase the expected utility of college graduates in an alternative destination ($W_{i,h}$ or $W^*_{i,h}$) have a positive effect on human capital formation (H_i) and on the positive selection of internal or international migrants (as reflected by the ratio of high-skilled to low-skilled emigration rates, ρ_i or ρ^*_i; see e.g. Abarcar and Theoharides, 2021, Khanna and Morales, 2021, Shrestha, 2017, Theoharides, 2018). Shocks that increase the expected utility of the less-educated in a different region or abroad ($W_{i,l}$ or $W^*_{i,l}$) have a negative effect on both variables (e.g., de Brauw and Giles, 2017, Kosack, 2021, McKenzie and Rapoport, 2011, Pan, 2017). This establishes the micro-foundations for the link between mobility prospects and pre-migration human capital formation in a dyadic framework encompassing both internal and international locations. In contrast, local expected utility shocks ($\Delta w_{i,s}$) induce a negative correlation between H_i and ρ_i or ρ^*_i.

Lastly, it is important to highlight that under the assumption of a Type I extreme-value distribution for ε, the conditional distribution (conditional on the selected alternative) and the unconditional distribution of maximum post-migration utility are equivalent, regardless of the chosen alternative (de Palma and Kilani, 2007). This implies that:

$$\Omega_{i,s} = \mathbb{E}\left[\ln w_{j,s} + \ln\left(1 - c_{ij,s}\right) + \varepsilon_{ij,s} | U_{i,j,s} = \max_{k \in \mathbb{J}} U_{i,k,s}\right] \ \forall j, \tag{7}$$

motivating the choice of $\Omega_{i,s}$ as a proxy for welfare.

Human capital accumulation (h_i). – The post-migration share of college graduates in the regional labor force can be expressed as the ratio of college-educated non-migrants to total non-migrant populations, adjusted for the number of immigrants ($I_{i,s}$):

$$h_i \equiv \frac{(1 - m_{i,h}) H_i N_i + I_{i,h}}{(1 - m_{i,h}) H_i N_i + I_{i,h} + (1 - m_{i,l})(1 - H_i) N_i + I_{i,l}}, \tag{8}$$

which increases with the proportion of remaining college graduates, $(1 - m_{i,h})H_i$, and decreases with the proportion of remaining low-skilled workers, $(1 - m_{i,l})(1 - H_i)$. For a given stock of immigrants ($I_{i,s} \equiv \sum_{j \neq i} m_{ji,s} N_{j,s}$), mobility-driven expected utility shocks affecting region i ($\Delta W_{i,s}$ or $\Delta W^*_{i,s}$) induce ambiguous effects on post-migration human capital accumulation as for a given H_i, h_i decreases with positive selection, in line with Beine et al. (2001, 2008, 2010) and Cha'Ngom et al. (2023).

Parameterization. – We parameterize our model to precisely align with the data on skill-specific wage rates, dyadic emigration stocks, and the size of the labor force by education level observed in the 45 *départements* of Senegal in 2013. To estimate skill-specific wages, we use labor income data from the Senegalese Labor Force Survey. We calculate the average yearly earnings of college graduates and less-educated workers in each *département*, adjusting for workers' participation rates. We then convert these wage rates into USD PPP, using the exchange rate from the WDI. In Senegal, college graduates earn, on average, approximately three times more than less-educated individuals. For the OECD destination option, we compute a population-weighted average GDP per worker for each skill group on the sample of countries that host immigrants from Senegal.

With regard to migration, we employ data on dyadic emigration stocks ($M_{ij,s}$), encompassing the population of non-movers ($M_{ii,s}$), categorized by education level as described in Section 2. In our set of destinations, we distinguish between the 45 departments of Senegal, a unified foreign entity comprising all OECD member states, and another entity aggregating the rest of the world, primarily encompassing contiguous African countries. Using Eq. (3), the ratio of movers to non-movers is determined by $M_{ij,s}/M_{ii,s} = (w_{j,s}/w_{i,s})^{1/\mu}(1-c_{ij,s})^{1/\mu}$. We observe wage ratios across all pairs of destinations and assume an elasticity of bilateral migration to the wage ratio equal to $1/\mu = 1/0.7$ (in line with Bertoli and Moraga, 2013). Consequently, dyadic migration costs ($c_{ij,s}$) are calculated as residuals to precisely match the ratio of movers to non-movers from the data.

As a validation exercise, Table 1 demonstrates that the calibrated levels of internal migration costs are positively correlated with the geodesic distance between *départements*, and this effect remains relatively consistent across skill groups. Moving costs for college graduates decrease with cultural proximity and the mean distance to roads within the *départements*. While only weakly significant, moving costs for less-educated individuals show a positive correlation with access to cities, which may imply that improved mobility within *départements* for low-skilled workers, including rural-to-urban migration, reduces the necessity to relocate to different locations. Mobility costs exhibit a negative correlation with the average income per worker at the department level, with this effect being more pronounced for college graduates. This suggests that migration costs are more manageable when local economic conditions at the origin are relatively favorable.

Figure 3 provides a visual representation of the calibrated levels of international and internal migration costs. For the sake of clarity, internal migration costs are specifically depicted for migration to Dakar. In many respects, these costs closely align with disparities in emigration rates, as illustrated in Figure 2.

In terms of international migration costs, they are usually substantial for college-

Table 1: Validation of calibrated internal migration cost

	(1) Mean cost	(2) Coll. graduates	(3) Less educated
Income p.w. (log)	-0.019***	-0.045***	-0.018***
	(0.003)	(0.012)	(0.003)
Mean distance (logs)	0.028***	0.027***	0.029***
	(0.004)	(0.010)	(0.006)
Dist. to road (logs)	-0.005*	-0.020***	-0.006*
	(0.003)	(0.006)	(0.003)
Dist. to coast (logs)	-0.004	-0.000	-0.005*
	(0.002)	(0.006)	(0.003)
Access to cities (logs)	0.003*	-0.002	0.005*
	(0.002)	(0.002)	(0.003)
Cultural prox.	-0.001	-0.005**	-0.001
	(0.001)	(0.002)	(0.001)
Nb. Obs.	1,936	1,936	1,936
R^2	0.47	0.48	0.44
FE Dest.	Yes	Yes	Yes

Notes: OLS regressions. Standard errors are robust to heteroskedasticity and clustered at the department level.

education individuals, with the exception of the Dakar region and Kanel in the Matam region. To a lesser extent, some departments such as Saint-Louis and Louga in the Saint-Louis region, Thiès and M'bour in the Thiès region, Foundiougne in the Fatick region, as well as Ziguinchor, Sédhiou, and the eastern part of the country also experience lower migration costs for college-educated individuals. However, except for Dakar, Guédiawaye, and Pikine, individuals with lower levels of education face significantly higher international migration costs.

Shifting focus to internal migration costs, college graduates generally encounter relatively low costs within the entire country, except in departments located in the north of the country (Dagana and Podor), in the Kaffrine region, in Koumpentoum, and in border areas with The Gambia (Bounkiling, Médina Yoro Foulah). In contrast, internal migration costs for less-educated individuals are notably higher, except in departments like Thiès, Djourbel, and Fatick, as well as in Ziguinchor, Sédhiou, and Salémata.

Regarding the education technology, we determine two unknown parameters, denoted as z and G_i, to fit data on emigration stocks and human capital levels. The parameter z dictates the sensitivity of pre-migration human capital levels to the prospects of selective migration. Cha'Ngom et al. (2023) calibrate this parameter to correspond with the semi-elasticities empirically estimated for four broad country income groups. We set $z = 3.8$, which corresponds to the long-run semi-elasticity they estimated for the lower-middle income country group, amounting to 3.2.[9] With z established, the scaling variable G_i is subsequently calibrated as a residual from Eq. (6) to match the observed pre-migration human capital levels, H_i, evident in the data.

In a validation exercise, Table 2 demonstrates that the calibrated values of G_i exhibit a positive correlation with the proportion of the population residing in urban areas, the average income per worker, and the number of schools at the department level. Despite the high collinearity among these variables, they all remain statistically significant when included jointly, and collectively explain more than 75% of the variance in G_i.

Figure 4 provides a visual representation of the calibrated level of access to education across Senegal. Except for the four departments in the Dakar region (Dakar, Guédiawaye, Pikine, and Rufisque), as well as Bambey in the Diourbel region, access to education is generally low to very low in the rest of the country. This indicates that selective emigration could potentially have little effects on human capital formation in poor regions.

[9] In practical terms, this implies that a 10 percentage-point disparity between high and low-skilled emigration rates stimulates pre-migration human capital levels by 32% (e.g., increasing the proportion of college graduates from 3.00% to 3.96%).

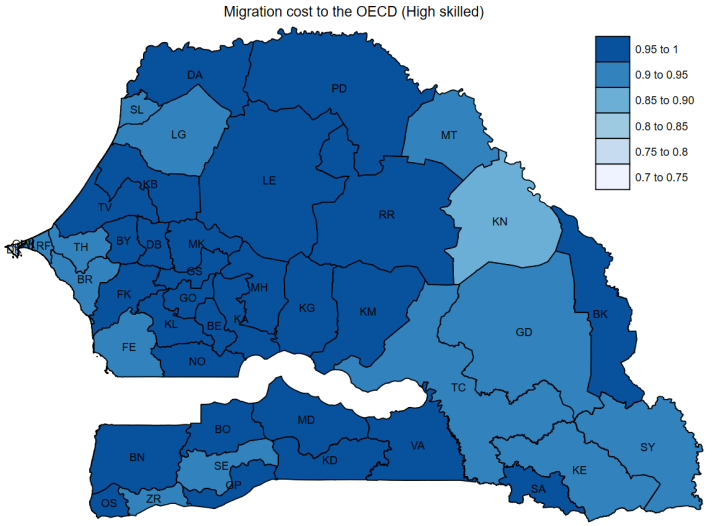
Table 2: Validation of calibrated provision of public education

	(1)	(2)	(3)
Urban (as %)	0.261***		0.148**
	(0.040)		(0.059)
Nb. schools (logs)		0.043***	0.026***
		(0.005)	(0.008)
Income p.w. (logs)	0.069***	0.106***	0.078***
	(0.019)	(0.018)	(0.020)
Nb. Obs.	45	45	45
R-Sq.	0.70	0.71	0.76

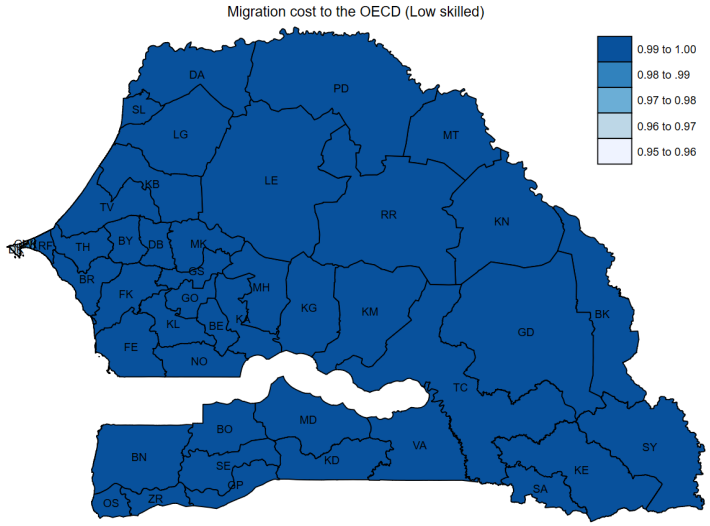
Notes: OLS regressions. Standard errors are robust to heteroskedasticity and clustered at department level

Figure 3: Calibrated migration costs ($m_{ij,s}$) by *département*

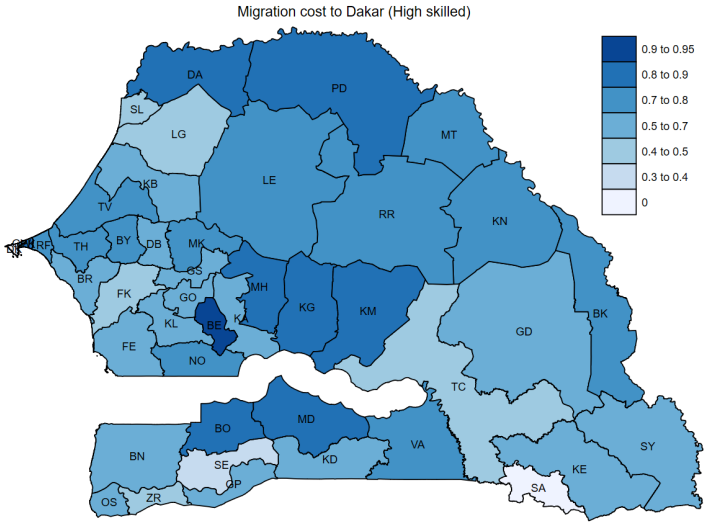
(a) International – College graduates



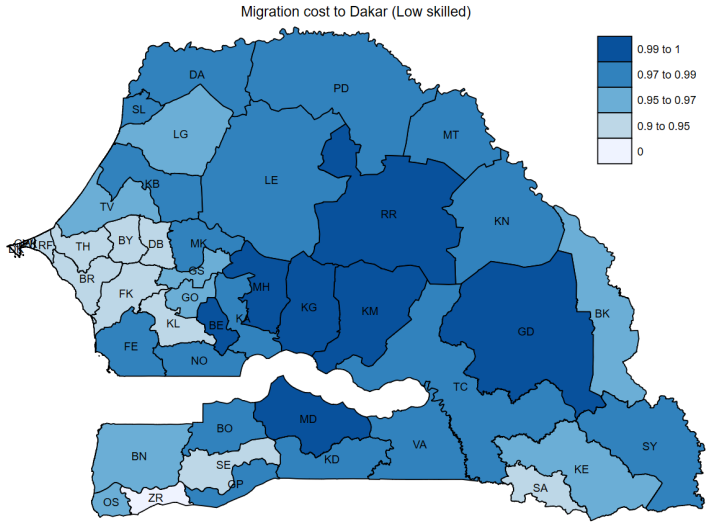
(b) International – Less educated



(c) Internal – College graduates

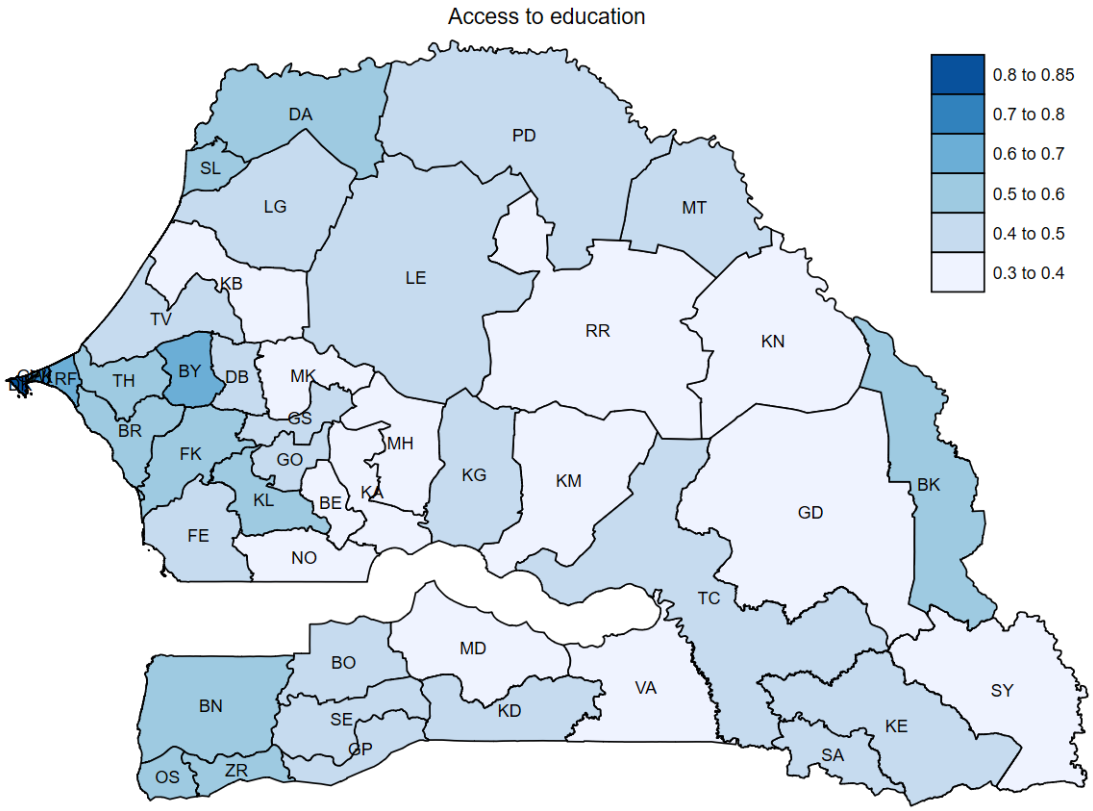


(d) Internal – Less educated



Note: Authors' computations. Note that we use different bandwidths for college graduates and less educated people for exposition purpose.

Figure 4: Calibrated access to education (G_i) by *département*



Note: Authors' computations.

4 Quantitative Findings

We employ our parameterized model to compare the current equilibrium with several counterfactual scenarios, assuming constant wages. These scenarios help us understand the impact of international and internal mobility on various aspects of the equilibrium. We begin by comparing the current situation with a counterfactual scenario that eliminates international migration opportunities (i.e., $c_{ij,s} = 1$ for all $j \in J^*$ and all s). Our primary focus is on emigration to OECD member states, as these countries are likely to have the most significant effects on selective migration prospects.[10] Next, we consider a second counterfactual scenario that eliminates internal migration opportunities (i.e., $c_{ij,s} = 1$ for all $j \in J \backslash i$ and all s). Finally, we investigate a third counterfactual scenario that combines

[10]Migration from Senegal to the rest of the world primarily includes movement to other African countries, including contiguous nations, South Africa, and Northern African countries. While our calibrated model accounts for international migration to the rest of the world, our estimates for skill-specific wages are less precise for these countries. Consequently, we do not alter migration costs to the rest of the world in our counterfactual analysis.

the first two (i.e., eliminates both international and internal migration opportunities).

Below, we first investigate the effects of international and internal mobility on average welfare disparities between birthplaces. Secondly, we assess the influence of mobility on the expected return to higher education. Lastly, we examine how mobility impacts the post-migration share of college graduates in the regional labor force. In each case, we compare the observed levels of these variables of interest to those derived from a counterfactual no-migration scenario, enabling us to quantify the consequences of mobility on these dimensions.

Effects on welfare. – To estimate the welfare gains resulting from emigration opportunities, we rely on the expected value of post-migration utility denoted as $\Omega_{i,s}$, as defined in Eq. (3). Remember that this variable measures both unconditional and conditional (on the chosen alternative) mean values of maximum utility for individuals born in region i. In Figure 5, we simulate the change in welfare due to migration opportunities, $\Delta\Omega_{i,s} \equiv \Omega_{i,s} - \Omega_{i,s}^{NM}$, and plot it against the no-migration counterfactuals, labeled as NM. Results for college graduates are displayed in the left panel, while those for the less educated are presented in the right panel. As $\Omega_{i,s}$ is the log of the expected value of post-migration income, we interpret $\Delta\Omega_{i,s}$ as the relative change in welfare resulting from selective emigration, expressed as a percentage of the NM counterfactual level.

The top panel of Figure 5 illustrates the welfare implications stemming from international migration opportunities. As expected, these opportunities substantially enhance the welfare of college graduates, with increases exceeding 30% in *départements* characterized by the highest emigration rates, such as Dakar, Guédiawaye, Pikine, Mbacké, Matam, Goudiry, Bakel, and Kanel (where welfare experiences a remarkable 85% rise). In contrast, the impact of international migration on welfare in the rest of the country is less pronounced. This is particularly evident in Salémata, a *département* that benefits significantly from internal migration opportunities (see below) but lacks international connectivity.

Overall, the correlation between the welfare effects of international migration and the no-migration baseline is relatively low, indicating that prospects for high-skilled emigration have a limited influence on inter-*département* disparities in welfare among college-educated individuals. A different pattern emerges when examining the welfare effects of international mobility on the less educated population. Except for select *départements*, mainly in the eastern regions bordering Mauritania and Mali, international connectivity heavily favors the wealthy *départements* of the Dakar region, where the welfare of the less educated increases by 5 to 13%. This increase is notably smaller compared to the welfare response to high-skilled migration. In less affluent *départements*, the welfare

impact of low-skilled migration is low, leading to the conclusion that international migration prospects tend to exacerbate inter-*département* disparities in welfare within the low-skilled population.

The middle panel of Figure 5 provides insights into the welfare effects stemming from internal migration opportunities. As illustrated in Figure 2, internal connectivity is relatively high for college graduates across all regions. In contrast to international migration, the wealthy *départements* of the Dakar region benefit less from high-skilled internal emigration than their less affluent counterpart. While welfare gains for college graduates reach approximately 25% in the Dakar region, they approach 100% in most other regions. Salémata, in particular, stands out with a substantial internal connectivity boost of 240% in welfare. This implies that high-skilled internal migration helps to reduce inter-*département* disparities in welfare among highly educated individuals.

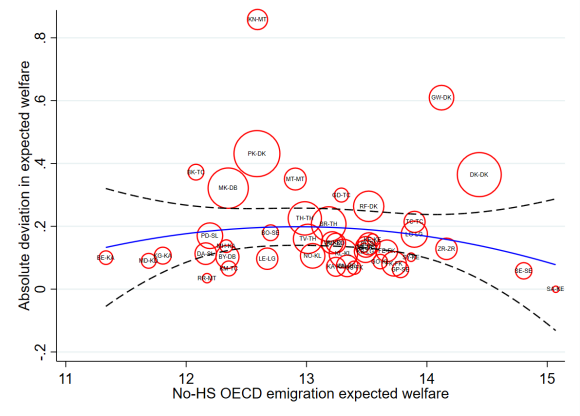
In contrast, for less educated individuals hailing from regions distant from Dakar, internal connectivity is generally low or very low, as highlighted in Figure 3, with the least internally connected *départements* located in the regions of Matam (Ranérou Ferlo, Kanel, Matam), Tambacounda (Goudiry, Koumpentoum, Tambacounda), Kolda (Vélingara, Médina Yoro Foulah), and Sédhiou (Bounkiling). These *départements* exhibit limited welfare gains of approximately 10%. Overall, internal migration prospects tend to increase inter-*département* disparities in welfare among the less educated, who constitute the overwhelming majority of the Senegalese population.

The combined effects of both internal and international migration, shown in the bottom panel of Figure 5, highlight that mobility slightly reduces welfare disparities within the college-educated population. It induces substantial welfare gains of approximately 100% in many *départements*. Conversely, mobility significantly increases welfare disparities within the less educated population, leading to substantial gains of around 60% in the wealthiest *départements* and smaller gains of about 15% in the least connected ones.

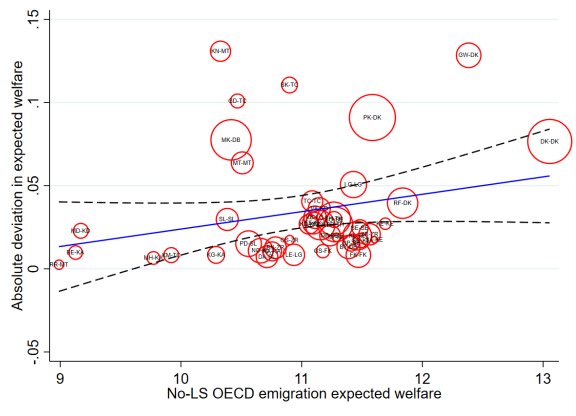
Effects on expected skill premium. – We now turn our attention to human capital formation. Selective migration prospects affect individual incentives to invest in higher education by increasing its expected return. In the top panels of Figure 6, we focus on the expected skill premium, as measured by λ_i defined in Eq. (5). We plot the migration-driven relative changes in the expected skill premium, $(\lambda_i - \lambda_i^{NM})/\lambda_i^{NM}$ (expressed as a percentage of the NM counterfactual level), against the no-migration counterfactual levels, λ_i^{NM}. These skill-premium responses are closely linked to the differential welfare effects experienced by college graduates and the less educated. Due to positive selection in international and internal migration, this differential is positive in nearly all *départements*. However, the magnitude of this differential varies significantly across regions.

Figure 5: Welfare analysis $(\Omega_{i,s} - \Omega_{i,s}^{NM})$ v.s. $\Omega_{i,s}^{NM}$ by *département*

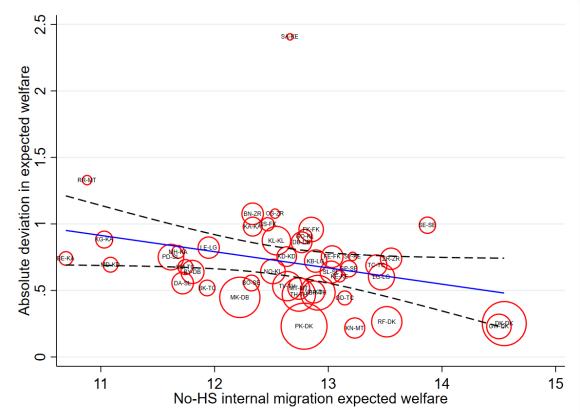
(a) International – College graduates



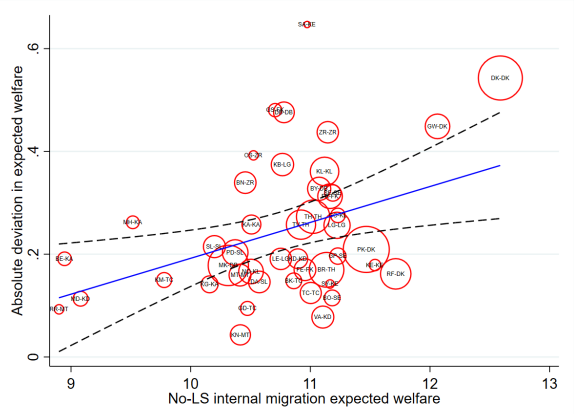
(b) International – Less educated



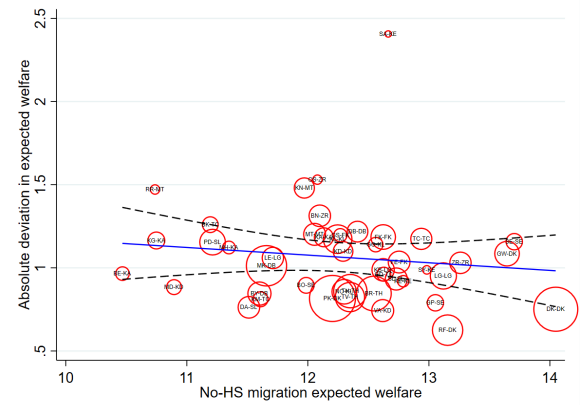
(c) Internal – College graduates



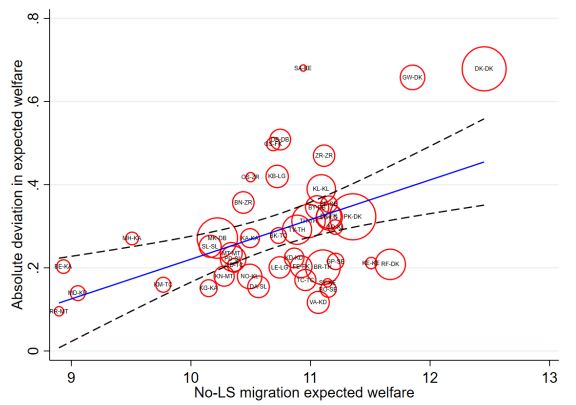
(d) Internal – Less educated



(e) Both – College graduates



(f) Both – Less educated



Note: Authors' computations. Each *département* is represented by a bubble, whose size is proportional to its population in 2013. The blue quadratic curve and its interval of confidence (dotted curves) depicts the relationship between the emigration-driven changes in welfare and the no-migration counterfactual. A negative (resp., positive) correlation means that emigration reduces (resp. increases) welfare disparities between *départements*.

In Panel (a), we observe the most significant skill-premium responses to international migration prospects in the wealthiest *départements*, where human capital is already abundant, and the no-migration skill premia are low. In the Dakar region, the skill premium increases by 30 to 60%, while in Kanel (Matam region), it surges by more than 100%. Conversely, in *départements* with scarce human capital and larger no-migration skill premia, the skill premium rises by less than 10%. Consequently, international migration tends to enhance incentives for human capital acquisition in the wealthiest regions, signifying that the national *brain gain* is predominantly driven by these *départements*.[11]

Panel (b) illustrates that internal migration prospects yield qualitatively similar effects, albeit with a somewhat weaker correlation. Internal connectivity is generally more substantial than international connectivity, except in Dakar. Consequently, in the Dakar region, internal migration prospects have a limited or even negative impact on the expected skill premium. However, in most other regions, positive effects ranging from 40 to 100% are observed. The most significant responses occur in *départements* located in the middle of the no-migration counterfactual distribution. For instance, the skill premium nearly triples in the *départements* of Kanel and Ranérou Ferlo in the Matam region.

In Panel (c), when considering the combined effects of internal and international migration, we observe that the overall impact of mobility on incentives to acquire human capital is predominantly influenced by internal migration prospects. Expected skill premia experience boosts of 100 to 200% in many regions, with the most substantial effects seen in Salémata, Ranérou Ferlo, Kanel, and Oussouye. Conversely, the smallest effects are observed in the wealthiest regions such as Dakar (Pikine, Rufisque, Guédiawaye, and Dakar), Thiès (Tivaouane, M'bour, and Thiès), or Diourbel (Bambey).

Effect on human capital accumulation. – We finally investigate the net effect of migration prospects on (post-migration) human capital accumulation, measured by h_i and defined in Eq. (8). In the bottom panels of Figure 6, we plot the migration-induced change in human capital, denoted as $\Delta h_i \equiv h_i - h_i^{NM}$ (expressed as a percentage point deviation), against the no-migration counterfactual level, h_i^{NM}. It is essential to note that human capital responses result from the reactions of natives to emigration prospects (including pre-migration incentives and post-migration composition effects) and from the migrant inflows from other *départements*. However, as depicted in Figure 1, the inflow of college graduates is negligible in most *départements*, except for Dakar and Thiès, which are joined by Diourbel when focusing on the less educated.

[11] The country-wide average share of college graduates in 2010 is approximately 3.0%. Cha'Ngom et al. (2023) estimate that this share would be one percentage point lower without selective international migration prospects.

Moving on to Panel (d), we observe that selective international migration prospects lead to increased domestic human capital accumulation in the Dakar region. Specifically, there is about a 2-percentage-point increase in human capital in Dakar, Guédiawaye, and Pikine, and roughly a 1-percentage-point increase in Rufisque. We also see an increase in domestic human capital in Ziguinchor, Salémata, Thiès, and Saint-Louis, which are four other *départements* where international migration prospects enhance skill premia and access to education is not too limited. In many other regions, the human capital response is minimal and close to zero.

In Panel (e), we observe that internal migration prospects increase human capital in the *départements* of the Dakar region, with Guédiawaye experiencing the most significant net gain. This overall increase is primarily driven by the influx of college graduates from other regions, as internal movements from Dakar are relatively limited. Moreover, these internal movements tend to involve individuals who are negatively selected in terms of human capital, so they do not generate positive domestic incentive effects. In the poorest *départements* of the country, the net effect is positive but small, with the exception of Bambey and Thiès, where larger gains are observed. However, four *départements* with limited access to education (Saint-Louis, Oussouye, Bignona, and Sédhiou) experience net losses of human capital due to internal migration.

Finally, Panel (f) dipslays the combined effects of internal and international migration. Our analysis demonstrates that migration prospects predominantly benefit the wealthiest *départements* of Senegal, primarily situated in the Dakar region. These gains are driven by substantial incentive effects resulting from selective emigration opportunities to OECD countries, as well as the inflow of college graduates from other regions within the country. Additionally, the positive effect is observed in *départements* with good access to education and strong connections to Dakar, such as Thiès and Bambey.

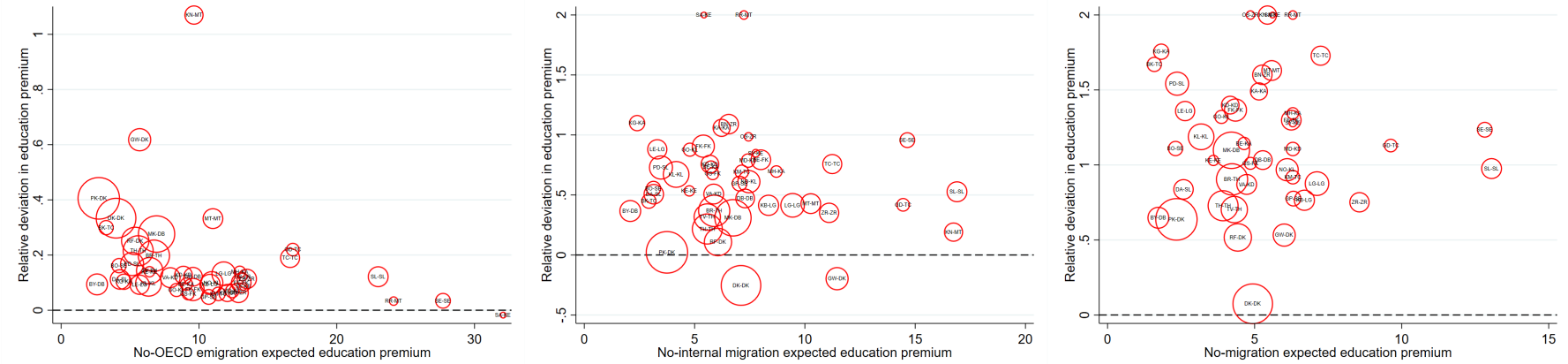
Conversely, in the remaining *départements*, the effect is either negligible or non-existent, confirming our initial assumption that the *brain gain* mechanism is predominantly governed by the observed effects in a few well-connected areas. Moreover, net losses of human capital are experienced in *départements* that are connected, either internationally or internally, but have limited access to education, exemplified by Saint-Louis, Oussouye, Bignona, and Sédhiou. This comprehensive analysis underscores the nuanced and localized impact of migration prospects on human capital accumulation across Senegal.

Figure 6: Skill premium and human capital effects by *département*

(a) International – Expected education premium

(b) Internal – Expected education premium

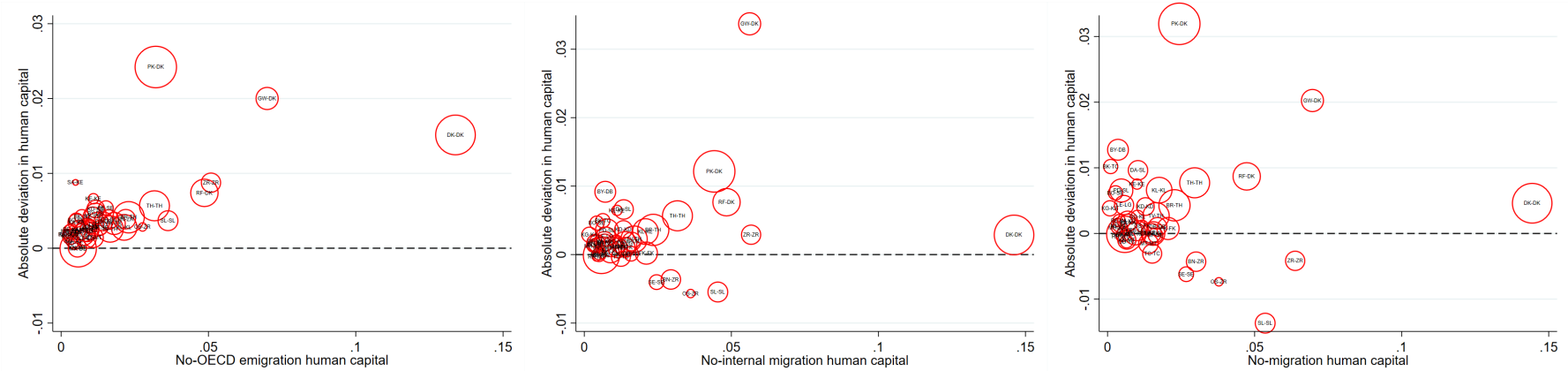
(c) Both – Expected education premium



(d) International – Human capital

(e) Internal – Human capital

(f) Both – Human capital



Note: Authors' computations. Each *département* is represented by a bubble, whose size is proportional to its population in 2013. Contrary to the previous figure, we do not provide quadratic trends here because their intervals of confidence are too large and average effects are driven by outliers.

5 Conclusion

The question of how emigration impacts the accumulation of upper-tail human capital in economically disadvantaged countries is of paramount importance in the context of achieving the United Nations Sustainable Development Goals. Concerns often arise due to the positive selection of emigrants along observable schooling levels (as well as unobservable skill dimensions). However, it is essential to recognize that selective emigration can also have positive effects on human capital formation. This can occur through increased incentives to pursue education, the transfer of norms and values, or the provision of financial remittances. Consequently, the net impact of emigration on the communities of origin is multifaceted and not straightforward.

Numerous case studies, cross-country regression analyses, and microfounded models have provided converging evidence suggesting that selective international emigration likely contributes to the enhancement of upper-tail human capital accumulation in some of the world's poorest countries. This phenomenon can help narrow the human capital gap between these countries and wealthier nations. However, an aspect that has received limited attention is the distribution of these *brain gain* effects within countries.

Furthermore, while international migration receives substantial attention, it is crucial to recognize that internal migration opportunities play a significant role in the complex relationship between education and migration. Internal migration, involving a movement within a country's regions, significantly outweighs international migration in terms of volume (United Nations, 2000).[12] This aspect has been somewhat overlooked in the context of the education-migration nexus.

Focusing on the case of Senegal, our research offers suggestive evidence that the *brain gain* mechanism, driven by selective international migration, predominantly benefits the wealthiest regions that are well-connected on the international stage and possess better educational access. In regions lacking international connectivity, or even in those with better connections but limited educational opportunities, human capital responses to international migration are minimal or, in some cases, negative. These patterns also extend to internal migration within Senegal, as highly vulnerable populations tend to remain concentrated in the least developed areas.

Our primary findings are likely applicable to numerous other developing countries, especially those where the high-skilled labor force and high-productivity activities are concentrated in a single or very few major cities (Wolff et al., 2020), while low-skilled population with limited assets and financial constraints are trapped in the least afflu-

[12] Considering shorter-distance internal moves (across the smallest administrative areas available), the ratio of internal to international migrants is in the vicinity of 60 (Bell et al., 2018).

ent regions. Such patterns have been identified in Asian countries such as Bangladesh (Bryan et al., 2014, Lagakos et al., 2023), the Philippines (Abarcar and Theoharides, 2021, Theoharides, 2018) and are likely to be observed in other countries such as Thailand or Indonesia (Swerts and Denis, 2015). Similar patterns of "urban macrocephaly" emerge in Latin American countries such as Colombia, Peru or Guatemala (Faraji et al., 2016). They are also prevalent in many sub-Saharan African countries, where factors such as high internal transportation costs (Storeygaard, 2016), historical colonial infrastructure (Bonfatti and Poelhekke, 2017, Jedwab and Moradi, 2016), natural resource booms (Gollin et al., 2016), or limited national institutional reach (Michalopoulos and Papaioannou, 2014) have contributed to the concentration of economic activity in major coastal cities or mining areas. Our study underscores the importance of examining the impacts of labor migration on human capital and economic outcomes at a more granular spatial level than just the national scale. This entails accounting for internal mobility and recognizing the disparities in access to education. We demonstrate that a place's connectivity profoundly shapes the opportunities available to its residents.

From a policy perspective, our research emphasizes the urgency of designing and implementing policies aimed at enhancing connectivity and improving educational access in remote and underserved areas across the developing world. These efforts are essential for promoting equitable development and ensuring that the benefits of migration reach all segments of the population.

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Appendix

Appendix

Table 5.1 lists the 45 *départements* included in our model, and provides their code and descriptive statistics. Cols. (1) to (6) give the size of the labor force, the share of college graduates among natives, internal emigration rates of college graduates and less educated workers, and international emigration rates of college graduates and less educated workers, respectively.

Table 5.1: Code and descriptive statistics by *Département*

Code	*Département*	$Labor_i$	H_i	m_{ih}^{int}	m_{il}^{int}	m_{ih}^{OECD}	m_{il}^{OECD}
DK	Dakar	529,079	0.149	0.223	0.419	0.306	0.074
PK	Pikine	577,718	0.056	0.207	0.189	0.351	0.087
RF	Ruffisque	251,428	0.056	0.233	0.150	0.232	0.039
GW	Guediawaye	163,646	0.090	0.206	0.362	0.457	0.121
BN	Bignona	125,670	0.026	0.659	0.288	0.072	0.013
OS	Oussouye	22,759	0.030	0.660	0.325	0.124	0.017
ZR	Ziguinchor	123,551	0.060	0.523	0.354	0.121	0.021
BY	Bambey	144,955	0.016	0.473	0.279	0.098	0.013
DB	Diourbel	116,246	0.018	0.578	0.379	0.126	0.020
MK	Mbacké	443,450	0.006	0.362	0.163	0.275	0.075
DA	Dagana	125,768	0.020	0.427	0.136	0.107	0.007
PD	Podor	177,932	0.011	0.528	0.184	0.157	0.015
SL	Saint Louis	131,003	0.040	0.472	0.193	0.135	0.029
BK	Bakel	66,157	0.011	0.405	0.138	0.311	0.105
TC	Tambacounda	120,581	0.012	0.498	0.117	0.193	0.040
GD	Goudiry	52,011	0.005	0.359	0.090	0.259	0.096
KM	Koupentoum	59,794	0.005	0.492	0.139	0.064	0.008
KL	Kaolack	221,133	0.024	0.583	0.303	0.107	0.020
NO	Nioro de Rip	163,599	0.009	0.475	0.153	0.101	0.011
GO	Guinguineo	55,993	0.013	0.596	0.241	0.084	0.017
BR	Mbour	327,593	0.027	0.384	0.156	0.187	0.026
TH	Thiès	301,965	0.037	0.375	0.239	0.202	0.030
TV	Tivouane	233,017	0.019	0.413	0.227	0.148	0.026
KB	Kébémer	135,105	0.010	0.514	0.312	0.114	0.031

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Table 5.1 – *Continued from previous page*

Code	*Département*	$Labor_i$	H_i	m_{ih}^{int}	m_{il}^{int}	m_{ih}^{OECD}	m_{il}^{OECD}
LE	Linguière	123,082	0.010	0.561	0.174	0.093	0.008
LG	Louga	186,555	0.015	0.453	0.226	0.161	0.049
FK	Fatick	163,488	0.021	0.617	0.269	0.078	0.008
FE	Foundiougne	128,264	0.015	0.530	0.156	0.115	0.027
GS	Gossas	46,734	0.013	0.632	0.382	0.066	0.011
KD	Kolda	103,922	0.017	0.530	0.174	0.137	0.027
VA	Vélingara	130,809	0.009	0.387	0.075	0.138	0.036
MD	Medina Yoro F.	59,038	0.005	0.501	0.107	0.087	0.023
MT	Matam	129,512	0.012	0.403	0.148	0.296	0.062
KN	Kanel	109,942	0.006	0.196	0.042	0.576	0.123
RR	Ranerou	23,226	0.004	0.736	0.089	0.035	0.003
KA	Kaffrine	96,997	0.009	0.625	0.227	0.069	0.011
BE	Birkilane	49,050	0.006	0.524	0.174	0.096	0.010
KG	Koungheul	76,456	0.005	0.587	0.132	0.101	0.008
MH	Malem Hoddar	42,846	0.004	0.546	0.231	0.128	0.007
KE	Kédougou	34,411	0.018	0.455	0.164	0.146	0.027
SA	Salemata	10,459	0.014	0.910	0.476	0.000	0.017
SY	Saraya	18,782	0.006	0.531	0.133	0.097	0.019
SE	Sédhiou	71,453	0.021	0.629	0.273	0.057	0.024
BO	Bounkiling	66,719	0.009	0.427	0.109	0.165	0.029
GP	Goudomp	71,741	0.016	0.485	0.178	0.061	0.016