UNIVERSITÉ DU LUXEMBOURG

PhD-FDEF-2024-020
The Faculty of Law, Economics and Finance

DISSERTATION

Defence held on October 21, 2024 in Esch-sur-Alzette
to obtain the degree of

DOCTEUR DE L'UNIVERSITÉ DU LUXEMBOURG EN SCIENCES ÉCONOMIQUES

by

Narcisse CHA'NGOM

Born on 5 April 1988 in These, (Cameroon)

SELECTIVE MIGRATION, HUMAN CAPITAL, AND THE GEOGRAPHY OF DEVELOPMENT

Dissertation defence committee

Dr Frédéric DOCQUIER, Dissertation supervisor
Vice executive director, Luxembourg Institute of Socio-Economic Research (LISER), Luxembourg

Dr Clément IMBERT
Professor, Sciences Po. Paris, France

Dr Michel BEINE, Chairman
Professor, Université du Luxembourg, Luxembourg

Dr Klaus DESMET
Professor, Southern Methodist University, USA

Dr Joël MACHADO, Vice Chairman
Research Scientist, Luxembourg Institute of Socio-Economic Research (LISER), Luxembourg

Acknowledgements

Regardless of the final outcome of this academic journey, I am truly grateful to have embarked on it. One of the main reasons for this gratitude is the remarkable people I have met along the way and the overwhelming kindness and support I have received from them. While I may inadvertently fail to mention everyone, I will fondly remember the people and institutions that have made this journey so memorable and meaningful.

First and foremost, I would like to express my sincere gratitude to the Luxembourg National Research Fund (FNR) for funding this thesis through the ACROSS Doctoral Training Unit. I am also deeply thankful to the Luxembourg Institute of Socio-Economic Research (LISER) for its unwavering support. This thesis would not have been possible without the invaluable contributions of these two institutions.

A special note of gratitude goes to my supervisor, Frédéric Docquier, whose guidance, expertise, and unwavering support have been instrumental throughout this journey. Frédéric, thank you for taking on a somewhat unruly supervisee who would drop by your office twice a week, often without regard for your singularly busy schedule. I certainly needed those frequent discussions to stay on track. I truly appreciate the independence you gave me to explore the questions that piqued my interest, and I don't take for granted the delicate balance you had to strike between these two objectives. Our conversations have profoundly shaped both this thesis and my personal growth.

Gratitude to Joël Machado, my co-supervisor, for tirelessly reading and rereading every chapter of my dissertation. We have had countless discussions, from framing ideas to refining model structures. Joël, I have benefited immensely from your constant support. Beyond the academic scope, it would be shameful of me not to acknowledge your incredible patience in listening to my lunchtime diatribes. You will never get those minutes of your life back, and that is entirely my fault.

I warmly thank Michel Beine, member of my doctoral committee for his review and comments on my work. I would also like to specially thank Clément Imbert and Klaus Desmet for their insightful comments and suggestions on this dissertation. I am also grateful to Martín Fernandez-Sanchez for his valuable comments and advice during the course of this thesis. I also thank my colleagues within the Crossing Borders Unit including Etienne Bacher, Felix Stips, Lucas Magalhaes, Julio Garbers for their continuous support and comments.

My deepest gratitude goes to my wife, Juliette, and my children, Nolan and Brunelle, for their tireless support and understanding of my hectic work schedule throughout this dissertation journey.

Contents

List of Figures

List of Tables

Abstract

This thesis revisits the relationship between selective migration, human capital, and development through the lens of economic geography. In a nutshell, it assesses the distributional effects of selective migration across and within countries. Specifically, (i) it first examines cross-country dynamics, proposing a generalized framework to assess the impact of selective international migration on sending countries, accounting for most of the transmission channels established by the existing literature to date. The focus then shifts to the distributional effects of international migration across sub-national regions within countries, and further explore the role of internal migration in this process. (ii) It emphasizes the human capital effects of selective migration within countries at the sub-national level. (iii) The analysis then extends beyond human capital to examine the implications for the geography of development, modeling internal and international migration decisions jointly to evaluate their impact on the spatial distribution of worker productivity and welfare, as well as the potential effects of reducing various spatial mobility frictions. (iv) Finally, it investigates whether local migration decisions, both internal and international, respond to local economic shocks, here proxied by exposure to local development aid projects. It shows that the distributional effects of migration vary across various geographical scales. While the poorest countries of the world experience the largest gains from migration, these gains are concentrated in wealthier regions within countries, leading to larger cross regional human capital and worker productivity disparities. Nevertheless, migration improves welfare overall, driven by the redistributive capacity of remittances.

Declaration of co-authorship

◇ **Chapter 1: Selective Migration and Economic Development: A Generalized Approach.**

Co-authored with Christoph Deuster (JRC, European Commission), Frédéric Docquier (LISER), and Joel Machado (LISER). Revised & Resubmitted *International Economic Review*

◇ **Chapter 2: Within Country Distribution of brain drain and brain gain: *A case study on Senegal*.**

Co-authored with Philippe Bocquier (UCLouvain), Frédéric Docquier (LISER), and Joel Machado (LISER). *Published in Journal of Demographic Economics*.

◇ **Chapter 3: Migration and Regional Development: Evidence from Senegal.** *Single-authored.*

◇ **Chapter 4: Local Exposure to Development Aid Projects and migration decisions: Evidence from Senegal.** *Single-authored.*

Introduction

Migration is a fundamental component of the integration process at various geographical scales (across and within countries) that connects locations, and shapes the distribution of labor and human capital across the globe. According to the United Nations, by 2020, there were over 281 million international migrants worldwide, representing 3.6% of the world population. However, alongside the extensive literature on international migration, internal migration defined as the migration within country's borders, remains the most significant component of human migration. According to the United Nations, internal migration outnumbers international migration by a large margin, with around 763 million people moving within their home countries across first order administrative boundaries. This estimation represents nearly 10% of the world population and is likely a lower bound as (i) it dates back to 2013, and (ii) only considers internal migrants across admin 1 units. This pattern highlights the dual importance of both internal and international migration as interconnected processes shaping the economic landscape across these scales.

Furthermore, the role of migration extends beyond mere population shifts, directly influencing who migrates (selection) and where they settle (sorting). Migration exhibits two notable features: migrants are both positively selected and sorted. This means that more educated individuals migrate more (positive selection) and often concentrate in wealthier destinations (positive sorting). The scale, selection, and sorting of migrants suggest significant implications for the spatial allocation of workers, the distribution of human capital, and the geography of development.

These considerations motivate the following question: How does migration influence the spatial distribution of human capital, worker productivity, and welfare both across and within countries? In essence, this thesis assesses the distributional effects of selective migration at national and sub-national levels. Specifically, (i) it first examines cross-country dynamics, proposing a generalized framework to assess the impact of selective international migration on sending countries, accounting for most of the transmission channels established by the existing literature to date. The focus then shifts to the distributional effects of international migration across sub-national regions within countries, exploring the role of internal migration in this process. (ii) It emphasizes the human capital effects of selective migration within countries at the sub-national level. (iii) The analysis then extends beyond human capital to examine the implications for the geography of development, modeling internal and international migration decisions jointly to evaluate their impact on the spatial distribution of worker productivity and welfare, as well as the potential effects of reducing various spatial mobility frictions. (iv) Finally, it investigates whether local migration decisions, both internal and international, respond to local economic shocks, here proxied by exposure to local development aid projects. This dissertation consists of four self-contained but interrelated chapters.

The first chapter develops a comprehensive framework to assess the overall impact of selective migration on sending countries, accounting for both its benefits and costs. This chapter unfolds in three stages. First, it begins with an updated empirical analysis of how human capital responds to selective international emigration to the OECD, enhancing existing literature by using three decades of skill-specific migration data. It applies a novel specification and identification strategy, estimating income-group-specific elasticities. Second, it establishes the theoretical micro-foundations of the emigration-driven human capital formation, leveraging the full dyadic structure of international migration and generalizing the empirical findings. Third, it incorporates this micro-founded relationship into a broader development accounting framework to jointly account for additional feedback effects of selective international migration identified in existing literature, including remittances, productivity, diaspora, fiscal, and market size externalities. The model is then calibrated to align with migration, income, and education data for 174 countries around 2010, as well as the empirically estimated average education response to migration prospects. Findings suggest that selective international emigration to the OECD stimulates human capital formation in the world's poorest countries, promoting cross-country convergence in human capital between rich and poor countries. Furthermore, it raises disposable income for those left behind, particularly in low- and lower-middle-income countries, and reduces the global number of individuals living in extreme poverty by nearly 105 million.

With these findings in hands, the focus now shifts to examining how these effects are distributed across regions within countries and the role of internal migration. To explore this sub-national dimension, data on internal and international migration at the sub-national level is required, including each individual's region of birth and current residence for both internal migrants and non-migrants. For each sub-national region, data is needed on the country of birth for international immigrants and the current residence country for international emigrants. The 2013 Senegal Census provides these detailed data points. Thus, the remaining chapters of the thesis focus on a within-country analysis, using Senegal as an illustrative case.

Beyond the availability of uniquely rich data, Senegal is an interesting case study. Indeed, its migration patterns, in terms of selection and sorting, reflect those in comparable countries, such as other lower-middle-income and Sub-Saharan African nations. Additionally, similar migration patterns emerge across regions within Senegal, extending the analysis to internal migration.

The second chapter investigates the human capital effects of migration and their distribution across regions, particularly given the uneven exposure to selective migration across regions within countries. This chapter calibrates the micro-founded model developed in chapter one on sub-national regions of Senegal. It shows that, unlike the cross-country evidence of human capital gains in the world's poorest countries, within countries, these gains are concentrated in wealthier regions, thereby intensifying cross-regional disparities in human capital. To the best of my knowledge, this is the first systematic analysis of impact of selective migration on human capital across regions within a country.

The third chapter builds on the generalized cross-country framework but shifts its focus to the often-overlooked within-country heterogeneity. While cross-country comparisons help identify broad trends, they fail to capture the significant role of sub-national migration patterns in shaping the spatial distribution of economic activity and welfare. This chapter uses detailed micro-data from Senegal to quantify how these heterogeneous migration patterns at the sub-national level impact the spatial distribution of economic activity and welfare. It comprehensively accounts for the full structure of local migration patterns, including skill-specific region-to-abroad migration, region-to-region internal migration, as well as rural-to-urban, urban-to-urban, and rural-to-rural migration within regions. First, the chapter combines census and survey data to present four key stylized facts about the interaction between disaggregated migration patterns and economic activity within Senegal. Second, it develops a Spatial General Equilibrium model to explain these facts. In this model, workers decide where to live and work, how to allocate their income between consumption (agricultural and non-agricultural), housing, and, if they migrate, how much to remit back home. These migration patterns directly affect the size and skill composition of local labor supply, which in turn influences local productive capacities. The model captures differences based on whether regions experience net immigration or net emigration and the strength of associated feedback effects, such as education incentives and remittances. Third, using plausibly exogenous sources of variation, the chapter empirically estimates key model parameters including the income elasticity of migration, the inverse of housing supply elasticity, and the elasticity of remitting costs relative to migration size. Fourth, the model is calibrated using observed migration, income, and other data, and is employed to conduct counterfactual experiments. These experiments are divided into two sets: the first isolates the actual distributional effects of various types of migration (total, internal, international, OECD migration), while the second predicts the potential impact of reducing frictions, such as migration costs and spatial disparities in education access. The findings show that for Senegal as a whole, migration reduces real per capita income but increases welfare, primarily due to remittances. Moreover, migration increases income disparities but reduces welfare disparities across sub-national regions. Finally, the chapter demonstrates that policies aimed at reducing mobility frictions tend to increase income inequality across regions, but at the same time reduce welfare inequality due to the redistributive power of remittances.

The fourth chapter assesses whether local economic shocks impacts internal and international migration decisions, with local economic shocks proxied by local exposure to foreign aid projects. Using Senegal as a case study, the chapter explores whether development aid deters emigration from recipient areas, as many donors expect. It specifically evaluates how local exposure to aid projects influences region-to-region internal migration and region-to-abroad international migration. This analysis draws on two rich data sources: (i) the 2013 Senegalese census, which provides detailed information on internal and international migration at a granular level; and (ii) AidData, which documents the universe of aid projects in Senegal, including the geographic locations, committed and disbursed amounts, project timelines, titles, and sectors involved. By employing a standard gravity model with a comprehensive set of fixed effects and using political proximity to the ruling leader at the time of project commitment as an exogenous source of variation, the chapter demonstrates that exposure to aid projects—particularly those focused on employment—reduces both internal migration and international migration to transit countries. However, this effect is contingent on the ability of these projects to meaningfully improve the economic conditions of the target populations.

In summary, the four chapters demonstrate that: (i) Internal and international migration are closely interconnected and must be jointly analyzed to understand their full distributional effects; (ii) A generalized approach that simultaneously accounts for most of the feedback effects of migration is crucial; (iii) the distributional effects of migration vary across various geographical scales. While the poorest countries benefit the most from international migration, these gains are often concentrated in wealthier regions within those countries, leading to larger cross regional income disparities. However, migration improves welfare, driven by the redistributive capacity of remittances. (iv) Reducing spatial mobility frictions, conditional on being sizable, increases workers productivity at the expense of larger spatial income disparities. Nevertheless, it improves welfare and reduces welfare disparities. (v) migration decisions respond to economic shocks, which not only influence migration patterns but also affect local productive capacities, thereby shaping the spatial distribution of economic activity and welfare.

Chapter 1

Selective Migration and Economic Development: A Generalized Approach

Abstract

International migration is a selective process that induces ambiguous effects on human capital and economic development in sending countries. We establish the theoretical micro-foundations of the relationship between selective emigration and human capital accumulation in a multi-country context. We then embed this migration-education nexus into a *development accounting* framework to quantify the effects of migration on development and inequality. We find that selective emigration stimulates human capital accumulation and the income of those remaining behind in a majority of countries, particularly in the least developed countries. The magnitude of the effect varies according to the level of development, the dyadic structure of migration costs, and education policies. Emigration significantly reduces the number of people living in extreme poverty worldwide.

1.1 Introduction

International migration raises concerns about the *brain drain* of highly skilled workers from poorer to richer countries, as college and university graduates exhibit a much higher propensity to emigrate internationally than the less educated, and tend to cluster in highly productive countries (Grogger and Hanson, 2011; Belot and Hatton, 2012; Docquier and Rapoport, 2012; Kerr et al., 2016). Nearly one in five college graduates born in low-income countries live and work in a high-income country, while the average emigration rate of the less educated is below 1 percent. In some small island developing states, the emigration rate of college graduates even reaches 70 percent.[1]

Positive selection results from migrants' self-selection – highly skilled people are more responsive to economic opportunities and political conditions abroad, have more transferable skills, have greater ability to gather information or finance emigration costs, etc. – and from skill-selective immigration policies implemented in the major destination countries. As human capital is usually seen as a proximate cause of development (e.g., Glaeser et al., 2004; Acemoglu et al., 2014; Jones, 2014), selective emigration, whether driven by individual characteristics or by skill-selective policies of destination countries, could deprive poor countries of the resources necessary to drive economic growth, provide essential public services, and articulate demands for greater democracy (Bhagwati and Hamada, 1974; Miyagiwa, 1991; Haque and Kim, 1995; Wong and Yip, 1999). By contrast, selective emigration prospects also increase the expected returns to human capital, thus leading more people to invest (or people to invest more) in education at home before deciding whether to emigrate (e.g., Djajic, 1989; Mountford, 1997; Stark et al., 1997; Vidal, 1998; Beine et al., 2001). Thus, while it is undisputed that moving abroad brings significant benefits to the majority of migrants (as evidenced in M. Clemens and Pritchett, 2008), the impact of international migration on those left behind is more controversial.

Assessing the overall impact of migration on the economic development in countries of origin and on global inequality is complex, as a variety of transmission mechanisms are at work. These are well established in existing literature and have been subject to several reviews (Commander et al., 2004; Docquier and Rapoport, 2012; M. Clemens et al., 2014; Ozden and Rapoport, 2018). What is missing is a unified approach that allows for a cross-country comparison of the effects of selective migration and the relative strength of the different channels at work. We propose a *generalized approach* – a microfounded, multi-country, general equilibrium model that reconciles and extends existing empirical cross-country and case studies – to study the impact of selective migration on human and economic development in

[1] To a lesser extent, emigration is also a concern for high-income countries, where college graduates are 1.25 to 1.5 times more likely to emigrate than the less educated.

source countries and on extreme poverty.

We proceed in three steps. Our first contribution is to revisit the link between selective emigration and human capital accumulation in the country of origin (a process we refer to as "*human development*" throughout this paper).[2] We first empirically estimate the semi-elasticity of human capital formation to emigration differentials (i.e. the difference between the emigration rate of highly educated and less educated individuals). We complement the existing literature (Beine et al., 2008; Beine et al., 2010; Beine et al., 2011) by using three decades of data, applying a different identification strategy based on an instrumental variable, and estimating income-group specific elasticities.

We then establish the micro-foundations of the migration-education channel in a dyadic and multi-destination context. Focusing on migration to OECD countries, we develop a micro-founded and dyadic framework that better accounts for the characteristics of each origin country and of all the potential destinations, including dyadic migration costs and access to education. After demonstrating that our *generalized framework* has desirable theoretical properties, we parameterize it to match migration and education data for 174 countries in the year 2010, as well as the average education response to migration prospects identified empirically. We use this tool to quantitatively predict the net effect of selective emigration on human capital accumulation in the country of origin.

Our generalized approach shows that selective emigration has heterogeneous effects on the expected returns to schooling, even within a broad group of countries with similar income per capita levels. This is because historical ties as well as the geographic or linguistic characteristics of countries determine the dyadic structure of emigration costs and the average wage gap with the most accessible destinations. In addition, access to education plays an important role, and country size influences the diversity of domestic jobs, thereby determining the gains from diversifying employment opportunities through international migration. We find that the incentive mechanism operates in a majority of countries, with the largest net gains occurring in the poorest countries. However, although a net "brain gain" is at work in a majority of low and lower-middle income countries, its overall effect on human capital disparities across countries is limited.

Our second contribution is to quantify the impact of selective emigration on income per capita in the country of origin (which we refer to as "*economic development*"). We embed our microfounded model within a broader *development accounting* framework. This framework has been used to quantify the contribution of various factors to observed differences in income levels across countries (e.g., Hsieh and Klenow, 2010; Jones, 2014) without endogenizing

[2] In the development literature, the term "*human development*" refers to a broader concept that goes beyond human capital accumulation and includes other aspects, such as health, life expectancy, poverty, etc.

the magnitude of these factors. For the first time, we use it to quantify the effect of selective migration on the level of human capital and economic development in each source country. Our extended model incorporates the human capital accumulation mechanism as well as additional channels, including complementarities between high- and low-skilled workers, schooling externalities, diaspora externalities, market size externalities, the fiscal impact of selective emigration, and remittances. We parameterize the various externalities included in this *development accounting* framework using benchmark parameter values from the empirical literature. We then simulate a counterfactual no-migration scenario and estimate real disposable income responses to selective emigration on a country-by-country basis.

We find that selective emigration increases real disposable income per worker in a large majority of countries, especially in the least developed ones. Despite positive selection, emigration *per se* contributes to income convergence across countries. Most countries show a gain in the range of 0 to 20 percent, but there is a non-negligible fraction of the sample for which the effect is larger. A negative effect is found in a minority of (small) countries from which emigrants are negatively or too positively selected. Not surprisingly, this convergence effect is even stronger if development is measured for people rather than for places (M. Clemens and Pritchett, 2008).

Our third contribution is to analyze how global migration affects the *world distribution of income and extreme poverty*. We solve our model for all countries jointly, endogenizing wages and education responses to emigration and immigration in all parts of the world. We then compare the global income distribution from a counterfactual no-migration scenario with the one from the observed equilibrium. We find that global migration reduces extreme poverty by 8.1 percent, and is harmful only for a tiny proportion of the world's low-skilled population. We conclude that international migration can be viewed as a driver of sustainable development that, with a few exceptions, contributes to improving the economic outcomes of both migrants and the communities left behind in the countries of origin.

Our paper addresses the literature on the *brain gain* and its implications for economic development. The latter effect has been identified empirically using cross-country regressions (Beine et al., 2008; Beine et al., 2010), which allow assessing the net educational response to selective emigration. Under certain conditions, the stimulus to skill formation appears to be strong enough to raise the stock of human capital in the economy to a higher level in the post-migration equilibrium. Evidence for such a brain gain mechanism is provided in several case studies that exploit quasi-natural experiments or long-lasting spatial variations in occupational or skill-biased migration prospects in low- and lower-middle-income countries (Chand and M. A. Clemens, 2008; Gibson and McKenzie, 2009; Shrestha, 2017; Theoharides, 2018; Abarcar and Theoharides, 2021; Khanna and Morales, 2017).[3] Other related work has found an effect of increased exposure to migration on education that goes beyond the pure incentive effect associated with expected returns to schooling. These include shocks to migrant earnings (Yang, 2008; Dinkelman and Mariotti, 2016; M. Clemens and Tiongson, 2017; Khanna et al., 2022), education spending and child labor (Yang, 2008; Batista et al., 2012; Bryan et al., 2014), exposure to the value of education (Fernández Sánchez, 2022) and the impact of missing household members (Antman, 2011; Gibson et al., 2011). These case studies are not directly comparable because they rely on different proxies for human capital, cover countries with very different characteristics, and involve different transmission mechanisms. By contrast, our microfounded framework captures the heterogeneity in population structures across countries and provides a homogeneous setup that allows for cross-country comparisons.

The impact of selective emigration on economic development goes beyond the human capital mechanism. Financial remittances are the least controversial compensating mechanism through which emigration affects income in the sending country (e.g., Bollard et al., 2011; Theoharides, 2020). Other studies show that migrant networks stimulate non-material transfers from destination to origin countries. They generate business links, stimulate trade and FDI, and induce political remittances and transfers of norms and values that influence the quality of institutions in the place of origin (e.g., Docquier et al., 2016). This, in turn, increases the level of the total factor productivity (e.g., Iranzo and Peri, 2009; Felbermayr et al., 2010; Parsons and Vezina, 2018; Kugler and Rapoport, 2007; Javorcik et al., 2011; Bahar and Rapoport, 2018). Conversely, emigration affects market size, the number of entrepreneurs, the variety of goods available to consumers (e.g., Giovanni et al., 2015; Aubry et al., 2016), and can be a source of fiscal costs for those left behind (e.g., Devesh et al., 2009; Egger et al., 2012; Teferra, 2007; World Bank, 2010; Alesina and Spolaore, 1997; Alesina and Wacziarg, 1998). We contribute to this literature by incorporating these different transmission channels into a *development accounting* framework that includes endogenous education and migration decisions. Our model builds on a static version of Delogu et al. (2018) and extends it by improving the educational technology. In particular, we account for country-specific scale parameters and calibrate country income group specific elasticities of higher education to emigration prospects. We then use it to derive theoretical propositions that rationalize existing empirical findings, and comparing the observed equilibrium with a no-migration counterfactual in line with Giovanni et al. (2015); Aubry et al. (2016); Biavaschi et al. (2020).

Accounting for trade and remittances, Giovanni et al. (2015) find that the average non-migrant in an OECD country experiences a welfare loss of 2.4% due to selective migration,

[3] Consistently, shocks that primarily affect migration opportunities for low-skilled workers are shown to reduce human capital formation (McKenzie and Rapoport, 2011; Brauw and Giles, 2017; Pan, 2017; Kosack, 2021; Caballero et al., 2021).

while in non-OECD countries, the loss amounts to 2%. Aubry et al. (2016) estimate that migration increases the average utility of non-migrants in OECD countries by 3%. Biavaschi et al. (2020) simulate a scenario where they neutralize the skill selection of the observed migrant stocks in 2010 and estimate that skill-selection of migrants increases welfare by 1.8% at the world level and by 3.5% for the OECD countries. A related literature quantifies the effects of liberalizing migration see, e.g., Docquier and Rapoport (2012); Delogu et al. (2018); Docquier and Machado (2016). With our simulations, we contribute to the growing literature that aims to quantify the welfare effects of migration with a particular focus on the tertiary education channel.

The remainder of this paper is organized as follows. In Section 1.2, we estimate country income group specific elasticities of education to emigration and establish the microfoundations of the link between selective emigration and human capital accumulation in the country of origin. We then simulate a no-migration scenario in order to quantify the effect of emigration on human capital accumulation in sending countries. In Section 1.3, we extend our model to include endogenous wages and several externalities that reflect the main feedback effects of emigration on income. We use this *development accounting* framework to quantify the effect of selective emigration on income at origin. In Section 1.4, we use a general equilibrium setup to quantify the effect of global migration on the world income distribution, taking into account endogenous labor structures, income levels, and educational responses in all countries. Section 1.5 concludes.

1.2 Selective Emigration and Human Development

We focus first on the relationship between selective emigration and human capital accumulation in the country of origin. The net effect of emigration on the share of high-skilled workers remaining in the country of origin results from the combination of two opposite effects: a *composition effect*, in which the highly educated people are more likely to emigrate than the less educated, and an *incentive effect*, in which the difference in emigration prospects raises the expected returns to education and thus leads more people to invest (or people to invest more) in education before deciding whether to emigrate. In line with empirical studies, we first abstract from the bilateral dimension in Section 1.2.1 and provide updated stylized facts on the magnitude of the composition and incentive effects. Then, in Section 1.2.2, we establish the microfoundations of the link between emigration rates and human capital formation in a "generalized" multi-destination framework that can be easily calibrated to conduct numerical simulations. In Section 1.2.3, we parameterize the model and compute the net human capital responses to selective emigration.

1.2.1 Updated Stylized Facts

The composition effect is illustrated in Table 1.1, which shows skill-specific emigration and selection rates for the year 2010 by income group and country size. Panel (a) shows that the average emigration rate of college graduates (Cols. (4-6)) exceeds the equivalent rate of the less educated (Cols. (1-3)), a sign of positive selection in emigration along the (observable) educational dimension. The average emigration rates of the high-skilled strongly decrease with economic development, while the average emigration rates of the low-skilled increase with economic development.[4] Positive selection, as proxied by the ratio of emigration rates in Cols. (7-9), thus declines with development and is particularly prevalent in low-income countries. The average ratio of high-skilled to low-skilled emigration rates ranges from 16 to 33 in low-income countries, while it varies from 1.1 to 1.4 in high-income countries. High-skilled emigration rates declined between 1990 and 2010 in all but the low-income group. Nevertheless, the global average high-skilled emigration rate has remained relatively stable across census rounds. This is due to the increasing demographic share of low-income countries – the group with the largest high-skilled emigration rates – in the world population. By contrast, low-skilled emigration rates increased in all groups. Hence, positive selection has declined since 1990. Unlike emigrant populations (or stocks), all skill-specific emigration rates decrease with country size. This is because large countries are more economically diverse and offer more opportunities for internal migration. As highlighted in Panel (b) of Table 1.1, the countries with the largest emigration rates are smaller countries with less than 2.5 million inhabitants.

With respect to the incentive effect, the link between selective emigration rates and pre-migration human capital formation has been theoretically investigated in two-country settings with a poor origin country and a rich destination country (Mountford, 1997; Stark et al., 1997; Vidal, 1998; Beine et al., 2001). Under certain conditions, the stimulus to skill formation may be strong enough to raise the stock of human capital in the economy to a higher level in the post-migration equilibrium. Micro-level evidence of a positive impact of selective emigration on the *net* stock of human capital in the country of origin has been provided for several case studies, as detailed in Section 2.1.

Although causality is difficult to establish with aggregate data, the macro-level literature provides evidence for the same relationship (Beine et al., 2008; Beine et al., 2011). We revisit the empirical cross-country analysis of the "brain gain" hypothesis using more

[4] A closer analysis reveals an inverted U-shape relationship between low-skilled emigration rates and per capita income: low-skilled emigration first increases and then decreases as a country experiences economic development. This relationship also holds for average emigration rates (Dao et al., 2018). Recent studies by Bencek and Schneiderheinze (2020), M. A. Clemens and Mendola (2020), and M. A. Clemens (2020) further discuss the relationship between economic development and emigration.

Table 1.1: Emigration and selection rates to OECD destination countries
(Data by group of countries and education level for the years 1990, 2000, and 2010)

	Rate low-sk. $(m_{i,l,t})$ (As %)			Rate high-sk. $(m_{i,h,t})$ (As %)			Selection index $(m_{i,h,t}/m_{i,l,t})$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1990	2000	2010	1990	2000	2010	1990	2000	2010
World	1.3	1.5	1.7	5.2	4.7	5.1	4.0	3.1	3.0
(a) By income group									
High-income	2.7	3.0	3.0	3.9	3.3	3.7	1.4	1.1	1.2
Upper-middle	0.9	1.3	1.6	6.4	5.5	5.1	7.1	4.2	3.2
Lower-middle	0.9	1.1	1.3	8.5	8.4	8.1	9.4	7.6	6.2
Low-income	0.5	0.8	1.1	16.4	16.2	18.0	32.8	20.3	16.4
(b) By country size									
High-pop	0.9	1.1	1.2	4.0	3.8	4.2	4.4	3.5	3.5
Upper-middle	2.9	3.6	4.3	10.2	8.8	9.4	3.5	2.4	2.2
Lower-middle	4.7	5.5	6.2	12.1	10.5	10.4	2.6	1.9	1.7
Low-pop	8.0	9.3	9.9	28.2	24.5	22.1	3.5	2.6	2.2

Note: Table 1.1 focuses on emigration to OECD destination countries only. Data are obtained from Arslan et al. (2015) for the years 2000 and 2010, and from Artuc et al. (2014) for the year 1990. For income groups, we follow the World Bank classification. For country size, we distinguish between countries with a population above 25 million (High-pop), between 10 and 25 million (Upper-middle), between 2.5 and 10 million (Lower-middle), and less than 2.5 million (Low-pop).

recent data, a more general specification, and an improved identification strategy. First, we pool data over two decades for which comparable data are available (1990-2000 and 2000-2010). Second, to overcome the limitations of previous approaches, we test whether the emigration differential between high-skilled and low-skilled workers is associated with human capital formation in the sending countries, allowing this incentive mechanism to vary with the level of development. Third, in an attempt to identify a causal effect, we use a gravity-based identification strategy that exploits exogenous variations in dyadic and destination-specific factors to predict emigration populations and rates, and to instrument for the emigration differential.[5]

Our new empirical model writes as:

$$\Delta \ln H_{i,t} = \gamma_0 + \gamma_1 \ln H_{i,t} + \gamma_2 \delta_{i,t} + \sum_{k=2,3,4} \gamma_3^k D_i^k + \sum_{k=2,3,4} \gamma_4^k \delta_{i,t} D_i^k + X'_{i,t}\Gamma + \Phi_t + \epsilon_{i,t}, \qquad (1.1)$$

where $\Delta \ln H_{i,t} \equiv \ln H_{i,t+1} - \ln H_{i,t}$ stands for the change in the logged share of natives with a

[5] We explain the advantages of our new specification in Appendix 1.A.1 and provide more details on data coverage and OLS estimation results in Appendix 1.A.2.

college degree; $\delta_{i,t} \equiv m_{i,h,t} - m_{i,l,t}$ is the emigration differential between high- and low-skilled adults; D_i^k is a dummy variable indicating the income group k to which country i belongs, in which low-income countries constitute the reference group and groups 2, 3 and 4 stand for lower-middle, upper-middle, and high-income countries respectively (as defined in 2010); $X'_{i,t}$ is the set of explanatory variables including population density; and Φ_t is a decade fixed effect.

Eq. (1.1) improves existing estimation strategies along three dimensions.[6] First, we allow for a heterogeneous effect of selective emigration on human capital formation across four country income groups, taking into account the fact that poorer countries are characterized by higher migration *premiums* and more severe financial constraints. The total effect of selective emigration is the combination of the effect of the emigration differential, $\delta_{i,t}$, and of its interaction with income group dummies. Thus, the semi-elasticity of human capital formation to emigration differentials varies with the level of economic development. Second, the use of emigration differentials neutralizes the influence of other transmission channels that are usually related to the average level of openness of the sending country – such as the transfer of norms and preferences regarding higher education. Third, the fact that the emigration differential is not expressed in logs allows us to overcome the limitations of previously used specifications. In particular, our specification is compatible with the cases of no-migration, no-selection, and negative selection.

The OLS regressions in Cols. (1) to (4) of Table 1.2 suggest that there is a positive and significant association between selective emigration prospects and human capital formation in countries belonging to the lower end of the per capita income distribution (i.e., low-income and lower-middle-income countries), in line with existing case studies. Our variable of interest, $\delta_{i,t}$, is endogenous due to potential reverse causality, unobserved heterogeneity, or measurement error. We adopt an IV strategy that relies on a pseudo-gravity approach and destination-specific factors. We implement the approach inspired by Munshi (2003); Boustan (2010); Kleemans and Magruder (2018) and Monras (2020), among others. They use instruments for immigration shocks at the destination, relying on push factors in origin countries that are not directly linked to shocks affecting the receiving country. Instead, we rely on pull factors in destination countries that can reasonably be assumed to be exogenous from the perspective of the sending country.[7]

Our IV strategy consists of three steps. First, we predict skill-specific bilateral migration populations ($\hat{M}_{ij,s,t}$) using a pseudo-gravity model. On the right hand side, we mostly

[6] The Cobb-Douglas form underlying our specification can be written as: $H_{i,t+1} = A_{i,t} H_{i,t}^{1+\gamma_1} \exp\left[\left(\gamma_2 + \gamma_4^k D_i^k\right)\left(m_{i,h,t} - m_{i,l,t}\right)\right]$.

[7] We detail each threat to identification in Appendix 1.A.3.

include destination and time fixed effects and exogenous dyadic controls (see Appendix 1.A.3). Second, we aggregate the predicted emigration stocks and divide them by the native population to predict skill-specific emigration rates ($\hat{m}_{i,s,t} \equiv \sum_j \hat{M}_{ij,s,t}/N_{i,s,t}$) and the aggregate emigration differential ($\hat{\delta}_{i,t} \equiv \hat{m_{i,h,t}} - \hat{m_{i,l,t}}$) for each decade. Third, we use the (gravity based) predicted emigration rates differentials, $\hat{\delta}_{i,t}$, to instrument the observed gap in emigration rates, $\delta_{i,t}$, in our first stage regression.

The results of the IV regressions are presented in the last four columns of Table 1.2, in which Cols. (5) and (6) restrict the sample to developing countries only, whilst Cols. (7) and (8) provide the results for the full sample. The long-run semi-elasticity of human capital formation to selective emigration prospects ranges between 3.1 and 3.5 and is inflated by about 20 percent compared to the OLS estimates. The income group dummies confirm that human capital formation increases with the level of development, which may be due to less severe financial constraints and/or more ambitious education policies. Population density at the national level has a positive but negligible effect when considering the full sample. The dummy for the 2000-2010 period is negative, suggesting that the average growth rates (not the levels) of human capital declined between the two decades.

These results confirm that selective emigration prospects are likely to have a positive impact on human capital formation in countries belonging to the bottom of the per capita income distribution, with a long-run semi-elasticity between 3.1 and 3.5 in lower-middle and low-income countries. Thus, a 10 percentage point increase in the emigration differential translates into a 31-35 percent increase in the long-run share of natives with a college degree. Assuming a poor country with an initial share of college graduates equal to 5 percent, this selective emigration shock raises the share to 6.8 percent in the long run.[8] After graduation, some of these graduates will emigrate, which means that the net effect on human capital in the country of origin is ambiguous. We provide a quantification of the net human capital effect of selective migration in Appendix 1.B.2.

1.2.2 Generalized Approach: Theory

We propose a generalized approach that establishes the microfoundations of the link between emigration rates and human capital formation, and combines the merits of existing empirical approaches. This means that our results are fully comparable across countries, and take into account country-specific factors that influence the dyadic structure of migration (such as dyadic migration costs, income disparities with easily accessible countries, and the elasticity of migration to income) as well as access to education. We build a static version of the model from Delogu et al. (2018) and modify it in order to better account for a country-specific

[8] We discuss the results based on a conservative variant based on the short-run elasticities in Section 1.A.4.

Table 1.2: Emigration differential and education incentives: short-term and long-term effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Developing		Full sample		Developing		Full sample	
	Least Squares				Instrumental variables			
A – Short-term estimates								
$\ln(H_{i,t})$	-0.360***	-0.378***	-0.387***	-0.405***	-0.361***	-0.379***	-0.387***	-0.405***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$m_{i,h,t} - m_{i,l,t} \equiv \delta_{i,t}$	1.132***	1.026***	1.164***	1.060***	1.262**	1.340**	1.211**	1.311**
	(0.38)	(0.37)	(0.38)	(0.38)	(0.50)	(0.55)	(0.51)	(0.55)
Lower-Middle	0.422***	0.403***	0.450***	0.431***	0.463***	0.463***	0.491***	0.495***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
Upper-Middle	0.677***	0.672***	0.731***	0.726***	0.722***	0.752***	0.763***	0.798***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
High-Income	-	-	0.919***	0.913***	-	-	0.919***	0.947***
	-	-	(0.12)	(0.12)	-	-	(0.12)	(0.13)
Lower-Middle × $\delta_{i,t}$	-0.640	-0.543	-0.656	-0.566	-0.924	-0.934	-0.973	-1.006
	(0.47)	(0.47)	(0.48)	(0.48)	(0.67)	(0.71)	(0.67)	(0.70)
Upper-Middle × $\delta_{i,t}$	-0.860*	-0.650	-0.880*	-0.645	-1.253*	-1.320*	-1.217*	-1.281*
	(0.47)	(0.48)	(0.48)	(0.50)	(0.64)	(0.68)	(0.66)	(0.68)
High-Income × $\delta_{i,t}$	-	-	-1.335***	-1.264**	-	-	-1.262**	-1.410**
	-	-	(0.49)	(0.49)	-	-	(0.64)	(0.67)
Population density	0.000	0.000	0.000**	0.000***	0.000	0.000	0.000**	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2000-2010 dummy	-0.862***	-0.846***	-0.816***	-0.800***	-0.870***	-0.853***	-0.825***	-0.808***
	(0.10)	(0.10)	(0.08)	(0.08)	(0.10)	(0.10)	(0.08)	(0.08)
Outliers	-	-0.214**	-	-0.232**	-	-0.192*	-	-0.208*
	-	(0.10)	-	(0.11)	-	(0.10)	-	(0.11)
B – Long-term estimates								
Low and Lower-Middle	3.146***	2.713***	3.010***	2.614***	3.492**	3.541**	3.126**	3.238**
	(1.03)	(0.97)	(0.98)	(0.93)	(1.40)	(1.46)	(1.31)	(1.36)
Upper-Middle	0.756	0.994***	0.734	1.022	0.026	0.053	-0.015	0.076
	(0.87)	(0.88)	(0.78)	(0.81)	(1.02)	(0.99)	(0.98)	(0.93)
High-Income	-	-	-0.442	-0.504	-	-	-0.131	-0.243
	-	-	(0.77)	(0.73)	-	-	(0.92)	(0.87)
Obs.	258	258	344	344	258	258	344	344
F-first stage	-	-	-	-	75.03	73.61	72.03	70.67
R^2	0.596	0.600	0.602	0.606	0.595	0.599	0.601	0.605

Note: Robust standard errors in parentheses are clustered at country level. Significant coefficients are denoted with stars as follows: *** p<0.01, ** p<0.05, and * p<0.1. Outliers are 11 countries for which our zero-stage, gravity model poorly predicts the emigration rates differential. These include ALB, COM, GNB, FSM, LBN, MDV, MLI, MOZ, NER, PAN, and STP.

educational structures.[9] Our new education technology better captures disparities in access to education, related to the role of education policy, the distribution of individual ability to access education, and the elasticity of education to returns to schooling. We also derive theoretical propositions that rationalize empirical findings from the existing literature.

We consider a country of origin $i \in I$ with a native population of working age denoted by N_i, which captures the population that is old enough to decide whether to emigrate or stay in the country of origin. Our model is static and features the relationship between

[9] Our focus is on understanding the impact of skill-selected emigration on medium-term development. We therefore improve the education technology but abstract from the endogenous fertility decisions included in Delogu et al. (2018). The latter emphasizes that endogenous fertility mostly affects the utility of emigrants from high-fertility origin to low-fertility destination countries.

emigration and education at the level of a given cohort, assuming that the implicit period of time represents the active life of one generation (say, 30 to 40 years). We therefore abstract from the time index t. Since country-specific emigration rates are very stable over time, calibrating the model parameters to match the long-run estimates from Section 1.2.1 allows us to approximate the impact of selective emigration prospects on education decisions on the balanced growth path. We divide the population into two skill groups $s = (h, l)$, with $s = h$ for college graduates and $s = l$ for the less educated, and we denote by $N_{i,s}$ the endogenous size of type-s native population. Thus, the share of college graduates in the native population is given by:[10]

$$H_i \equiv \frac{N_{i,h}}{N_{i,l} + N_{i,h}}.$$

Individuals have the choice of staying in their home country i or emigrating to a foreign country j. Because the data do not distinguish between permanent and temporary migrants, we assume that migrants spend their entire working career in the foreign country and abstract from temporary/circular movements.[11] We denote by $M_{ij,s}$ the number of type-s individuals who decide to move from i to j. Thus, the skill-specific emigration rate is defined as:

$$m_{i,s} \equiv \frac{\sum_{j \neq i} M_{ij,s}}{N_{i,s}},$$

implying that the number of non-migrants (or stayers) is given by
$M_{ii,s} \equiv N_{i,s} - \sum_{j \neq i} M_{ij,s} = N_{i,s}(1 - m_{i,s})$.

To jointly endogenize H_i and $m_{i,s}$, we model migration and education decisions as outcomes of a Random Utility Model (RUM) in a multi-country setting. The standard RUM assumes that the utility of a type-s individual λ born in country i and moving to a destination country j is composed of a deterministic component that takes into account the average

[10] Throughout the paper, H_i denotes the share of educated natives from origin country i, independently on where they live. In contrast, h_i denotes the (post-migration) proportion of college graduates in the resident labor force of country i.

[11] Accounting for multiple moves would make the model exponentially more complex (**kennanwalker2011**). In addition, we calibrate the model on stock data because skill-specific flow data are not available bilaterally. In the calibration, $M_{ij,s}$ is measured as the skill-specific stock of migrants living in each possible destination country at a given point in time, be they permanent or temporary migrants. Temporary migration would likely mitigate some of the benefits (i.e., reduced remittances and social transfers) and some of the negative consequences of high-skilled emigration (i.e., TFP of fiscal externalities). The incentives to educate may also be lower if migration spells are expected to be temporary. Thus, by matching existing stock data, our estimates and calibrated parameters capture the average effects of temporary and permanent migrations. Finally, we cannot distinguish between economic migrants and refugees who have not had time to prepare their move. According to UNHCR, there were about 10.8 million refugees in the world in 2010, including almost 2 million in OECD countries. This represents less than 4% of the (migrant) stocks of interest. As each country is calibrated separately, explicitly accounting for asylum migration would only affect results for countries affected by humanitarian crisis (e.g., Afghanistan, Iraq, Sudan...).

income in the destination country ($w_{j,s} \in \Re^{+}$), the average level of moving costs ($c_{ij,s} < 1$), and of a random component ($\varepsilon_{ij,s}^{\lambda} \in \Re$) that captures heterogeneity across individuals (i.e., heterogeneity in preferences, in moving costs, in the ability to value job-related skills and experience abroad, etc.). To model the interdependencies between migration and education decisions, we introduce a second source of heterogeneity, through the cost of higher education, $e_h^{\lambda} \in [0,1]$.

We allow the individual-specific effort to acquire education to decrease with the (exogenous) provision of public education, and to vary with other country-specific characteristics that affect access to basic (primary and secondary) and higher education (all of which are reflected in a scale variable G_i). For tractability, we assume G_i is exogenous. Our assumption is also motivated by the fact that the literature has identified conflicting effects of selective migration on the optimal provision of public education. On the one hand, some studies have shown that selective migration reduces the optimal level of public education because it increases the expected utility of education and reduces the gap between the social and private returns to education (see, among others, Docquier et al., 2008; Justman and Thisse, 1997; Stark and Wang, 2002). On the other hand, others highlight the complementarity between public spending on education and students' efforts to acquire human capital in response to career opportunities at home and abroad (Djajić et al., 2019).[12] Emphasizing the complementarity between public education and individual efforts to accumulate human capital is particularly relevant when considering the investment in education in poor, developing countries, where credit markets to finance private education are underdeveloped. Thus, working-age individuals have heterogeneous abilities to acquire higher education, and heterogeneous preferences regarding destination countries. The utility function of an individual λ choosing education type s and moving from i to j has a logarithmic form and is expressed as:

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

As is standard in the literature on migration, we assume that the random component of utility $\varepsilon_{ij,s}^{\lambda}$ follows a Type I Extreme Value distribution, also known as the double exponential cumulative distribution function:

$$\varepsilon_{ij,s}^{\lambda} \rightsquigarrow F_1\left(\varepsilon\right) = \exp\left[-\exp\left(-\frac{\varepsilon}{\mu} - \kappa\right)\right] \quad \forall i, j, s,$$

[12] Our framework is compatible with the fact that some individuals acquire education abroad. Our scale variable G_i can be seen as a weighted average of access to domestic and foreign education. Compared to domestically educated individuals, the foreign-trained might encounter higher returns to schooling abroad and lower moving costs. This heterogeneity is captured by the random component of the utility function ($\varepsilon_{ij,s}^{\lambda}$).

where $\mu > 0$ is a common scale parameter governing the responsiveness of migration decisions to income differences and κ is Euler's constant.

Regarding the cost of the higher education, no effort is required if the individual does not acquire higher education ($e_l^\lambda = 0$). By contrast, investing in higher education requires a positive level of effort ($e_h^\lambda \geq 0$). We assume that e_h^λ is distributed on $[0, 1]$ according to the following cumulative distribution function:

$$F_2(e_h) = e_h^{1+z},$$

where $z \in \Re^+$ is a parameter that determines the slope of the density function, $f_2(e_h) = (1+z)e_h^z$, which is increasing in e_h. The greater the value of z, the smaller the proportion of individuals with a high ability to acquire education (i.e., with a low cost of education). In other words, z determines the scarcity of high-ability individuals, and/or the ability of domestic agents to allocate resources to education. The scaling factor $(1+z)$ in $f_2(e_h)$ ensures that $\int_0^1 f_2\left(e_h^z\right) = 1$.[13]

Timing of Decisions. The timing of decisions reflects the availability of information about the two random individual characteristics, e_h^λ and $\varepsilon_{ij,s}^\lambda$. First, individuals discover their ability to educate, e_h^λ. They do not know their migration type, $\varepsilon_{ij,s}^\lambda$, but they know its distribution. Given expectations about $w_{j,s}$ and $c_{ij,s}$, each individual decides whether to pursue higher education. Second, after the education decision is implemented, individuals discover their migration type, $\varepsilon_{ij,s}^\lambda$, and decide where to emigrate, or to stay at home.[14]

Higher Education Decisions. In the first stage, individuals acquire higher education if the expected utility gain from having a college education degree exceeds the effort cost. Under the Type I Extreme Value distribution for $\varepsilon_{ij,s}^\lambda$, the expression for the ex-ante expected utility of choosing type s is given by $\mathbb{E}\left(U_{i,s}\right) = \ln \sum_j e^{[\ln(w_{j,s}) + \ln(1-c_{ij,s})]/\mu} + \ln\left(1 - \frac{e_s^\lambda}{G_i}\right)$ (see, for example, Palma and Kilani, 2007). Thus, investing in college education is optimal if $\mathbb{E}\left(U_{i,h}\right) \geq \mathbb{E}\left(U_{i,l}\right)$.

[13] When $z = 0$, the distribution is uniform. When $z > 0$, the density is strictly increasing in e_h: there are more individuals facing larger education costs than individuals facing lower education costs. The parameter z can be calibrated to match the semi-elasticity of human capital formation to the emigration differential estimated in Section 1.2.1 for broad country income groups.

[14] We abstract from explicitly modelling the possibility that individuals emigrate to study for two reasons. First, less than 3% of students worldwide (and 5% in the least developed countries) study in a country other than their country of origin (see Figure 20.3 in UNESCO (2023)). Second, cross-country data do not break down country of education by country of origin. Therefore, we assume that the local cost of education is a good proxy for the cost of obtaining an education.

This condition can be expressed as:

$$\left(1 - \frac{e_s^\lambda}{G_i}\right) \sum_{j=1}^{I} (w_{j,h})^{1/\mu} (1 - c_{ij,h})^{1/\mu} \geq \sum_{j=1}^{I} (w_{j,l})^{1/\mu} (1 - c_{ij,l})^{1/\mu} \tag{1.2}$$

A variable that plays a key role in this condition is the expected returns to investment in higher education, which takes into account skill-specific migration prospects. It is defined as:

$$\Lambda_i \equiv \frac{\sum_{j=1}^{I} (w_{j,h})^{1/\mu} (1 - c_{ij,h})^{1/\mu}}{\sum_{j=1}^{I} (w_{j,l})^{1/\mu} (1 - c_{ij,l})^{1/\mu}} \equiv \frac{(w_{i,h})^{1/\mu} + (W_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu} + (W_{i,l})^{1/\mu}} , \tag{1.3}$$

where $(W_{i,s})^{1/\mu} \equiv \sum_{j \neq i} (w_{j,s})^{1/\mu} (1 - c_{ij,s})^{1/\mu} \; \forall s$ is the expected income component related to emigration prospects individuals of type-s .

In a no-migration (or closed) economy (i.e., when $W_{i,s} = 0$), the expected returns to investment in higher education are fully determined by the local wage ratio ($\Lambda_i^{NM} = (w_{i,h}/w_{i,l})^{1/\mu}$). In an open-economy context, the influence of emigration prospects is large when the ratios $W_{i,s}/w_{i,s}$ are high. This is the case when foreign wages are high and migration costs are low. In an open economy (i.e., when $W_{i,s} > 0$), the expected return to investment in higher education is affected by emigration prospects. From (1.2) and (1.3), investment in college education is optimal when

$$e_h^\lambda \leq G_i \left[\frac{\Lambda_i - 1}{\Lambda_i}\right] \equiv \chi_i, \tag{1.4}$$

where χ_i is the (endogenous) critical cost level below which investment in higher education is optimal. As in the two-country setting of Djajić et al. (2019), this critical level increases with the provision of public education (G_i) and with the expected college premium (Λ_i), which takes into account the wage structure in all potential destination countries, net of dyadic and skill-specific migration costs. It is worth noting that these migration costs include all types of barriers faced by movers from i to j, including transportation costs, visa and passport costs, or the difficulty of gathering information about job opportunities, prices, and wages in the destination country. If any of these cost components is large, $c_{ij,s}$ approaches unity and the corridor j becomes irrelevant for individuals from country i. In practice, only a few corridors matter.

Given the cumulative distribution function $F_2(e_h)$ defined above, the proportion of natives who choose to invest in higher education can be expressed as:

$$H_i = F_2(\chi_i) = G_i^{1+z} \left[\frac{\Lambda_i - 1}{\Lambda_i} \right]^{1+z}. \tag{1.5}$$

This proportion depends on $w_{i,s}$ and G_i, the components of the expected utility affected by the home country characteristics (i.e, domestic wages and education policy), and on $W_{i,s}$, the component driven by emigration prospects (i.e., wages in destination countries and the migration costs). As noted above, the share of natives investing in education is high when wages in the country of origin are lower than in other countries, and when emigration costs are low. In a closed economy framework ($c_{ij,s} = 1 \; \forall s, j \neq i$), the critical level of effort below which college education is beneficial is locally determined; it increases with G_i and with the local skill premium ($w_{i,h}/w_{i,l}$). The no-migration level of human capital is denoted by H_i^{NM}.

The model has two properties that are consistent with the existing literature:

Proposition 1 *For a given education policy* (G_i)*, skill-biased emigration prospects increase investment in higher education if the expected return to higher education with emigration exceeds the local return in the country of origin* $\frac{W_{i,h}}{W_{i,l}} > \frac{w_{i,h}}{w_{i,l}}$.

Proof. Given Eq. (1.4), the condition $\frac{W_{i,h}}{W_{i,l}} > \frac{w_{i,h}}{w_{i,l}}$ is equivalent to $\Lambda_i > \Lambda_i^{NM}$. *QED*

Proposition 2 *When* $\frac{W_{i,h}}{W_{i,l}} > \frac{w_{i,h}}{w_{i,l}}$*, skill-biased emigration prospects increase the marginal effect of education subsidies on human capital investments.*

Proof. From Eq. (1.5), the marginal benefit from education subsidies is given by $\frac{\partial H_i}{\partial G_i} = (1+z)G_i^z \left[\frac{\Lambda_i - 1}{\Lambda_i}\right]^{1+z} > 0$ if $\Lambda_i > 1$. This implies that $\frac{\partial^2 H_i}{\partial G_i \partial \Lambda_i} = (1+z)^2 G_i^z \left[\frac{\Lambda_i - 1}{\Lambda_i}\right]^z \frac{1}{\Lambda_i^2} > 0$. *QED*

This result is in line with Djajić et al. (2019), who highlight the complementarity between public spending on education, and students' efforts to acquire human capital. However, this does not mean that the effectiveness of public education increases with selective emigration prospects. This is because part of the domestically produced human capital benefits abroad rather than the home country (reducing the social returns to public education), and the relevant high-skilled emigrants leave the country without paying back to public finances. However, selective emigration prospects increase the enrollment response to public education spending, as more individuals are incentivized to invest in education for a given public education policy (G_i).

Emigration Decisions. In the second stage, education has been determined and individuals choose to migrate to a country j if $\ln(w_{j,s}) + \ln(1 - c_{ij,s}) + \varepsilon_{ij,s}^{\lambda}$ exceeds the level attainable in any other location. Consistent with McFadden (1974), under the Type I Extreme Value distribution, the probability that an individual of type-s born in country i moves to country j is given by a multinomial logit expression:

$$\frac{M_{ij,s}}{N_{i,s}} = \frac{e^{[\ln(w_{j,s})+\ln(1-c_{ij,s})]/\mu}}{\sum_{k=1}^{J} e^{\left[\ln\left(w_{k,s}\right)+\ln\left(1-c_{ik,s}\right)\right]/\mu}} = \frac{(w_{j,s})^{1/\mu}(1-c_{ij,s})^{1/\mu}}{\sum_{k=1}^{J}(w_{k,s})^{1/\mu}(1-c_{ik,s})^{1/\mu}}.$$

The skill-specific emigration rates are endogenous and lie between 0 and 1. The multinomial logit expression implies that the emigration rate from i to j depends on the characteristics of all potential destinations k (e.g., a crisis in Greece affects the emigration rate from Romania to Germany). The stay rates $(M_{ii,s}/N_{i,s})$ are determined by the same multinomial logit expression. The emigrant-to-stayer ratio in Eq. (1.6) and the aggregation constraint in Eq. (1.7) fully characterize the equilibrium distribution of the population:

$$m_{ij,s} \equiv \frac{M_{ij,s}}{M_{ii,s}} = \frac{e^{[\ln w_{j,s}+\ln(1-c_{ij,s})]/\mu}}{e^{[\ln w_{i,s}]/\mu}} = \left(\frac{w_{j,s}}{w_{i,s}}\right)^{1/\mu}(1-c_{ij,s})^{1/\mu},\ \forall j \neq i \tag{1.6}$$

$$N_{i,s} = M_{ii,s} + \sum_{j\neq i} M_{ij,s} = \left(1+\sum_{j\neq i} m_{ij,s}\right) M_{ii,s}. \tag{1.7}$$

From Eq. (1.6), it appears that $1/\mu$ can be interpreted as the elasticity of the migrant-to-stayer ratio to wage differentials. The ratio of emigrants to stayers depends only on the characteristics of the destination and origin countries: it increases with the income gap between the two countries and it decreases with the dyadic migration costs. Heterogeneity in migration preferences implies that emigrants choose all destinations for which $c_{ij,s} < 1$. If $c_{ij,s} = 1$, the corridor is empty. All corridors with $c_{ij,s}$ and $c_{ji,s}$ smaller than unity have bidirectional migration flows.

Brain Gain in a Dyadic Context. The aggregate emigration rate $(m_{i,s})$ and the ratio of emigration rates (ρ_i) from country i (an index of skill selection as shown in Table 1.1) are jointly determined and are given by the following expressions:

$$m_{i,s} \equiv \frac{\sum_{j\neq i} M_{ij,s}}{N_{i,s}} = \frac{(W_{i,s})^{1/\mu}}{(w_{i,s})^{1/\mu}+(W_{i,s})^{1/\mu}},$$

$$\rho_i \equiv \frac{m_{i,h}}{m_{i,l}} = \frac{(W_{i,h})^{1/\mu}}{(W_{i,l})^{1/\mu}}\left[\frac{(w_{i,h})^{1/\mu}+(W_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu}+(W_{i,l})^{1/\mu}}\right]^{-1}. \tag{1.8}$$

This implies:

Proposition 3 *Emigration-driven expected utility shocks ($\Delta W_{i,s}$) induce a positive correlation between human capital formation (H_i) and the ratio of emigration rates (ρ_i). Local expected utility shocks ($\Delta w_{i,s}$) induce a negative correlation between H_i and ρ_i.*

Proof. From Eq. (1.8), the ratio of high-skilled to low-skilled emigration rates increases with $W_{i,h}$ and $w_{i,l}$, and decreases with $W_{i,l}$ and $w_{i,h}$. From Eq. (1.5), the proportion of college graduates in the native population increases with $W_{i,h}$ and $w_{i,h}$, and decreases with $W_{i,l}$ and $w_{i,l}$. Consequently, we have $sgn\left(\frac{\partial H_i}{\partial W_{i,s}}\right) = sgn\left(\frac{\partial \rho_i}{\partial W_{i,s}}\right)$ and $sgn\left(\frac{\partial H_i}{\partial w_{i,s}}\right) \neq sgn\left(\frac{\partial \rho_i}{\partial w_{i,s}}\right)$. *QED*

In particular, an increase in the high-skilled wage at origin, $w_{i,h}$, increases the expected returns to higher education, Λ_i, and human capital formation, H_i, given Eqs. (1.4) and (1.5), while it decreases the ratio of high-skilled to low-skilled emigration rates ρ_i through lower incentives to emigrate for college graduates. Similarly, a rise in $w_{i,l}$ decreases the expected return to higher education and human capital formation, while it increases ρ_i through lower incentives to emigrate for the less educated. Turning to shocks to foreign wages and/or migration costs, we find the opposite correlations. Shocks that increase the expected utility of college graduates abroad ($W_{i,h}$) have a positive effect on human capital formation (H_i) and on the positive selection of emigrants (as reflected in the ratio of high-skilled to low-skilled emigration rates, ρ_i, and in line with Abarcar and Theoharides (2021); Khanna and Morales (2017); Shrestha (2017); Theoharides (2018)). Shocks that increase the expected utility of the less educated abroad ($W_{i,l}$) have a negative effect on both variables (e.g., McKenzie and Rapoport, 2011; Brauw and Giles, 2017; Pan, 2017; Kosack, 2021). This establishes the microfoundations of the link between emigration rates and pre-migration human capital formation in a multi-destination framework.

The post-migration share of college graduates in the resident labor force, h_i, can be expressed as the ratio of college-educated non-migrants to the total non-migrant population, adjusted for the exogenous number of immigrants ($I_{i,s}$):[15]

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

which increases with the share of remaining college graduates, $(1-m_{i,h})H_i$, and decreases with the share of remaining low-skilled workers, $(1-m_{i,l})(1-H_i)$.

It follows that emigration-driven expected utility shocks ($\Delta W_{i,s}$) induce ambiguous effects on ex-post (i.e., post-migration) human capital levels in the country of origin (h_i). A rise

[15] The lack of skill-specific immigration data in non-OECD countries limits our ability to adjust for the skill structure of immigration. The assumption of exogenous immigrant stocks in all countries implies that the migration-education channel only operates through emigration.

in $W_{i,h}$ increases H_i and $m_{i,h}$ jointly, leading to ambiguous net effects on the post-migration human capital levels of the non-migrant population (h_i). The same result holds after a rise in $W_{i,l}$, which decreases H_i and $m_{i,l}$ jointly.

Our final consideration relates to the importance of selection vs. the extent of emigration in determining human capital decisions. Biavaschi et al. (2020) compare the current world equilibrium with a counterfactual scenario that assumes the same number of observed bilateral migrants, but in which these migrants are neutrally selected (NS) from their countries of origin. In our context, this means a world with $m_{ij,h} = m_{ij,l} = \overline{m}_{ij}, \forall j$. The implications of neutrally selected emigration for human capital accumulation are governed by the following proposition:

Proposition 4 *In a world with neutral selection and exogenous wages, $(m_{ij,h} = m_{ij,l} = \overline{m}_{ij}, \forall j)$, the expected return on education is identical to that of the no-migration counterfactual, $\Lambda_i^{NS} = \Lambda_i^{NM}$. It follows that $H_i^{NS} = H_i^{NM}$ whatever the migration intensity $\overline{m}_{ij}$.*

Proof. From Eq. (1.6), $m_{ij,h} = m_{ij,l}\ \forall j$ implies that $\left(\frac{w_{j,h}}{w_{i,h}}\right)^{1/\mu}(1-c_{ij,h})^{1/\mu} = \left(\frac{w_{j,l}}{w_{i,l}}\right)^{1/\mu}(1-c_{ij,l})^{1/\mu}$. Summing over all possible destinations gives $\frac{w_{j,h}^{1/\mu}+W_{j,h}^{1/\mu}}{w_{i,h}^{1/\mu}} = \frac{w_{j,l}^{1/\mu}+W_{j,l}^{1/\mu}}{w_{i,l}^{1/\mu}}$, which implies that $\frac{(w_{i,h})^{1/\mu}+(W_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu}+(W_{i,l})^{1/\mu}} = \frac{(w_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu}}$, or equivalently, $\Lambda_i^{NS} = \Lambda_i^{NM}$. *QED*

Although the overall emigration level is likely to influence the economic impact of emigration in the origin country through multiple channels (as discussed below), in a partial equilibrium framework with exogenous wages, the direct effect of emigration on human capital accumulation is entirely due to selection along the skill dimension (see Eq. (1.5)). However, in a general equilibrium context where the average emigration rate induces spillover effects on income (e.g., through remittances) and productivity (e.g., through business linkages), the effects of selection and migration are not identical.[16]

1.2.3 Generalized Approach: Quantitative Applications

We parameterize the dyadic model for 174 countries and for the year 2010, and use this to assess the human capital response to selective emigration on a country-by-country basis. We compare the current situation with a counterfactual no-migration equilibrium (i.e., we assume $c_{ij,s} = 1$ for all s and for all $j \neq i$).[17] In this section, the analysis is conducted in a partial equilibrium context with constant wage rates.

[16] We simulate and discuss a no-selection counterfactual in Appendix 1.C.3.

[17] Proposition 4 shows that the no-selection and no-migration counterfactuals induce the same changes on expected returns to education (i.e. on incentives to acquire education) and the same human capital responses in the partial equilibrium framework.

Parameterization – We summarize here our parameterization strategy for the migration and education technologies and provide details in Appendix 1.B.1. With regard to the migration technology, we use data from the ADOP (Artuc et al., 2014) and DIOC (Arslan et al., 2015) databases to characterize skill-specific emigration stocks and rates ($M_{ij,s}$ and $m_{ij,s}$), as summarized in Table 1.1. We restrict our sample to emigrants aged 25 and above who migrated to one of the OECD member states, and distinguish between those with a college degree ($s = h$) and the less educated ($s = l$). The choice to focus on OECD destinations is guided by the fact that such migration is the best documented, fastest growing, and most positively selected component of international migration.[18] It is the type of migration that is likely to determine differences in emigration rates between high-skilled and low-skilled people, and to provide educational incentives. We combine data on GDP per worker in PPP value and the income ratio between skill groups to proxy wage rates by skill group ($w_{i,s}$), and assume an elasticity of migration to income, $1/\mu$, equal to 0.7, in line with Bertoli et al. (2013). Migration costs ($c_{ij,s}$) are calibrated as a residual from Eq. (1.6). In Appendix 1.B.1, we show that the calibrated migration costs have the expected correlations with the standard determinants identified in the literature (i.e., including distance, linguistic proximity, and colonial ties).

With respect to the training technology, we parameterize two unknown parameters per country, z_i and G_i to match data on emigration stocks and human capital, as well as semi-elasticities of pre-migration human capital (H_i) to selective migration prospects ($m_{i,h} - m_{i,l}$), empirically identified for broad income groups in Section 1.2.

Our *benchmark* scenario is based on the *long-run semi-elasticity* (LR), which captures the effect of migration shocks on the long-run human capital accumulation path. We obtain a long-run semi-elasticity of 3.2 for low-income and lower-middle-income countries, and values close to zero for other countries.[19]

We use a *Monte-Carlo* computational algorithm that works as follows. We combine wage rates and migration costs to compute Λ_i using Eq. (1.3). We assume that z_i is constant within an income group, while G_i is country-specific. We iteratively calibrate these two unknowns. For different vectors of z_i, we calibrate G_i to match H_i using Eq. (1.5), and then subject the model to various selective emigration shocks. We choose the values of z_i that match the four estimated semi-elasticities by country group from Table 1.2. When fitting long-term semi-elasticities (benchmark scenario), we find $z^*_{LOW} = 5.3$, $z^*_{LMI} = 3.8$ and $z^*_{UMI} = z^*_{HIC} = 0$ for low-income (LOW), lower-middle-income (LMI), upper-middle-income

[18] Migration to non-OECD countries is less prone to strong positive selection (see Artuc et al., 2014).

[19] In Appendix 1.B.3, we repeat our exercise for a *conservative* scenario based on the *short-run semi-elasticity* (SR), which captures the effect of migration shocks on human capital within a ten-year period. We have a short-run semi-elasticity of 1.3 for low-income and lower-middle income countries, and values close to zero for upper-middle-income and high-income countries.

(UMI), and high-income countries (HIC), respectively.[20] This implies that the distribution of ability to acquire education is uniform in upper-middle and high-income countries, which limits incentive effects there. However, since z is a proxy for "talent scarcity" (understood here as the ability to acquire higher education at low cost), it is reassuring that it decreases with the level of development. In addition, we show in Appendix 1.B.1 that the calibrated levels of G_i are adequately correlated with traditional proxies for access to education (such as public education spending, urbanization rate, and GDP per capita). These differences in access to education are crucial for predicting the human capital responses to selective emigration.

Results – Our no-migration scenario neutralizes any educational incentive effects generated by emigration prospects. The latter are affected by differences in wages and migration costs across destinations, which may have been influenced by skill-selective policies. However, since the option to emigrate is shut down in the counterfactual simulations, the sources of the observed skill-selection in bilateral migration stocks do not affect our results.

Our quantitative results are shown in Figure 1.1. Panel (a) plots the density of the effect of (observed) selective migration on the expected returns to higher education, $(\Lambda_i - \Lambda_i^{NM})/\Lambda_i^{NM}$. The effect is positive in 164 out of 174 countries in our sample, for which $\Lambda_i > \Lambda_i^{NM}$ implies that selective emigration stimulates the pre-migration human capital formation. Ten countries in our sample have negative emigration differentials (i.e., negative selection), implying that international migration reduces Λ_i and thus optimal investment in education. The peak of the density is around 5 percent. However, the distribution is right-skewed and shows large differences between countries within each income group. For example, within a given income group, the returns to higher education are more sensitive to emigration in small countries than in larger countries. This is because small countries are highly specialized economies with limited domestic job diversity. They benefit more from diversifying employment opportunities through international migration, which is reflected in our model by lower net migration costs for both types of workers. The average level of development of the main destinations (determined by colonial links, and geographical and linguistic distances) also influences the gains from emigration. This explains why a dyadic approach that accounts for heterogeneity in migration costs and destination choices is likely to produce more accurate predictions than a framework that ignores these dimensions. The impact of selective emigration on Λ_i exceeds 20 percent in a non-negligible number of countries and even exceeds 40 percent in 22 countries.[21] The largest effects on Λ_i are observed

[20] When matching the short-term elasticities (conservative scenario), we obtain $z^*_{LOW} = 1.7$, $z^*_{LMI} = 0.9$ and $z^*_{UMI} = z^*_{HIC} = 0$.

[21] These countries are: Sierra Leone, Zimbabwe, Rwanda, Jamaica, Belize, Lebanon, Samoa, Suriname, Fiji, Mozambique, Saint Vincent and the Grenadines, Cape Verde, Barbados, Tonga, Trinidad and Tobago, Grenada, Mauritius, Guyana, Liberia, Haiti, Guinea Bissau, Sao Tome and Principe.

in small and poor countries. The open economy level of Λ_i is at least 75 percent larger than the no-migration level in Mauritius, Guyana, Lebanon, Sao Tome and Principe, Haiti, Liberia, Trinidad and Tobago, Barbados, Tonga, Grenada, and Cape Verde.

To examine whether emigration prospects induce convergence or divergence in the expected returns to higher education, Panel (b) compares the emigration-induced relative change in Λ_i with the no-migration counterfactual level. The slope of the relationship is positive, implying that selective emigration leads to divergence in the distribution of Λ_i. The effect is stronger in poor countries where the no-migration levels of Λ_i^{NM} are already at the highest levels.[22]

Panel (c) shows the variation in (post-migration) human capital ($\Delta h_{i,t}$ on the vertical axis) as a function of the no-migration level of human capital ($h_{i,t}^{NM}$ on the horizontal axis). We find a net "brain gain" in 128 countries (74% of our sample), and a human capital loss in 46 countries. The effect is positive in almost all lower-middle and low-income countries, where we identify 57 winners and only 1 loser (Bolivia, where the emigration differential is negative). The net gain exceeds 1 p.p. in 48 countries, and the largest effects are observed in Moldova (6.8 p.p.), Norway (6.6 p.p.), Jamaica (6.4 p.p.), Fiji (6.3 p.p.), the Philippines (6.0 p.p.), New Zealand (5.5 p.p.), Cuba (4.6 p.p.), Czechia (4.5 p.p.), Guyana (4.4 p.p.), Slovakia (4.1 p.p.) and Sweden (4.0 p.p.).

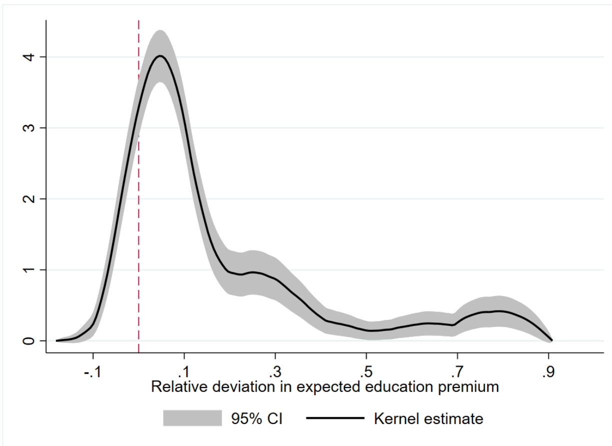
In Panel (d) of Figure 1.1, we compare the observed and counterfactual levels of human capital. Many observations are close to the 45-degree line, suggesting that the overall response of human capital to selective emigration is rather limited. However, although human capital remains low, selective emigration nearly doubles the share of college graduates in Cape Verde, Cuba, Fiji, Guyana, Haiti, Liberia, Moldova and Zimbabwe – and in small states in the top quartile of the human capital distribution.[23]

[22] It is worth emphasizing that $(\Lambda_i - \Lambda_i^{NM})/\Lambda_i^{NM}$ is independent of the level of μ when the model is properly calibrated (i.e., when the migration costs are recalibrated to match the current state of the economy). This is because, from Eq. (1.8), $(W_{i,s})^{1/\mu}$ can be written as $\frac{m_{i,s}}{1-m_{i,s}}(w_{i,s})^{1/\mu}$. Plugging this expression into Eq. (1.3) and comparing with the no-migration equilibrium, we have that $\Lambda_i/\Lambda_i^{NM} = (1-m_{i,l})/(1-m_{i,h})$.

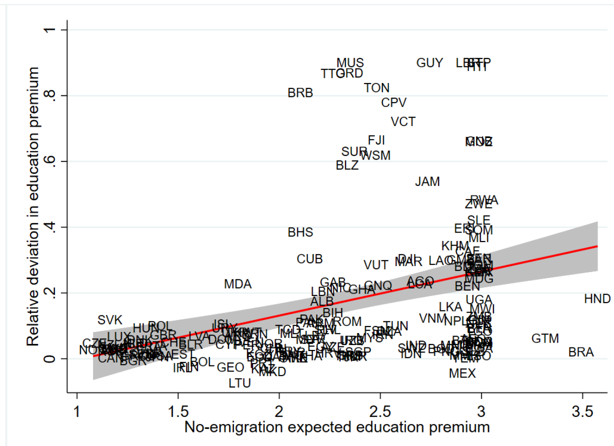
[23] In Appendix 1.B.2, we show that the effects of selective emigration on human capital in countries of origin obtained with our generalized approach are more positive than those obtained with the empirical model.

Figure 1.1: Effect of selective emigration on human capital accumulation (h_i)
Insights from the generalized approach

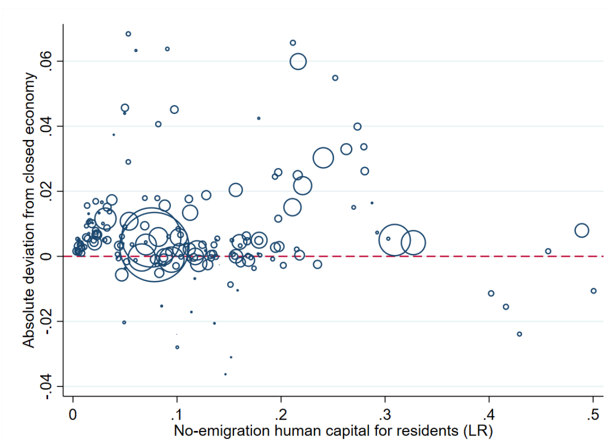
(a) Density of $(\Lambda_i - \Lambda_i^{NM})/\Lambda_i^{NM}$



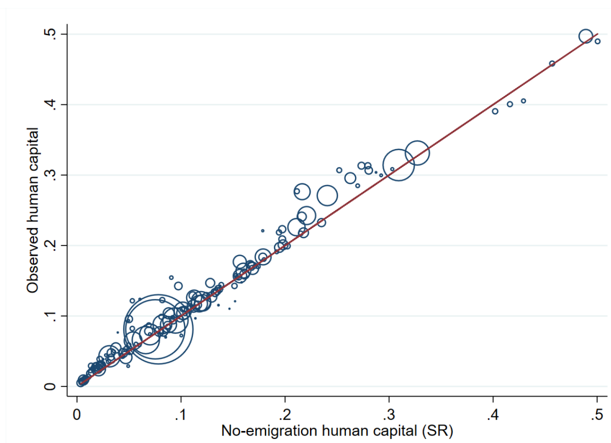
(b) $(\Lambda_i - \Lambda_i^{NM})/\Lambda_i^{NM}$ vs. Λ_i^{NM}



(c) Long-term (LR) effect (Δh_i)



(d) Observed vs. no-migration (LR)



Note: Panel (a) gives the density of the migration-driven relative change in expected returns to schooling (Λ_i). Panel (b) compares the relative change in expected returns to schooling with the no-migration counterfactual level. Panel (c) compares the variation Δh_i (i.e. the difference between the observed proportion of college graduates (h_i) and the no-migration proportion (h_i^{NM})) as a function of the no-migration counterfactual level (h_i^{NM}). Panel (d) compares the observed proportion of college graduates h_i with the no-migration proportion h_i^{NM}. Results are obtained for the benchmark scenario. Each circle represents a country, and its size represents the size of the labor force.

1.3 Selective Emigration and Economic Development

In this section, we estimate the net impact of emigration on the real disposable income of individuals remaining in the countries of origin. We embed our microfounded model of migration and human capital accumulation into an extended *development accounting* framework, which has been used to quantify the contribution of various factors to observed differences in income levels across countries (e.g., Hsieh and Klenow, 2010; Jones, 2014) without endogenizing the magnitude of these factors. We use it to quantify the effect of selective migration on the level of human capital and economic development in each source country. To do so, we extend the human capital accumulation mechanism of Section 1.2 with a production function as well as additional channels, including complementarities between high- and low-skilled workers, schooling externalities, diaspora externalities, market size externalities, the fiscal impact of selective emigration, and remittances. The *development accounting* framework is described in Section 1.3.1. In Section 1.3.2, we explain its calibration and simulate the response of disposable income to selective emigration.

1.3.1 Development Accounting: Theory

The core of our *development accounting* framework is a constant elasticity of substitution (CES) production function. Such a framework has been widely used in labor/growth literature to explain differences in macroeconomic performance across countries (e.g. and the patterns of wage inequality between skill groups).[24]

We focus on the average real disposable income of those remaining behind, which is a function of the average real wage (Y_i/L_i), the average income tax rate (τ_i), and the share of remittance inflows in domestic income (r_i). Assuming constant returns to scale, the level of real disposable income per worker ($y_i \equiv \frac{(1-\tau_i+r_i)Y_i}{L_i}$) is given by:

$$y_i = \frac{(1-\tau_i+r_i)A_i}{P_i}\left[\frac{\Gamma_i}{1+\Gamma_i}h_i^{\frac{\sigma-1}{\sigma}} + \frac{1}{1+\Gamma_i}(1-h_i)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad (1.9)$$

$$= \frac{(1-\tau_i+r_i)A_iQ(\Gamma_i,h_i)}{P_i}, \quad (1.10)$$

where $h_i \equiv L_{i,h}/L_i$ is the share of college-educated workers in the resident labor force affected by selective emigration as detailed in Section 1.2.2.[25] $Q(\Gamma_i, h_i)$ is the CES labor composite, A_i denotes total factor productivity (TFP), P_i is the ideal/average price index in the economy, Γ_i

[24] See Appendix 1.C.1 for more details.

[25] In particular, $L_{i,h} \equiv \left(1-\sum_{j\in i} m_{ij,h}\right) N_{i,h} + \sum_{j\in i} m_{ji,h}N_{j,h}$, with $N_{i,h} = G_i^{1+z}\left(1-1/\Lambda_i\right)^{1+z} N_i$ and Λ_i is given by Eq. 1.3.

determines the relative productivity and firms' preference for college-educated workers, and σ is the elasticity of substitution between skill groups. Such a production function without physical capital characterizes a globalized economy with a common international interest rate.

By affecting human capital accumulation (h_i), selective emigration influences disposable income through complementarity between high-skilled and low-skilled workers (neoclassical force), as reflected in the term $Q(\Gamma_i, h_i)$. In particular, income per worker increases with human capital if the marginal productivity of college-educated workers exceeds that of less educated workers. However, the overall impact on disposable income goes beyond this pure neoclassical mechanism and depends on a wider range of effects, which are detailed below.

Schooling Externalities. Recent studies show that college-educated workers are instrumental in supporting democratization (e.g., Castelló-Climent and Mukhopadhyay, 2013; Bobba and Coviello, 2007; Murtin and Wacziarg, 2014; Docquier et al., 2016), and in facilitating innovation and technology diffusion when knowledge becomes economically useful (e.g., Benhabib and Spiegel, 1994; Caselli and Coleman, 2006; Ciccone and Papaioannou, 2009). We consider two education-driven externalities on TFP: an aggregate productivity externality and directed technical change:

$$A_i = \overline{\overline{A}}_i \left(\frac{h_i}{1 - h_i} \right)^{\epsilon}, \tag{1.11}$$

$$\Gamma_i = \overline{\Gamma}_i \left(\frac{h_i}{1 - h_i} \right)^{\kappa}. \tag{1.12}$$

The aggregate externality in Eq. (1.11) assumes that the scale of the TFP is a concave function of the skill ratio in the resident labor force with an elasticity ϵ, while $\overline{\overline{A}}_i$ is a scale factor. The skill-biased technical change in Eq. (1.12) affects the relative productivity of high-skilled workers with an elasticity κ, while $\overline{\Gamma}_i$ is a residual scale factor (see Acemoglu, 2002; Restuccia and Vandenbroucke, 2013; Autor et al., 2003).

Diaspora Externalities. It has been empirically shown that diasporas abroad help reduce transaction costs between countries and facilitate trade and foreign direct investment (e.g., Iranzo and Peri, 2009; Felbermayr et al., 2010; Parsons and Vezina, 2018; Kugler and Rapoport, 2007; Javorcik et al., 2011). Starting from Eq. (1.11), we allow $\overline{\overline{A}}_i$ to depend on the emigration rate

$\left(\overline{\overline{A}}_i = \overline{A}_i \left(\overline{m} + m_i\right)^{\rho}\right)$ and modify the TFP function as follows:

$$A_i = \overline{A}_i \left(\overline{m} + m_i\right)^{\rho} \left(\frac{h_i}{1 - h_i}\right)^{\epsilon}, \tag{1.13}$$

where ρ is the elasticity of TFP to the diaspora abroad (proxied by the average emigration rate, m_i), $\overline{m}$ is a constant added to avoid having TFP equal to zero when the average emigration rate is zero, and $\overline{A}_i$ is the adjusted scale factor, assumed to be exogenous. Combining estimates from the literature gives a conservative elasticity of TFP to emigration of 0.032.

Remittances. The least disputable mechanism is the remittance channel. Data on the proportion of remittance inflows in domestic income, r_i, is obtained from the World Development Indicators. Remittances reallocate income from donor to recipient countries, and reinforce (or attenuate, respectively) the income gain (loss, respectively) due to selective emigration, as shown in Giovanni et al. (2015) and Theoharides (2020). In the no-migration counterfactual, r_i is equal to zero.

Market Size Externalities. Selective emigration affects the aggregate demand for goods and services in the country of origin by reducing aggregate income and consumption. As the domestic market size decreases, fewer entrepreneurs can operate in it, the number of goods decreases, and the ideal price index increases (Krugman, 1980; Giovanni et al., 2015; Aubry et al., 2016). For simplicity, we account for market size effects by dividing our CES output aggregate by an endogenous equilibrium price index P_i, which can be expressed as a nonlinear function of the total output demanded (for private goods):

$$P_i = \overline{P}_i \left[A_i L_i Q(\Gamma_i, h_i)(1 - \tau_i + r_i)\right]^{\frac{-1}{\lambda - 1}}, \tag{1.14}$$

where λ is the elasticity of substitution between goods in the utility function, and $\overline{P}_i$ is normalized to generate an equilibrium price equal to one in the observed equilibrium without loss of generality.

Fiscal Effects of Emigration. We consider two sources of fiscal costs in our model. First, education systems are heavily dominated by public institutions, especially in developing countries (Devesh et al., 2009; Egger et al., 2012; Djajić et al., 2019; World Bank, 2010; Teferra, 2007). Most emigrants have benefited from education subsidies and leave the country without paying their way. Second, Alesina and Spolaore (1997) and Alesina and Wacziarg (1998) argue that spreading the cost of non-rival goods and services over a larger pool of taxpayers reduces the fiscal burden on residents. Hence, per capita government consumption declines with population size. We define a government budget constraint imposing that a proportional tax on nominal income is levied to finance the education expenditures of stayers and emigrants as well as public consumption.[26] This budget constraint can be written as $\tau_i L_i A_i Q(\Gamma_i, h_i) = \hat{g}_i P_i N_i + \hat{c}_i P_i L_i^{1-\eta}$, where $1-\eta$ is the elasticity of public consumption to population, $\hat{c}_i$ is a scale factor that governs public consumption per resident, and $\hat{g}_i$ is the average level of education expenditures (all levels) per native expressed in real terms.

We define $g_i \equiv \frac{\hat{g}_i P_i}{A_i Q(\Gamma_i, h_i)}$ as the ratio of education expenditure per person to income per worker, and $c_i \equiv \frac{\hat{c}_i P_i}{N_i^{\eta} A_i Q(\Gamma_i, h_i)}$ as the ratio of public consumption per person to per capita income in the no-migration economy. For simplicity, we assume that these two ratios are exogenous. If a fraction m_i of the native labor force leaves the country, the equilibrium tax rate becomes:

$$\tau_i = \frac{g_i}{1-m_i} + \frac{c_i}{(1-m_i)^{\eta}}.$$

The first term captures the fact that education spending is now supported by a smaller number of resident taxpayers, while the second term captures the increase in public consumption per resident due to the smaller population size.

1.3.2 Development Accounting: Quantitative Application

The *development accounting* block is used to estimate the relative changes in disposable income per worker due to (selective) emigration, $(y_i - y_i^{NM})/y_i^{NM}$, for each country. We calibrate the income block of the model to exactly match the observed level of disposable income in 2010, and use estimated elasticities from empirical studies. In the benchmark case, we consider the long-term effect of selective emigration on human capital accumulation (see Section 1.2.3), and we use intermediate elasticity levels from the existing literature.[27] Table 1.3 lists the consensus parameter values used in the benchmark simulations and their main sources.[28]

Our benchmark results are summarized in Figure 1.2. In Panel (a), the density of the net impact of emigration on disposable income is skewed to the right. The peak and median

[26] For simplicity, we abstract from potentially progressive income taxation. Progressive taxation would increase the fiscal loss from positively selected emigration because high skilled workers would contribute more in taxes.

[27] In Appendix 1.C.2, we replicate our results under a conservative scenario using the short-term human capital response to emigration and doubling or halving the elasticity levels to generate smaller income gains or larger income losses relative to the benchmark scenario. Moreover, in additional results available upon request, we use an alternative 'optimistic' scenario, with parameter changes opposite to those in the pessimistic scenario. These results further confirm the important role played by the remittances channel.

[28] The calibration of the technological parameters is detailed in Appendix 1.C.1, and more conservative values are considered in the robustness checks detailed in Appendix 1.C.2. In addition, in Appendix 1.C.4, we show that the results are robust to alternative values of the elasticity of bilateral migration to the wage ratio (by changing μ) and the elasticity of substitution between skill groups, σ, in the production function.

Table 1.3: Calibration of the income block

Parameter		Benchmark	Source
Change in human capital	Δh_i	LR	Section 1.2.3
Substitution HS/LS	σ	2.0	Ottaviano and Peri (2012)
Migration-income elasticity	$1/\mu$	0.7	Bertoli and Moraga (2013)
Schooling ext. aggregate	ϵ	0.10	Caselli and Ciccone (2013)
Schooling ext. skill-biased	κ	0.10	Burzyński et al. (2020)
Diaspora externality	ρ	0.032	Larch et al. (2017); Feyrer (2019)
Substitution between goods	λ	8.0	Feenstra (1994)
Fiscal externality	η	0.056	Alesina and Spolaore (1997)

of the distribution are around +3.5 percent, while the unweighted average income response equals +5.7 percent.

These gains can be driven by large remittance inflows, large "brain gain" responses, or large diaspora externalities. Panel (b) shows the density of each transmission mechanism in isolation: the neoclassical effects and schooling externalities (ambiguous effects), diaspora externalities (positive), fiscal externalities (negative), market size effects (negative), and remittances (positive). The effect of remittances is dominant in a large number of countries. On average, recorded remittances only represent 3 percent of GDP in developing countries, but 135 countries have a share above the average. These include Tajikistan (38%) , Tonga (36%), Lesotho (34%), Bosnia (29%), Jordan (22%), Samoa (20%), Palestine (17%), Albania (16%), Haiti, Yemen and, Cape Verde (all 15%). The median intensity of the other mechanisms is relatively small, but their variability and their combined effect on disposable income can be large.

Panel (c) compares the income response to emigration with the no-migration counterfactual income level (in logs). The curve is mostly above zero, implying that, on average and with a few exceptions, emigration increases income per worker at all levels of development. As the slope is negative, the income response is larger in poor countries. The average income gain is about 10 percent in the least developed countries, compared to 1 percent at the top end of the distribution. Although selective, emigration *per se* tends to reduce cross-country differences in disposable income per worker and contributes to income convergence.

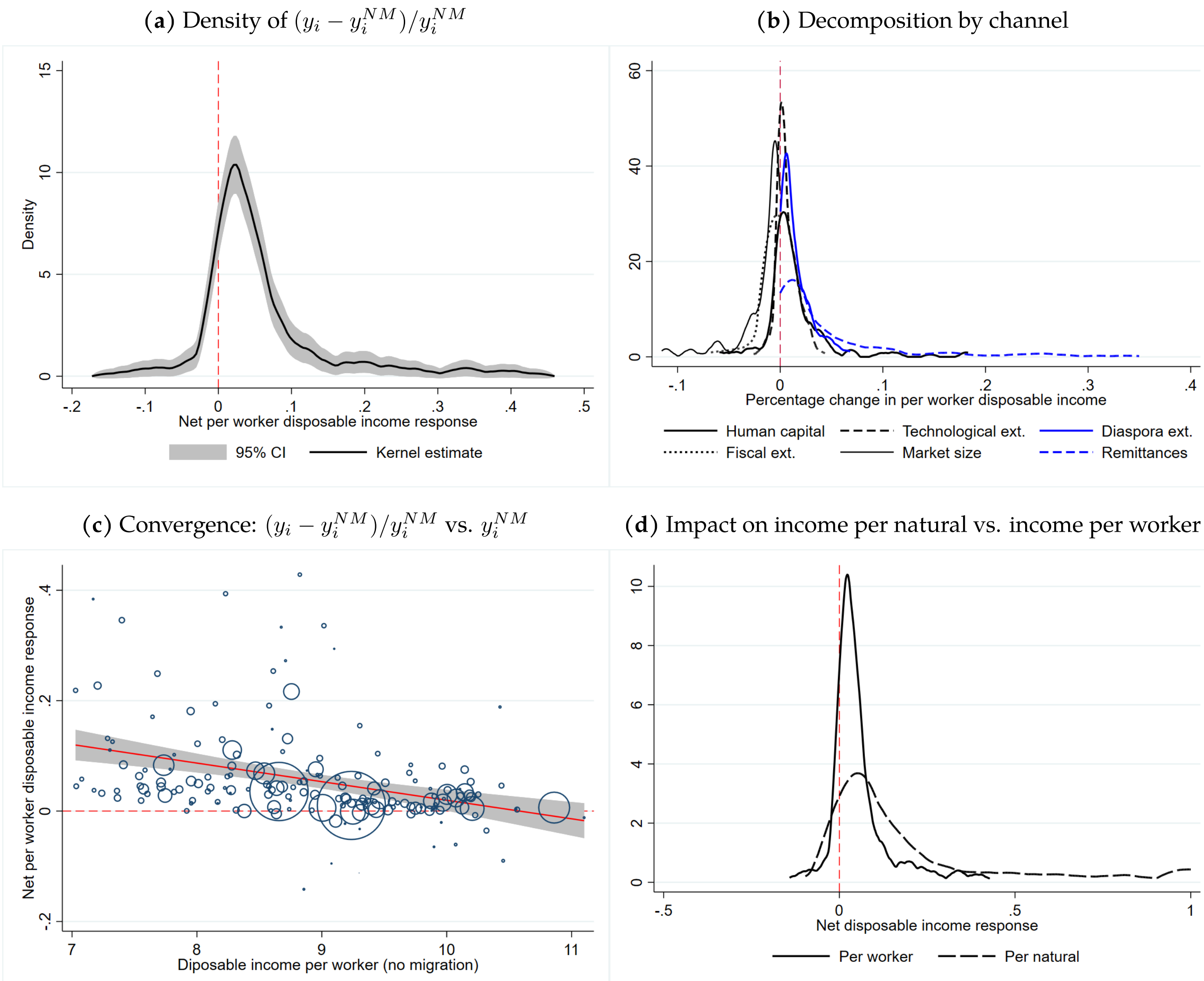
This convergence effect is even more pronounced if development is measured in terms of people rather than places. Defining income per natural as the average annual income of all people born in a given country, regardless of where they live, M. Clemens and Pritchett (2008) emphasize the role of emigration in raising the world production frontier and reducing cross-country income disparities. In Panel (d), we aggregate the income of non-migrants and emigrants from all countries, and compute the variation in income per natural. The density shifts to the right relative to income per worker. Most countries show an increase in the range of 0-20 percent, and there is a non-negligible fraction of the sample for which selective emigration increases income per natural by more than 40 percent.

In the benchmark scenario, we identify 156 winners and 18 losers. Losses exceed 5 percent in six small island states: Mauritius (-6.1%), Barbados (-6.5%), Trinidad and Tobago (-9.0%), Saint Vincent and the Grenadines (-9.5%), Grenada (-11.2%), and Suriname (-14.2%). At the other end of the distribution, gains of more than 20 percent are recorded in 13 countries: Jamaica (42.8%), Madagascar (39.4%), Comoros (38.4%), Haiti (34.6%), Lebanon (33.6%), Guyana (33.3%), Samoa (29.4%), Fiji (27.2%), Slovenia (25.4%), Zimbabwe (24.9%), Tajikistan (22.7%), Lesotho (21.9%), and the Philippines (21.7%).

Figure 1.3 shows the population-weighted average disposable income response to selective emigration per worker (left bars), and per natural (right bars) for the different country income groups. The average income per worker increases by 1.9 percent in the benchmark scenario. The income per natural, which takes into account the income gains of migrants, increases by 4.6 percent on average. Since the average share of emigrants is small (about 2.25 percent of the total population), the semi-elasticity of real disposable income to migration in our model is close to 2.0.[29]

[29] In Delogu et al. (2018), the global gain from observed migration is estimated at 3.8 percent in the short run, and a "secular" gain of 19 percent is obtained when accounting for the cumulative effect of South-North migration on the world population growth (changes in the fertility rate and in access to education for future generations).

Figure 1.2: Effect of selective emigration on disposable income (y_i)
Results obtained under the benchmark scenario (long-term human capital responses and benchmark elasticity values)



(**a**) Density of $(y_i - y_i^{NM})/y_i^{NM}$

(**b**) Decomposition by channel

(**c**) Convergence: $(y_i - y_i^{NM})/y_i^{NM}$ vs. y_i^{NM}

(**d**) Impact on income per natural vs. income per worker

Note: Each circle represents a country, and its size represents the size of the labor force.

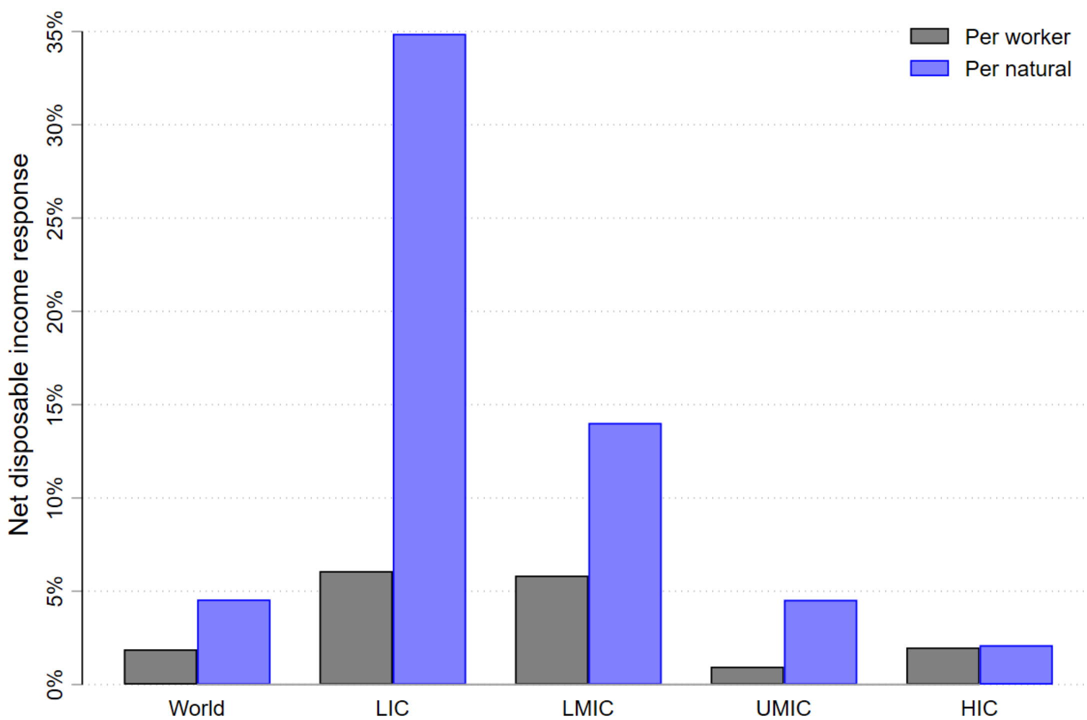
Average income per capita increases most in lower-middle and low-income countries (6.1% and 5.8% respectively), while gains in upper-middle and high-income countries do not exceed 1.0%. These results are more optimistic than those reported in Giovanni et al. (2015) and Biavaschi et al. (2020). Focusing only on remittances and market size effects, Giovanni et al. (2015) find an average gain from emigration of about 2.0 percent for non-migrants in non-OECD countries. Although our benchmark scenario assumes more conservative market size effects, we account for the "brain gain" mechanism and induced schooling externalities. Accounting for similar mechanisms but less optimistic educational responses, Biavaschi et al. (2020) find a gain of 0.3 percent in non-OECD countries. This confirms that the size of the "brain gain" mechanism is a key determinant of the development impact of selective emigration. Our microfounded model, calibrated to match updated empirical elasticities and country-specific drivers of education and migration decisions, substantially reinforces the predictions of less sophisticated approaches. When migrants' income gains are taken into account, the average effect, as measured by the income per natural, declines with the level of development of the country of origin. It is 35 percent in low-income countries and 14 percent in lower-middle-income countries. The average gain is less than 5 percent in upper-middle and high-income countries. This shows that the "place premium" plays a key role in determining the economic gains from emigration, in line with M. Clemens and Pritchett (2008).

1.4 Selective Migration and Global Inequality

We now turn to the responses of inequality and extreme poverty to global migration in the context of the world economy. These effects are ambiguous. On the one hand, we show in Section 1.3.2 that selective emigration induces convergence in disposable income per worker between countries. On the other hand, international migration reallocates people from poor to rich countries, raises the global average income level, and induces uncertain redistributive effects within countries (between low-skilled and high-skilled workers).

In the previous Section 1.3, we compute the effect of selective emigration on real disposable income per worker in each country of origin separately (one at a time), taking foreign income levels as given. This abstracts from the fact that an emigrant from an origin country is at the same time an immigrant in a (different) destination country. To quantify the impact of global migration on the world distribution of income, we simulate a no-migration counterfactual for all countries jointly, endogenizing income and education responses in all parts of the world. This allows us to account for the fact that stopping emigration changes the size and structure of the labor force not only in the countries of origin but also in all destination countries, with consequences for productivity, prices, taxes, and income levels.

Figure 1.3: Average disposable income responses to selective emigration



Note: Average disposable income responses to selective emigration on income per worker and income per natural calculated as % change of a no-migration scenario relative to the observed equilibrium.

The resident labor force in country i is given by:

$$L_{i,s} = \sum_j M_{ji,s}, \tag{1.15}$$

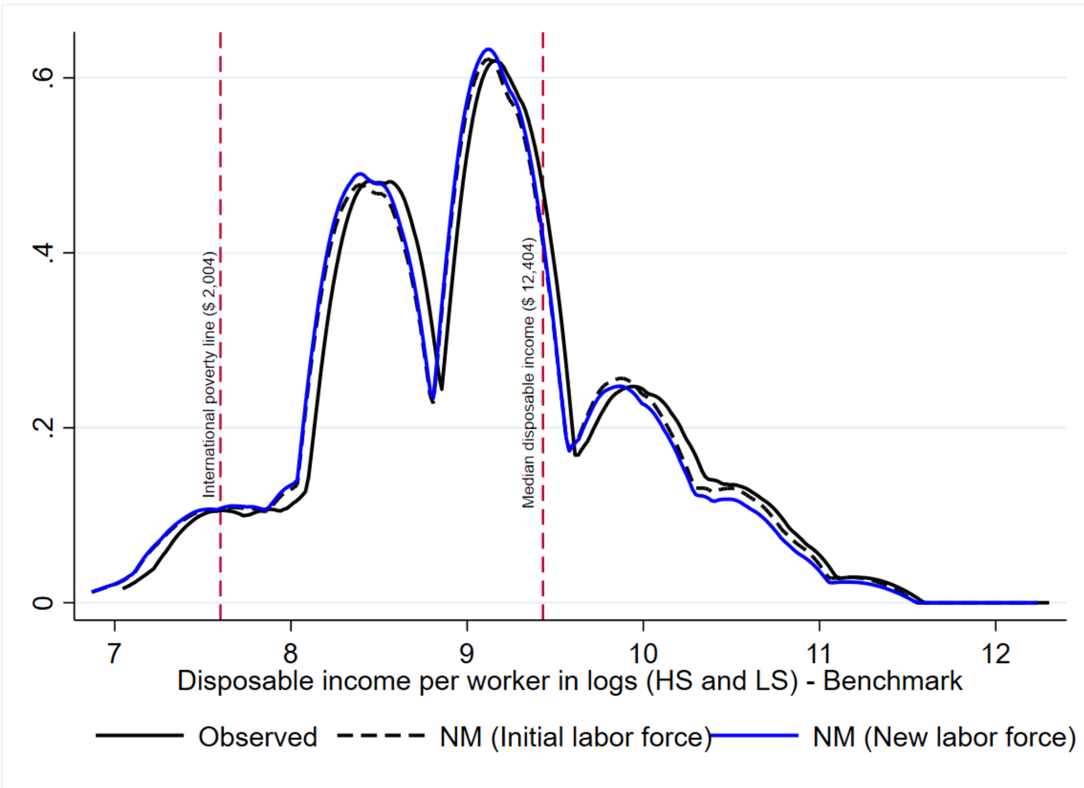
which implies that when $M_{ji,s}$ varies, it directly affects both sending and receiving countries, and indirectly affects educational decisions in all the other countries. In this global setting, the world economy equilibrium is an allocation of labor $\{L_{ij,s}\}_{\forall i,j,s}$ and a vector of income levels $\{y_{j,s}\}_{\forall j,s}$ satisfying the utility and profit maximization conditions, as well as worldwide aggregation constraints. We use this setting to simulate the impact of global migration on the world distribution of income.

In Figure 1.4, we pool all the countries and skill groups, and compare the counterfactual distribution of income (shown in blue) with the observed one (shown in black).[30] The vertical lines represent the United Nations poverty line (5.5 USD per day or 2,000 USD per year in PPP terms) and the median of the income distribution observed in the year 2010 (34 USD per day or 12,404 USD per year in PPP values).

[30] We repeat this exercise using the conservative scenario in Appendix 1.D.1. In Appendix 1.D.2, we also use the Theil index to discuss inequality under the benchmark and conservative scenarios.

Global migration shifts the density of the income distribution to the right. This is the case at low income levels (i.e., below 5,000 USD), as well as at high income levels (i.e., above the median). There is a quasi-perfect stochastic dominance between the observed and counterfactual densities. Importantly, the proportion of people living below the poverty line falls by 8.1 percent, or 104.6 million people.

Figure 1.4: Emigration and world income distribution



Note: This figure shows the observed income distribution (in black) and the counterfactual no-migration distributions when incomes are weighted by observed locations (dashed black line) or counterfactual locations (straight blue line). The vertical lines represent the United Nations poverty line (USD 5.5 per day or USD 2,000 per year in PPP terms) and the median of the income distribution observed in the year 2010 (USD 34 per day or USD 12,404 per year in PPP terms).

Compared with the no-migration counterfactual, we compute the world income distribution by considering the reallocation of people (the black continuous curve in Figure 1.4) or by considering a constant population allocation (the dashed black line). Most of the effect in developing countries is driven by changes in the level of income per worker; this is due to the fact that the average share of emigrants is very small (about 2 percent). By contrast, when focusing on the countries at the top end of the distribution (i.e., the main OECD destination countries), the changes are dominated by the composition effect: the share of immigrants in the working-age population is around 15 percent in the main destination countries.

1.5 Conclusion

International migrants are positively selected in terms of education, and the movement of highly educated workers from developing to developed countries has been the subject of extensive research over the past four decades. Selective emigration has long been viewed as beneficial for migrants, but with ambiguous effects on the growth potential of sending countries and the welfare of those left behind. Earlier literature emphasized the risk of harmful effects for the least developed countries where positive selection is substantial. This view has been challenged by recent literature showing that limited high-skilled emigration can be beneficial for growth and development. The standard empirical approach suggests that substantial "brain gain" effects can occur if high-skilled emigration rates are not too high (Beine et al., 2008). While these findings are confirmed globally when pooling old and recent data on skill-specific emigration rates, the standard approach ignores cross-country heterogeneity in migration opportunities, development differentials, and access to education.

We propose a new dyadic approach that is compatible with updated empirical evidence and that fully accounts for the characteristics of each origin country and of all potential OECD destinations. We establish the micro-foundations of the relationship between selective emigration and human capital accumulation in this dyadic context. Parameterized for the year 2010, our model first shows that selective emigration prospects stimulate human capital formation and induce brain gain effects in 74 percent of the countries in our sample, including small states and a few industrialized countries.

We then embed the migration-education nexus into a *development accounting* framework that considers the main transmission mechanisms through which emigration affects economic development in each country of origin separately. The quantitative analysis suggests that emigration increases income per worker in most countries, and especially in low-income countries. Despite strong selection patterns, international migration tends to reduce disparities in average income across countries. It shifts the world income distribution to the right and reduces the share of the world population living in extreme poverty. We estimate that selective migration reduces the proportion of people living on less than USD 5.5 a day by 8 percent (or 105 million people), and increases the average global income per worker by 1.9 percent. These estimates may even be conservative. This is because (i) we probably do not capture the full benefits associated with temporary migration and brain circulation, and (ii) we do not consider potential mechanisms such as the transmission of behavioral norms (fertility, education, gender equality, culture, etc.) or political remittances (the influence of diasporas on voter turnout and political preferences). Adding these effects to our quantitative framework would be a challenging task. However, our study gives credit to the 2030 Agenda for Sustainable Development, which views regular and well-managed international migration as a phenomenon that improves the lives of migrants and communities in their countries of origin.

Bibliography

Abarcar, P. and C. Theoharides (2021). "Medical Worker Migration and Origin-Country Human Capital: Evidence from U.S. Visa Policy". In: *Review of Economics and Statistics* forthcoming, pp. 1–46.

Acemoglu, D. (2002). "Technical Change, Inequality, and the Labor Market". In: *Journal of Economic Literature* 40(1), pp. 7–72.

Acemoglu, D., F. F.A. Gallego, and J. Robinson (2014). "Institutions, Human Capital and Development". In: *Annual Review of Economics* 6, pp. 875–912.

Alesina, A. and E. Spolaore (1997). "On the number and size of nations". In: *The Quarterly Journal of Economics* 112(4), pp. 1027–1056.

Alesina, A. and R. Wacziarg (1998). "Openness, country size and government". In: *Journal of Public Economics* 69(3), pp. 305–321.

Antman, F. M. (2011). "The intergenerational effects of paternal migration on schooling and work: What can we learn from children's time allocations?" In: *Journal of Development Economics* 96(2), pp. 200–208.

Arslan, C., J.-C. Dumont, Z. Kone, Y. Moullan, C. Ozden, C. Parsons, and T. Xenogiani (2015). "A new profile of migrants in the aftermath of the recent economic crisis". In: *OECD Social Employment and Migration Working Papers* 160.

Artuc, E., F. Docquier, Ç. Özden, and C. Parsons (2014). *A global assessment of human capital mobility: the role of non-OECD destinations*. The World Bank.

Aubry, A., M. Burzyński, and F. Docquier (2016). "The welfare impact of global migration in OECD countries". In: *Journal of International Economics* 101(C), pp. 1–21.

Autor, D. H., F. Levy, and R. J. Murnane (2003). "The skill content of recent technological change: An empirical exploration". In: *The Quarterly journal of economics* 118(4), pp. 1279–1333.

Bahar, D. and H. Rapoport (2018). "Migration, Knowledge Diffusion and the Comparative Advantage of Nations". In: *Economic Journal* 128(612), F273–F305.

Batista, C., A. Lacuesta, and P. C. Vicente (2012). "Testing the 'brain gain' hypothesis: Micro evidence from Cape Verde". In: *Journal of Development Economics* 97(1), pp. 32–45.

Beine, M., F. Docquier, and H. Rapoport (2008). "Brain drain and human capital formation in developing countries: winners and losers". In: *The Economic Journal* 118(528), pp. 631–652.

Beine, M., F. Docquier, and C. Oden-Defoort (2011). "A panel data analysis of the brain gain". In: *World Development* 39(4), pp. 523–532.

Beine, M., F. Docquier, and H. Rapoport (2001). "Brain drain and economic growth: theory and evidence". In: *Journal of Development Economics* 64(1), pp. 275–289.

Beine, M., F. Docquier, and H. Rapoport (2010). "On the robustness of brain gain estimates". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 143–165.

Belot, M. V. and T. J. Hatton (2012). "Immigrant Selection in the OECD". In: *The Scandinavian Journal of Economics* 114(4), pp. 1105–1128.

Bencek, D. and C. Schneiderheinze (2020). *Higher economic growth in poor countries, lower migration flows to the OECD: Revisiting the migration hump with panel data*. Kiel Working Papers 2145. Kiel Institute for the World Economy (IfW).

Benhabib, J. and M. M. Spiegel (1994). "The role of human capital in economic development evidence from aggregate cross-country data". In: *Journal of Monetary Economics* 34(2), pp. 143–173.

Bertoli, S. and J. F.-H. Moraga (2013). "Multilateral resistance to migration". In: *Journal of development economics* 102, pp. 79–100.

Bertoli, S., J. Moraga, and F. Ortega (2013). "Crossing the border: self-selection, earnings and individual migration decisions". In: *Journal of Development Economics* 101(1), pp. 75–91.

Bhagwati, J. and K. Hamada (1974). "The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis". In: *Journal of Development Economics* 1(1), pp. 19–42.

Biavaschi, C., M. Burzyński, B. Elsner, and J. Machado (2020). "Taking the skill bias out of global migration". In: *Journal of Development Economics* 142, p. 102317.

Bobba, M. and D. Coviello (2007). "Weak instruments and weak identification, in estimating the effects of education, on democracy". In: *Economics Letters* 96(3), pp. 301–306.

Bollard, A., D. McKenzie, M. Morten, and H. Rapoport (2011). "Remittances and the Brain Drain Revisited: The Microdata Show That More Educated Migrants Remit More". In: *World Bank Economic Review* 25(1), pp. 132–156.

Bolt, J., R. Inklaar, H. de Jong, and J. L. van Zanden (2018). "Rebasing 'Maddison': new income comparisons and the shape of long-run economic development". In: *Maddison Project Working Paper* 10.

Bolt, J. and J. L. Van Zanden (2014). "The Maddison Project: collaborative research on historical national accounts". In: *The Economic History Review* 67(3), pp. 627–651.

Boustan, L. (2010). “Was Postwar Suburbanization “White Flight”? Evidence from the Black Migration”. In: *Quarterly Journal of Economics* 125(1), pp. 417–443.

Brauw, A. de and J. Giles (2017). “Migrant Opportunity and the Educational Attainment of Youth in Rural China”. In: *Journal of Human Resources* 52(1), pp. 272–311.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014). “Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh”. In: *Econometrica* 82, pp. 1671–1748.

Burzyński, M., C. Deuster, and F. Docquier (2020). “Geography of skills and global inequality”. In: *Journal of Development Economics* 142, p. 102333.

Caballero, M. E., B. Cadena, and B. K. Kovak (2021). *The International Transmission of Local Economic Shocks Through Migrant Networks*. NBER Working Papers 28696. National Bureau of Economic Research, Inc.

Caselli, F. and A. Ciccone (2013). “The contribution of schooling in development accounting: Results from a nonparametric upper bound”. In: *Journal of Development Economics* 104(C), pp. 199–211.

Caselli, F. and W. J. I. Coleman (2006). “The World Technology Frontier”. In: *American Economic Review* 96(3), pp. 499–522.

Castelló-Climent, A. and A. Mukhopadhyay (2013). “Mass education or a minority well educated elite in the process of growth: The case of India”. In: *Journal of Development Economics* 105, pp. 303–320.

Chand, S. and M. A. Clemens (2008). “Skilled emigration and skill creation: a quasi-experiment”. In: *Available at SSRN 1299135*.

Ciccone, A. and E. Papaioannou (2009). “Human Capital, the Structure of Production, and Growth”. In: *Review of Economics and Statistics* 91(1), pp. 66–82.

Clemens, M., C. Ozden, and H. Rapoport (2014). “Migration and Development Research is Moving Far Beyond Remittances”. In: *World Development* 64, pp. 121–124.

Clemens, M. and L. Pritchett (2008). “Income per Natural: Measuring Development for People Rather Than Places”. In: *Population and Development Review* 34(3), pp. 395–434.

Clemens, M. and E. R. Tiongson (2017). “Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work”. In: *Review of Economics and Statistics* 99(3), pp. 531–543.

Clemens, M. A. (2020). *The Emigration Life Cycle: How Development Shapes Emigration from Poor Countries*. IZA Discussion Papers 13614. Institute of Labor Economics (IZA).

Clemens, M. A. and M. Mendola (2020). *Migration from Developing Countries: Selection, Income Elasticity, and Simpson’s Paradox*. IZA Discussion Papers 13612. Institute of Labor Economics (IZA).

Commander, S., M. Kangasniemi, and L. A. Winters (2004). "The Brain Drain: Curse or Boon? A Survey of the Literature". In: *Challenges to Globalization: Analyzing the Economics*. NBER Chapters. National Bureau of Economic Research, Inc, pp. 235–278.

Dao, T. H., F. Docquier, C. Parsons, and G. Peri (2018). "Migration and development: Dissecting the anatomy of the mobility transition". In: *Journal of Development Economics* 132, pp. 88–101.

Delogu, M., F. Docquier, and J. Machado (2018). "Globalizing labor and the world economy: the role of human capital". In: *Journal of Economic Growth* 23(2), pp. 223–258.

Devesh, K., J. McHale, and K. Rogers (2009). "The Fiscal Impact of High-Skilled Emigration: Flows of Indians to the U.S." In: *Journal of Development Economics* 88(1), pp. 32–44.

Dinkelman, T. and M. Mariotti (2016). "The Long-Run Effects of Labor Migration on Human Capital Formation in Communities of Origin". In: *American Economic Journal: applied Economics* 8(4), pp. 1–35.

Djajic, S. (1989). "Skills and the pattern of migration: the role of qualitative and quantitative restrictions on international labor mobility". In: *International Economic Review*, pp. 795–809.

Djajić, S., F. Docquier, and M. S. Michael (2019). "Optimal education policy and human capital accumulation in the context of brain drain". In: *Journal of Demographic Economics* 85(4), pp. 271–303.

Docquier, F., O. Faye, and P. Pestieau (2008). "Is migration a good substitute for education subsidies?" In: *Journal of Development Economics* 86(2), pp. 263–276.

Docquier, F., E. Lodigiani, H. Rapoport, and M. Schiff (2016). "Emigration and democracy". In: *Journal of Development Economics* 120, pp. 209–223.

Docquier, F., B. L. Lowell, and A. Marfouk (2009). "A gendered assessment of highly skilled emigration". In: *Population and Development Review* 35(2), pp. 297–321.

Docquier, F. and J. Machado (2016). "Global Competition for Attracting Talents and the World Economy". In: *The World Economy* 39(4), pp. 530–542. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/twec.12267.

Docquier, F. and H. Rapoport (2012). "Globalization, brain drain, and development". In: *Journal of Economic Literature* 50(3), pp. 681–730.

Egger, H., J. Falkinger, and V. Grossmann (2012). "Brain drain, fiscal competition, and public education expenditure". In: *Review of International Economics* 20(1), pp. 81–94.

Feenstra, R. C. (1994). "New Product Varieties and the Measurement of International Prices". In: *American Economic Review* 84(1), pp. 157–177.

Felbermayr, G. J., B. Jung, and F. Toubal (2010). "Ethnic Networks, Information, and International Trade: Revisiting the Evidence". In: *Annals of Economics and Statistics* 97-98, pp. 41–70.

Fernández Sánchez, M. (2022). *Mass Emigration and Human Capital over a Century: Evidence from the Galician Diaspora*. Tech. rep. Luxembourg Institute of Socio-Economic Research (LISER).

Feyrer, J. (2009). *Distance, trade, and income - the 1967 to 1975 closing of the Suez canal as a natural experiment*. Tech. rep. National Bureau of Economic Research.

Feyrer, J. (2019). "Trade and Income — Exploiting Time Series in Geography". In: *American Economic Journal: Applied Economics* 11(4), pp. 1–35.

Gibson, J. and D. McKenzie (2009). *The microeconomic determinants of emigration and return migration of the best and brightest: Evidence from the Pacific*. The World Bank.

Gibson, J., D. McKenzie, and S. Stillman (2011). "The Impacts of International Migration on Remaining Household Members: Omnibus Results from a Migration Lottery Program". In: *The Review of Economics and Statistics* 93(4), pp. 1297–1318.

Giovanni, J. di, A. A. Levchenko, and F. Ortega (2015). "A global view of cross-border migration". In: *Journal of the European Economic Association* 13(1), pp. 168–202.

Glaeser, E. L., R. La Porta, F. Lopez-de-Silanes, and A. Shleifer (2004). "Do institutions cause growth?" In: *Journal of Economic Growth* 9(3), pp. 271–303.

Grogger, J. and G. H. Hanson (2011). "Income maximization and the selection and sorting of international migrants". In: *Journal of Development Economics* 95(1), pp. 42–57.

Haque, N. U. and S.-J. Kim (1995). ""Human capital flight": Impact of migration on income and growth". In: *Staff Papers* 42(3), pp. 577–607.

Hendricks, L. (2004). *A database of Mincerian earnings regressions*.

Hsieh, C.-T. and P. J. Klenow (2010). "Development accounting". In: *American Economic Journal: Macroeconomics* 2(1), pp. 207–223.

Iranzo, S. and G. Peri (2009). "Migration and trade: Theory with an application to the Eastern-Western European integration". In: *Journal of International Economics* 79(1), pp. 1–19.

Javorcik, B. S., C. Ozden, M. Spatareanu, and C. Neagu (2011). "Migrant networks and foreign direct investment". In: *Journal of Development Economics* 94(2), pp. 231–241.

Jones, B. F. (2014). "The human capital stock: a generalized approach". In: *American Economic Review* 104(11), pp. 3752–77.

Justman, M. and J.-F. Thisse (1997). "Implications of the mobility of skilled labor for local public funding of higher education". In: *Economics Letters* 55(3), pp. 409–412.

Kerr, S. P., W. Kerr, Ç. Özden, and C. Parsons (2016). "Global talent flows". In: *Journal of Economic Perspectives* 30(4), pp. 83–106.

Khanna, G. and N. Morales (2017). *The IT Boom and Other Unintended Consequences of Chasing the American Dream*. Working Paper 460. Center for Global Development.

Khanna, G., E. Murathanoglu, C. Theoharides, and D. Yang (2022). *Abundance from abroad: migrant income and long-run economic development*. Working Paper 29862. NBER.

Kleemans, M. and J. Magruder (2018). "Labour Market Responses To Immigration: Evidence From Internal Migration Driven By Weather Shocks". In: *The Economic Journal* 128(613), pp. 2032–2065.

Kosack, E. (2021). "Guest Worker Programs and Human Capital Investment – The Bracero Program in Mexico, 1942–1964". In: *Journal of Human Resources* 56(2), pp. 570–592.

Krugman, P. (1980). "Scale Economies, Product Differentiation, and the Pattern of Trade". In: *American Economic Review* 70(5), pp. 950–959.

Kugler, M. and H. Rapoport (2007). "International labor and capital flows: Complements or substitutes?" In: *Economics Letters* 94(2), pp. 155–162.

Larch, M., J. E. Anderson, and Y. V. Yotov (2017). *Trade Liberalization, Growth, and FDI: A Structural Estimation Framework*. Annual Conference 2017 (Vienna): Alternative Structures for Money and Banking 168071. German Economic Association.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior". In: *Frontiers in econometrics*. Ed. by P. Zarembka. Academic Press: New York. Chap. 4, pp. 105–142.

McKenzie, D. and H. Rapoport (2011). "Can Migration Reduce Educational Attaintment? Evidence from Mexico". In: *Journal of Population Economics* 24(4), pp. 1331–1358.

Miyagiwa, K. (1991). "Scale economies in education and the brain drain problem". In: *International Economic Review*, pp. 743–759.

Monras, J. (2020). "Immigration and Wage Dynamics: Evidence from the Mexican Peso Crisis". In: *Journal of Political Economy* 128(8), pp. 3017–3089.

Mountford, A. (1997). "Can a brain drain be good for growth in the source economy?" In: *Journal of Development Economics* 53(2), pp. 287–303.

Munshi, K. (2003). "Networks in the Modern Economy: Mexican Migrants in the U.S. Labor Market". In: *Quarterly Journal of Economics* 118(2), pp. 549–599.

Murtin, F. and R. Wacziarg (2014). "The democratic transition". In: *Journal of Economic Growth* 19(2), pp. 141–181.

Ottaviano, G. I. and G. Peri (2012). "Rethinking the effect of immigration on wages". In: *Journal of the European Economic Association* 10(1), pp. 152–197.

Ozden, C. and H. Rapoport (2018). "Cross-country Perspectives on Migration and Development". In: *The Economic Journal* 128(612), pp. 174–178.

Palma, A. de and K. Kilani (2007). "Invariance of conditional maximum utility". In: *Journal of Economic Theory* 132(1), pp. 137–146.

Pan, Y. (2017). "The Impact of Removing Selective Migration Restrictions on Education: Evidence from China". In: *Journal of Human Resources* 52(3), pp. 859–885.

Parsons, C. R. and P.-L. Vezina (2018). "Migrant Networks and Trade: The Vietnamese Boat People as a Natural Experiment". In: *The Economic Journal* 128(612), pp. 210–234.

Restuccia, D. and G. Vandenbroucke (2013). "The evolution of education: A macroeconomic analysis". In: *International Economic Review* 54(3), pp. 915–936.

Shrestha, S. A. (2017). "No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants". In: *The Economic Journal* 127(600), pp. 495–521.

Silva, J. S. and S. Tenreyro (2011). "Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator". In: *Economics Letters* 112(2), pp. 220–222.

Stark, O., C. Helmenstein, and A. Prskawetz (1997). "A brain gain with a brain drain". In: *Economics letters* 55(2), pp. 227–234.

Stark, O. and Y. Wang (2002). "Inducing human capital formation: migration as a substitute for subsidies". In: *Journal of Public Economics* 86(1), pp. 29–46.

Teferra, D. (2007). "Higher education in sub-Saharan Africa". In: *International handbook of higher education*. Springer, pp. 557–569.

Theoharides, C. (2018). "Manila to Malaysia, Quezon to Qatar International Migration and Its Effects on Origin-Country Human Capital". In: *Journal of Human Resources* 53(4), pp. 1022–1049.

Theoharides, C. (2020). "The unintended consequences of migration policy on origin-country labor market decisions". In: *Journal of Development Economics* 142, p. 102271.

UNESCO (2023). *Global Education Monitoring Report 2023: Technology in education – A tool on whose terms?* Tech. rep. Paris.

Vidal, J.-P. (1998). "The effect of emigration on human capital formation". In: *Journal of Population Economics* 11(4), pp. 589–600.

Wong, K.-y. and C. K. Yip (1999). "Education, economic growth, and brain drain". In: *Journal of Economic Dynamics and Control* 23(5-6), pp. 699–726.

World Bank (2010). *Financing higher education in Africa*. The World Bank.

Yang, D. (2008). "International Migration, Remittances and Household Investment: Evidence from Philippine Migrants' Exchange Rate Shocks". In: *Economic Journal* 118(528), pp. 591–630.

Appendix

1.A Selective Emigration and Human Development: Updated Empirical Estimations

In Section 1.2.1 of the main text, we provide updated estimates of the effect of skill-biased migration opportunities on human capital formation in the country of origin. Compared to existing studies, we use a more general specification and an improved identification strategy. This section of the Appendix explains our modeling choices and provides detailed estimation results.

1.A.1 Model Specification

Our starting point is the empirical model of Beine et al. (2008), who estimate a dynamic β-convergence model that analytically boils down to a Cobb-Douglas relationship between human capital and emigration:

$$H_{i,t+1} = A_{i,t} H_{i,t}^{1+\gamma_1} m_{i,h,t}^{\gamma_2},$$

where $H_{i,t}$ is the share of college graduates in the native labor force of country i in year t, and $A_{i,t}$ is a country-specific scaling factor. Their specification is written as $\Delta \ln H_{i,t} = \gamma_0 + \gamma_1 \ln H_{i,t} + \gamma_2 \ln (m_{i,h,t}) + X'_{i,t}\Gamma + \epsilon_{i,t}$. The vector of controls $(X'_{i,t})$ includes population density, a dummy for sub-Saharan African countries and for Latin American countries; $\epsilon_{i,t}$ is the error term. Thus, the scaling factor is given by $A_{i,t} = \exp\left(\gamma_0 + X'_{i,t}\Gamma + \epsilon_{i,t}\right)$. The coefficient γ_2 is the short-run elasticity of human capital to emigration prospects. The model is stable if $\gamma_1 \in]-1, 0[$, and the human capital stock converges toward $H_i = A_i^{-1/\gamma_1} m_{i,h}^{-\gamma_2/\gamma_1}$, so that the long-run elasticity of human capital to emigration equals $-\gamma_2/\gamma_1$. They show that a doubling of a country's emigration rate of high-skilled workers is associated with a 20 percent increase in the natives' long-run stock of human capital (including emigrants), and with a 4.5 percent increase in the short-run (within a decade in their context).

Beine et al. (2010) find that the brain gain mechanism holds when using alternative measures of brain drain that control for whether migrants acquired their skills in the home or host country, or when using alternative specifications and/or indicators of human capital formation. Beine et al. (2011) confirm these effects in a panel setting covering 147 countries of origin and 6 countries of destination for the period 1975-2000.

In addition to the inherent limitations of using cross-sectional data, the β-convergence specification described above suffers from three main limitations. First, in the absence of skilled emigration ($m_{i,h,t} = 0$), this specification implies that human capital is equal to zero ($H_{i,t+1} = 0$). Second, it ignores the role of low-skilled emigration.[31] Third, it is assumed that the elasticity of education to emigration prospects (γ_2) is identical across countries and independent of a country's level of economic development.

In this context, our specification in Eq. (1.1) has advantages over commonly used alternatives, such as the ratio of skill-specific emigration rates, $\ln(m_{i,h,t}/m_{i,l,t})$, or a log-log specification, $\ln(m_{i,h,t} - m_{i,l,t})$. First, $m_{i,h,t}/m_{i,l,t}$ is incompatible with zero emigration rates and is neutral with respect to the magnitude of emigration. For instance, two countries with $(m_{i,h,t}, m_{i,l,t})$ equal to $(0.06, 0.03)$ or to $(0.6, 0.3)$ exhibit an identical ratio of skill-specific emigration rates. Second, the β-convergence specification with the log difference in emigration rates between the two skill groups can be derived from a Cobb-Douglas function of the form $H_{i,t+1} = A_{i,t} H_{i,t}^{1+\gamma_1} (m_{i,h,t} - m_{i,l,t})^{\gamma_2 + \gamma_4^k I_i^k}$, which is incompatible with $m_{i,h,t} \leq m_{i,l,t}$ since it leads to $H_{i,t+1} \leq 0$.

1.A.2 Data and OLS estimates

We first estimate Eq. (1.1) using standard OLS techniques. Our data on migration and human capital are taken from the ADOP and DIOC databases, which characterize the evolution of emigration stocks and rates over the years 1990, 2000, and 2010. We restrict our sample to emigrants aged 25 and over who migrated to one of the OECD member states, and distinguish between college graduates ($s = h$) and the less educated ($s = l$). Data on emigration for the year 1990 are taken from the ADOP database. For the years 2000 and 2010, we use the DIOC. We denote by $M_{ij,s,t}$ the population of migrants from any origin country i to an OECD destination country j in the skill group s at time t. To obtain the emigration rates, we need

[31] Beine et al. (2010) consider a specification with the ratio of emigration rates ($m_{i,h,t}/m_{i,l,t}$) but find less significant results. They also consider a specification with $1 + m_{i,h,t}$, which is compatible with a no-migration situation.

to proxy the size and skill structure of the native (pre-migration) population of the origin country, denoted by $N_{i,s,t}$. To do this, we combine data on the resident population aged 25 years and over with data on the share of college educated individuals from various data sources,[32] and obtain the resident labor force by skill group, denoted by $L_{i,s,t}$. Subtracting the number of immigrants, $I_{i,s,t}$, from the resident labor force gives the number of native stayers by skill group.

For virtually all the countries in the world, the skill-specific emigration rates ($m_{i,s,t}$) are approximated by the ratio of emigrants to OECD destination countries ($M_{i,s,t} \equiv \sum_{j \neq i} M_{ij,s,t}$) to the sum of the emigrant and native-stayer populations ($L_{i,s,t} - I_{i,s,t}$). We write:

$$m_{i,s,t} \equiv \frac{M_{i,s,t}}{N_{i,s,t}} \equiv \frac{\sum_{j \neq i} M_{ij,s,t}}{\sum_{j \neq i} M_{ij,s,t} + L_{i,s,t} - I_{i,s,t}}. \tag{1.16}$$

OLS results are shown in the first four columns of Table 1.2. In the table, Cols. (1) and (2) focus on developing countries only – as in Beine et al. (2008) – while Cols. (3) and (4) show the results for the full sample, including high-income countries. Although our database on skill-specific emigration rates includes 174 countries pooled over the decades 1990-2000 and 2000-2010 (a total of 348 observations), we lose two countries (Belize, and Serbia and Montenegro) for which data on bilateral skill-specific emigration stocks are missing for some years. Hence, our full sample includes 129 developing countries and 43 high-income countries (i.e., 344 observations). In the second column of each country group specification, we add a dummy variable to control for the 11 countries for which the emigration differential is poorly predicted by the zero stage of the gravity model (see IV strategy below).

Two main parameters are of interest. First, we focus on the short-term impact of the emigration differential on human capital formation, as well as on the impact of the country's level of development on the emigration-education nexus. This is captured by the coefficient of the emigration differential (γ_2) for the reference group (i.e., low-income countries), and by summing the coefficient of the reference group and those for the other income groups (i.e., lower-middle, upper-middle, and high-income countries) as $\gamma_2 + \gamma_4^k D_i^k \;\; \forall k = 2, 3, 4$. Second, we are also interested in the long-run effect of the emigration differential, which can be obtained by dividing the short-run effect by the convergence parameter ($-\gamma_1$). The long-run effects by income group are reported in Panel B of Table 1.2.

The results are robust with regard to the treatment of outliers and to the sample, as our

[32] For the years 1990, and 2000, we use population data by educational attainment from Docquier et al. (2009). For the year 2010, we use a combination of data from Docquier et al. (2009) and the *Wittgenstein* database.

specification includes income group dummies and interaction terms. The short-run semi-elasticity γ_2 in the low-income reference group ranges from 1.03 to 1.13 when the sample is restricted to developing countries, and from 1.06 to 1.16 when we use the full sample. These coefficients are statistically significant at the 1 percent level. In addition, the coefficient γ_1 related to the lagged dependent term belongs to $]-1, 0[$, which ensures that the model is stable and that the stock of human capital converges toward equilibrium in the long run. For the low-income reference group, the long-run semi-elasticity is between 2.71 and 3.15 when using the sample of developing countries, and between 2.61 and 3.01 when using the full sample. These coefficients are significant at the 1 percent level. Compared with low-income countries, we find that the short-run and long-run semi-elasticities are not statistically different for the lower-middle-income group. They are, however, lower for the upper-middle and high-income countries (see the interaction terms in Table 1.2).

1.A.3 IV strategy

Our variable of interest ($\delta_{i,h,t} \equiv m_{i,h,t} - m_{i,l,t}$) is endogenous due to potential reverse causality, unobserved heterogeneity, or measurement errors. The risk of reverse causality is mitigated by the fact that emigration rates are computed using migration stocks rather than flows. This implies that $\delta_{i,h,t}$ results from the accumulation of emigration flows over the 40 to 50 years preceding time t. These past migration flows are unlikely to be directly affected by human capital accumulation after time t. However, we cannot ignore the fact that a fast-growing stock of human capital may reduce the local skill premium and make high-skilled people more likely to emigrate, leading to positive reverse causality. An opposite bias is expected if fast-growing human capital translates into skill-biased technological change, higher local skill premiums, and lower emigration pressure. Bias can also occur if low human capital growth rates generate negative externalities (e.g., low levels of democracy, political instability, violent conflict, etc.) that encourage the more educated to leave the country.

With respect to unobserved heterogeneity, an increase in the quality of education in the country of origin may encourage people to educate themselves and facilitate their access to work permits and visas in wealthier countries. Alternatively, a sudden exodus of low-skilled workers to non-OECD countries can also artificially increase the share of skilled workers among natives, while being only partially reflected in the emigration differential because we ignore non-OECD destinations. Thus, unobserved heterogeneity can lead to upward or downward biased estimates of the causal effect of emigration prospects on human capital formation.

Although causality is difficult to establish with cross-country data, we implement an IV strategy that relies on a pseudo-gravity approach and destination-specific factors. We rely on destination pull factors that can be reasonably considered as exogenous from the perspective of the origin country. Our IV strategy consists of three steps.

First Step: Zero-Stage Gravity Model. – We predict skill-specific bilateral migration populations ($\hat{M}_{ij,s,t}$) using a pseudo-gravity model. On the right hand side, we mainly include destination and time fixed effects and exogenous dyadic controls.

The gravity-based prediction of skill-specific bilateral migration stocks $\hat{M}_{ij,s,t}$ is obtained using the following pseudo-gravity model:

$$\begin{aligned} \ln M_{ij,t,s} = & \beta_0^s + \beta_1^s \ln Pop_{i,t} + \beta_2^s \ln Dist_{ij} + \beta_3^s \ln w_{j,t} + \beta_4^s \ln Network_{ij,t-20} \\ & + \beta_5^s Lang_{ij} + \beta_6^s Col_{ij} + \beta_7^s Cont_{ij} \\ & + \sum_{t=00,10} \beta_8^s \delta_t + \sum_{t=00,10} \beta_9^s \rho_t \times \ln Dist_{ij} + \mu_j + \epsilon_{ij,t} \, , \end{aligned} \tag{1.17}$$

where $\ln Dist_{ij}$ is the log of weighted distance between i and j based on bilateral distances between the most populous cities in each of the two countries weighted by the share of each city in the country's total population; alternatively, to capture the fact that the cost of distance may have changed over time, we use $\rho_t \times \ln Dist_{ij}$, the interaction between distance and time dummies; $\ln w_{j,t}$ is the log wage in the OECD destination country j; $Lang_{ij}$ is a dummy variable equal to 1 if the same language is spoken by at least 9% of the population in both countries and 0 otherwise; Col_{ij} and $Cont_{ij}$ are two dummy variables that take the value 1 if countries i and j have a colonial link and share a common border, respectively, and 0 otherwise; μ_j and δ_t are destination and time fixed effects.

Thus, we avoid using variables related to the country of origin. We only control for the log of total population at origin at time t ($\ln Pop_{i,t}$), to capture country size. We also include $\ln Network_{ij,t-20}$, the log of network size in the destination country j proxied by the total stock of migrants from i to j twenty years earlier. The network variable is not skill specific and includes young foreign-born individuals under the age of 25, mitigating endogeneity concerns.

We estimate Eq. (1.17) after pooling dyadic migration data for the years 1990, 2000 and 2010. We use Poisson Pseudo-maximum Likelihood (PPML) *à la* Silva and Tenreyro (2011) to deal with the large number of zeroes in the dependent variable and the heteroscedasticity.[33] The standard errors are robust and clustered at country level. Since most of our determinants

[33] This approach is relevant because the proportion of zeros in the migration data is quite important (26.6 to 39.01% for less educated migrants and 27.4 to 40.8% for college educated migrants).

of the skill-specific emigration rate are time-invariant (except for the time pattern and the network in $t-20$), we follow Feyrer (2009) and move to a panel setting where we add time fixed effects and interaction terms between time fixed effects and the weighted distance between i and j to capture gradual changes in migration costs.

Table A.1: Pseudo-Gravity model for dyadic migration stocks ($M_{ij,s}$)

	M_{ijht}	M_{ijlt}	M_{ijht}	M_{ijlt}
	(1)	(2)	(3)	(4)
Population size origin (log)	0.316***	0.115***	0.317***	0.115***
	(0.030)	(0.025)	(0.030)	(0.025)
Distance (log)	-0.260***	-0.169*	-0.122***	-0.139
	(0.044)	(0.087)	(0.041)	(0.094)
Distance (log) × 2000			-0.115***	-0.050**
			(0.024)	(0.025)
Distance (log) × 2000			-0.208***	-0.031
			(0.058)	(0.057)
Wage at destination (log)	0.145**	0.182*	0.148**	0.183*
	(0.065)	(0.109)	(0.066)	(0.108)
Network 20 years ago (log)	0.503***	0.727***	0.504***	0.726***
	(0.023)	(0.045)	(0.022)	(0.045)
Common language	0.551***	-0.127	0.557***	-0.126
	(0.040)	(0.225)	(0.041)	(0.225)
Colony	0.234***	0.078	0.226***	0.077
	(0.065)	(0.260)	(0.062)	(0.261)
Contiguity	-0.191**	0.350	-0.185**	0.351
	(0.085)	(0.330)	(0.086)	(0.327)
Observations	17,612	17,612	17,612	17,612
Pseudo R^2	0.915	0.868	0.916	0.868
Destination FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Notes: Pseudo Maximum Likelihood (PPML) coefficients with standard errors clustered at oigin-destination pair in parentheses. ***, **, and * denote significance at the 1%, 5% and 10% level respectively.

The results of the zero-stage gravity regressions are provided in Table A.1. Cols. (1) and (2) use a specification with the log of distance for college-educated and less educated migrants, respectively. Cols (3) and (4) add to this specification with the interaction between distance and year dummies for 2000 and 2010 (1990 being the reference period). Migration stocks decrease with geographic distance, and the effect of distance decreases over time. This suggests that migration costs have decreased over time, in line with Feyrer (2009). The size of dyadic migration stocks increases with the population size of the origin country, with the dyadic network in $t-20$, and with the wage rates in the destination country. The dyadic network variable absorbs much of the effects of distance, colonial links and common language. However, in line with existing empirical evidence, college-educated workers are sensitive to linguistic proximity, which is a key factor governing the transferability of human capital across countries; this is not the case for low-skilled workers.

Second Step: Building Instruments. – In the second step, we sum the predicted emigration stocks and divide them by the native population to predict skill-specific emigration rates ($\hat{m}_{i,s,t} \equiv \sum_j \hat{M}_{ij,s,t}/N_{i,s,t}$) and the aggregate emigration differential ($\hat{\delta}_{i,t} \equiv \hat{m_{i,h,t}} - \hat{m_{i,l,t}}$) for each corresponding year.

Third Step: First-Stage Equation – In the third step, we use the (gravity-based) predicted emigration rate differentials ($\hat{\delta}_{i,t}$) to instrument the observed differentials ($\delta_{i,t} \equiv m_{i,h,t} - m_{i,l,t}$) in our first stage regression, which can be written as:

$$\begin{aligned} \delta_{i,t} =& a_0 + a_1\hat{\delta}_{i,t} + a_2 \ln(H_{i,t}) + \sum_{k=2,3,4} a_3^k I_i^k \\ &+ \sum_{k=2,3,4} a_4^k \hat{\delta}_{i,t} \times I_i^k + X_{i,t}^{'} b + \Phi_t + \epsilon_{i,t}, \end{aligned} \tag{1.18}$$

where we combine the external instruments and the set of controls used in the second stage regression.

The first stage estimates in Table A.2 show that the predicted emigration rate differential ($\hat{m}_{i,h,t} - \hat{m}_{i,l,t}$) is a very good predictor of $m_{i,h,t} - m_{i,l,t}$. The coefficient of the external instrument is close to one. The interactions between country income group dummies and the external instrument are weakly significant. The R^2 of the first-stage regression is in the range of 0.7 to 0.8. Regarding the internal instrument, $\delta_{i,t}$ is significantly correlated with the lagged level of human capital and with the time dummy. The remaining internal instruments are insignificant.

1.A.4 IV estimates: Short-Run Elasticity

The results of the IV regressions are presented in the last four columns of Table 1.2 in the core of the text, in which Cols. (5) and (6) restrict the sample to developing countries only, whilst Cols. (7) and (8) provide the results for the full sample.

Table A.2: First-stage regression (instrumenting $\delta_{i,t}$ in 1990 and 2000)

	(1)	(2)	(3)	(4)	(5)	(6)
	Developing Countries			All		
ln $(H_{i,t})$	0.050***	0.047***	0.041***	0.050***	0.047***	0.042***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\hat{\delta_{it}}$	0.946***	0.964***	1.074***	0.962***	0.981***	1.098***
	(0.14)	(0.12)	(0.06)	(0.14)	(0.12)	(0.06)
Lower-Middle	0.003	0.003	0.012	0.008	0.009	0.018
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
Upper-Middle	-0.026	-0.020	-0.008	-0.021	-0.015	-0.004
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
High-Income				-0.038	-0.034	-0.014
				(0.03)	(0.03)	(0.02)
Lower-Mid × $\hat{\delta_{it}}$	-0.106	-0.111	-0.175*	-0.126	-0.133	-0.200*
	(0.16)	(0.14)	(0.10)	(0.16)	(0.14)	(0.10)
Upper-Mid × $\hat{\delta_{it}}$	0.058	0.044	-0.104	0.070	0.060	-0.102
	(0.16)	(0.15)	(0.09)	(0.16)	(0.15)	(0.10)
High-Inc × $\hat{\delta_{it}}$				0.109	0.082	-0.046
				(0.17)	(0.16)	(0.12)
Pop. density	0.000	0.000*	0.000*	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2010 Dummy	-0.063***	-0.060***	-0.060***	-0.055***	-0.052***	-0.052***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outliers		-0.046			-0.041	
		(0.04)			(0.04)	
Obs	256	256	237	340	340	321
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.721	0.729	0.803	0.753	0.758	0.813

Note: Robust standard errors in parentheses. Standard error are clustered at country level. Significant coefficients are denoted with stars as follows: *** p<0.01, ** p<0.05, and * p<0.1.

The short-run semi-elasticity of human capital formation to selective emigration prospects ranges between 3.1 and 3.5. Compared with the OLS estimates, it is inflated by about 20 percent. Similar relative changes are found for the coefficients of interaction with income group dummies. These results confirm that selective emigration prospects are likely to have a positive impact on human capital formation in countries belonging to the lower end of the income per capita distribution, with a short-run elasticity varying between 1.2 and 1.3 in lower-middle and low-income countries. Hence, a 10 percentage point increase in the emigration differential translates into a 12-13 percent increase in the stock of human capital over ten years. Assuming a poor country with an initial share of college graduates of 5 percent, this selective emigration shock raises the share to 5.5 percent after ten years.

1.B Generalized Approach: Parameterization and Additional Results

In this section, we detail the parameterization of our model. In Section 1.B.1, we first calibrate the dyadic model to exactly match the dyadic size and skill structure of international migration and the observed level of human capital. Then, in Section 1.B.2, we compare the net human capital responses predicted by the empirical approach with those of our generalized approach. Finally, we simulate the human capital response to selective emigration under a conservative variant in Section 1.B.3. In Section 1.B.4, we provide country-level human capital responses to selective emigration for the no-migration simulations obtained with the empirical estimations and the microfounded model, respectively.

1.B.1 Parameterization of the Human Development Block

We parameterize the dyadic model of Section 1.2.2 for 174 countries and for the year 2010.

Migration technology. – We use proxies for skill-specific wages and calibrate migration costs to exactly match the observed structure of the labor force and international migration stocks. We use the same data on dyadic emigration stocks ($M_{ij,s}$) and size of stayers ($N_{ii,s}$) by education level as in Section 1.A. As in Eq. (1.16), we define the native population as $N_{i,s} = \sum_{j \neq i} M_{ij,s} + M_{ii,s}$. Then, Eqs. (1.6) and (1.7) show that dyadic migration stocks, $M_{ij,s}$, depend on the wage differentials between countries ($w_{j,s}/w_{i,s}$) and on migration costs ($c_{ij,s}$).

To produce estimates of the skill-specific wages, we use data on GDP in PPP value from the Maddison project described in Bolt and Van Zanden (2014), and data on the wage ratio between college graduates and less educated workers ($R_i \equiv w_{i,h}/w_{i,l}$) from Hendricks (2004). The data are available for 143 out of the 174 countries in our larger sample. We obtain the GDP in PPP by multiplying the GDP per capita by the population size. For missing observations, we use rescaled GDP data from the *World Development Indicators* (WDI) provided by the World Bank.[34] Assuming that total labor income (W_i) is equal to 2/3 of the GDP, we have $W_i = L_{i,h}w_{i,h} + L_{i,l}w_{i,l} = w_{i,l}(L_{i,h}R_i + L_{i,l})$. We identify $w_{i,l}$ from this equation and use $w_{i,h} = w_{i,l}R_i$ for the high-skilled wage.

Migration costs ($c_{ij,s}$) are calibrated as a residual from Eq. (1.6), assuming an elasticity

[34] The data are rescaled in a way that matches the GDP in the United States. This is done by dividing the GDP obtained from the Maddison project by the GDP obtained from the WDI for the United States. The GDP from the WDI is then multiplied by this quotient for the missing observations in order to obtain comparable GDP measures.

of bilateral migration to the wage ratio, $1/\mu$, where μ is set to 0.7 (in line with Bertoli et al. (2013)). Alternative values for $1/\mu$ are considered in the robustness analysis (see Figure A.5). As a validation exercise, we show below that the calibrated levels of migration costs are positively correlated with distance and negatively correlated with colonial links, common language and migrant stocks in the 1990s. Furthermore, in an earlier version of this paper deuster2018unesco, we assessed the ability of our model to replicate past emigration rates (i.e., to predict the skill structure of emigrant stocks by education level in 1990 and 2000). The correlation between actual and predicted stocks equals 0.907 for college graduates and 0.905 for the less educated in 2000, and 0.766 and 0.803 in 1990. Not surprisingly, the correlation decreases as we move further away from 2010. This is because we do not control for past changes in migration policies (e.g., the Schengen Agreement in the European Union, changes in the H1B visa policy in the U.S., etc.), for conflicts, etc. Nevertheless, the large correlations provide evidence that our model does a good job of explaining migration patterns.

Calibration of Migration Costs: Validation. – The calibrated migration costs $c_{ij,s}$ capture differences in amenities and other residual factors that are not explicitly controlled for in the utility term of our model. Thus, their values should therefore not be over-interpreted. Nevertheless, an analysis of the correlation between the calibrated level of the migration costs and control variables that have been identified as determinants of the size of migration flows and stocks in the literature allows us to verify whether the between-corridor variation appears to be empirically valid. Therefore, we regress the values of our calibrated migration costs, $c_{ij,s}$, on origin - and destination country fixed effects as well as bilateral control variables, including: a binary indicator for a shared colonial link, a shared common language, log of the distance between countries and the log of bilateral migrant stocks in 1990. Migration costs are expected to be positively correlated with distance and negatively correlated with colonial ties, common language and migrant stocks in the 1990s.

We also include three different proxies for migration policies. The first is provided by DEMIG (2015) visa data, which constructs an indicator for entry visa requirements based on data reported in the Travel Information Manuals published by the International Air Transport Association (IATA). The indicator is equal to 1 in case a destination country j requires nationals from origin i to hold a visa to enter the country. We calculate the average intensity of the requirement for each corridor as the long-un average over the period for which data are available, going from 1973 to 2010.[35] Although this variable is only a proxy, it is fair to assume that countries with stricter migration laws may also impose more restrictive conditions on

[35] We tried alternative definitions, such as using the year 2009 instead of an average value, or using the average over the period 2000 and 2010. The results are robust and available upon request.

travelers' entrance. A visa requirement for travelers can be seen as a first tool for destination countries to control (legal) entries into the country. Thus, we expect the visa indicator to be positively correlated with our calibrated migration cost, $c_{ij,s}$. The second indicator that we rely on is a binary variable with value of 1 if a guest worker program was in place at destination country j for origin country i. We expect that bilateral migration corridors with a history of guest-worker programs will, on average, have lower migration costs. The third indicator takes into account the skill selectivity of immigrant stocks in the destination country in the previous decade. For each $i - j$ dyad, we construct the share of high-skilled emigrants in destination j excluding immigrants from i.

Table A.1 confirms that migration costs are on average lower for high-skilled migrants (Cols. (1) to (3)) compared to low-skilled migrants (Cols. (4) to (6)), as indicated by the values of the constant terms. For both education groups, migration costs are negatively correlated with shared colonial ties, a shared common language and bilateral migrant stocks in 1990. They are positively correlated with distance, as expected. Regarding the two proxies for visa costs, we find a counterintuitive negative correlation with the long-run average visa requirement, which is significant for the low-skilled only (at the 5% level). This result can be explained by several factors. First, the requirement of a visa at entry is at best an imperfect measure of actual visa restrictions. In fact, it only specifies a particular type of legal requirement that a visitor from a particular country of origin must meet in order to legally enter a particular country of destination. It does not say anything about other aspects, such as the length of stay allowed or whether individuals can look for a job. Second, visa policies are endogenous and evolve as migrant flows and desired levels of migration change in destination countries. Destinations that were particularly attractive in the past might have opted for stricter visa policies in order to control/limit the immigration flows, leading to a positive correlation between high immigrant stocks (translated into low migration costs in our calibration strategy) and increased visa restrictions. Thus, problems of reverse causality and collinearity may arise in our regressions.

As expected, the indicator for the existence of guest worker programs in the 1990s is negatively correlated with migration costs, although not significantly. However, this indicator suffers from the fact that most guest worker programs occurred in the 1960s and 1970s and only a few persisted thereafter. In addition, the problems of reverse causality and collinearity that affect the visa requirements are also likely to impact guest worker programs. Finally, Cols. (3) and (6) show that migration costs for both skills are negatively correlated to the observed skill selection in destination countries (although the coefficient is only weakly significant for the high skilled). Again, reverse causality could explain the counterintuitive negative correlation as it is likely that the most attractive destinations (characterized by high migrant stocks and hence relatively lower migration costs) tend to implement selective policies.

Table A.1: Validating the calibrated migration costs

	c_{ijh}			c_{ijl}		
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	0.00606***	0.00605***	0.00589***	0.00072***	0.00072***	0.00066***
	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)
Common language	-0.01918***	-0.01947***	-0.01971***	-0.00107***	-0.00112***	-0.00121***
	(0.004)	(0.004)	(0.004)	(0.000)	(0.000)	(0.000)
Colonial link	-0.02524**	-0.02555**	-0.02513**	-0.00211**	-0.00216**	-0.00201**
	(0.012)	(0.012)	(0.012)	(0.001)	(0.001)	(0.001)
Network 20 years ago (log)	-0.00225***	-0.00221***	-0.00213***	-0.00019***	-0.00019***	-0.00016***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Visa requirements		-0.00487	-0.00468		-0.00071**	-0.00064**
		(0.003)	(0.003)		(0.000)	(0.000)
Guestwork prog. 90s		-0.00552	-0.00536		-0.00063	-0.00057
		(0.008)	(0.008)		(0.001)	(0.001)
Skill selection index 10 years ago (log)			-0.09467*			-0.03400***
			(0.052)			(0.010)
Constant	0.95639***	0.95994***	0.82185***	0.99452***	0.99498***	0.94538***
	(0.017)	(0.016)	(0.081)	(0.002)	(0.002)	(0.015)
Observations	5,882	5,879	5,879	5,882	5,879	5,879
Adj. R-squared	0.115	0.116	0.116	0.111	0.113	0.134
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes

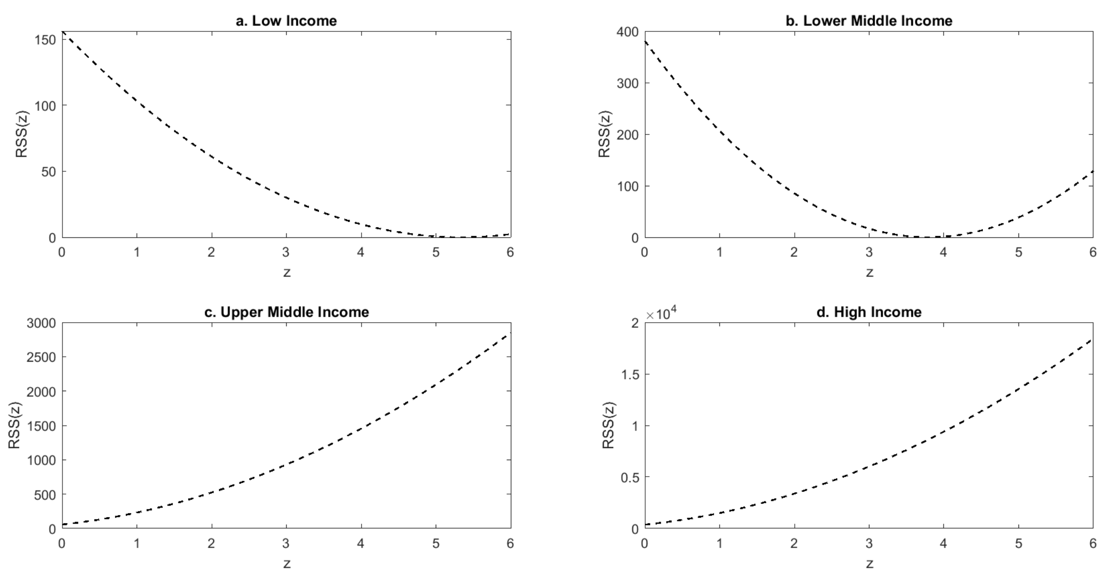
Notes: Robust standard errors in parentheses are robust to heteroskedasticity. ***, **, and * denote significance at the 1%, 5% and 10% level respectively..

Training technology. – Turning to the parameterization of the human capital technology, we use the skill-specific wage proxies and the level of dyadic migration costs to calibrate Λ_i from Eq. (1.4). Then, Eq. (1.5) shows that the ex-ante share of college graduates (H_i) depends on two unknown parameters, namely z which governs the sensitivity of education decisions to the expected return on higher education, and G_i which governs access to education in the country of origin. We calibrate these two parameters iteratively, assuming that z depends on the level of development (in line with our empirical results of Appendix 1.A), and that G_i is country-specific.

We arbitrarily assign alternative values to z (e.g. 0, 0.1, 0.2, 0.3, etc.) and, for each z, we calibrate the scale variable G_i to the level that exactly matches H_i as a residual from Eq. (1.5). Let us denote by $G_i(z)$ the scaling factor corresponding to the arbitrary level of z. To identify a level of z that generates realistic human capital responses to migration shocks, we simulate several skill-specific migration shocks and identify the change in H_i. These shocks consist in reducing and increasing migration costs (i.e. $1 - c_{ij,s}$) by 10, 20 and 30 percentage points. For each of these shocks and for each pair of z and $G_i(z)$, we compute the changes in emigration rates ($\Delta m_{i,s}$), and the human capital responses expressed in log variations ($\Delta \ln H_i$). In line with our empirical model depicted in Eq. (1.1), we then regress $\Delta \ln H_i$ on the corresponding changes in the emigration rate differential, $\delta_{i,t} \equiv m_{i,h} - m_{i,l}$, using the same sample of countries as in the empirical section (see Appendix 1.A). Finally, we choose the level of z that minimizes the residual sum of squares (RSS) obtained as the sum of the quadratic differences between the estimated $\gamma^k_{2,v}(z)$ at each potential value of z and the long-run semi-elasticity obtained in Appendix 1.A (i.e. γ^k_2), and hence $RSS_k = 1/n \sum_{v=1}^{V} (\gamma^k_{2,v} - \gamma^k_{2,LR})^2$.

As shown in Figure A.1, we find that $z^*_{LOW} = 5.3$, $z^*_{LMI} = 3.8$ and $z^*_{UMI} = z^*_{HIC} = 0$ are the most relevant values respectively for low-income (LOW), lower-middle (LMI), upper-middle (UMI), and high-income countries (HIC), respectively. These values of z^* are consistent with the long-run semi-elasticities of human capital to the emigration differential estimated in our empirical model, and exactly match the observed share of college graduates in the native population of 2010. Since z is a proxy for talent scarcity or low access to education, it is reassuring that it declines with the level of development.

Figure A.1: Calibration of z by income group



Note: Each panel depicts, for a specific country income group, the residual sum of squares (RSS) on the vertical axis for a given value of z on the horizontal axis. For each country income group, we chose the level z^* that minimizes the RSS.

Calibration of Training Technology: Validation. – The choice of z^* determines the calibration of the proxy for education policy, $G_i(z^*)$. The mean and standard error of $G_i(z^*)$ equal 0.710 and 0.528, respectively. To validate the calibration strategy, we regress $G_i(z^*)$ (in logs) on empirical proxies for access to education in the country of origin. We use the level of public education spending as a percentage of GDP, the log of the urbanization rate, the log of GDP per capita, and interactions between education spending and income group dummies. The first column of Table A.2 shows that $G_i(z^*)$ is positively correlated with the log of public education expenditure and urbanization, and negatively correlated with GDP per capita. Adding interaction terms in Col. (2), the correlations with public education expenditure and urbanization increase and become more significant. The highest correlation with public expenditure on education is found in high-income countries, where the average distance to schools is low. In developing countries, access to education is also determined by geographic factors and thus the urbanization rate is a key determinant of access to education.

Table A.2: Calibration of $\ln G_i$ (access to education) – Validation

	(1) $\ln G_i$	(2) $\ln G_i$
log Public expenditure (as % of GDP)	0.279*	0.240**
	(0.15)	(0.09)
log Urbanization rate (as % of population)	0.271**	0.445***
	(0.12)	(0.08)
log GDP per capita	-0.133**	–
	(0.06)	–
Lower-middle × Public exp. (as % of GDP)	–	-0.231*
	–	(0.13)
Upper-middle × Public exp. (as % of GDP)	–	-0.451*
	–	(0.25)
High-income × Public exp. (as % of GDP)	–	1.041***
	–	(0.37)
Constant	1.688*	1.091***
	(0.87)	(0.37)
Obs	162	162
Income-group dummies	No	Yes
R^2	0.049	0.558

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

1.B.2 Net Human Capital Response: Comparison with the Empirical Approach

Consistent with the generalized approach of Section 1.2, the results of the empirical model can also be used to quantify the effect of selective emigration on human capital accumulation in the country of origin. Human capital is proxied by the share of college graduates in the resident population, which is related to emigration rates, pre-migration human capital levels, and immigration through the following relationship:

$$h_{i,t} \equiv \frac{(1-m_{i,h,t})H_{i,t}N_{i,t} + I_{i,h,t}}{(1-m_{i,h,t})H_{i,t}N_{i,t} + I_{i,h,t} + (1-m_{i,l,t})(1-H_{i,t})N_{i,t} + I_{i,l,t}}, \tag{1.19}$$

where $N_{i,t}$ denotes the total native population in year t, and $I_{i,s,t}$ is the population of immigrants of type s. These two variables are assumed to be exogenous.

Using the estimated semi-elasticity of human capital formation to emigration, we can simulate the counterfactual proportions of educated natives and residents that would be observed in a no-migration counterfactual scenario (i.e., when $m_{i,h,t} = m_{i,l,t} = 0$), as if no natives had left their home country.[36] Compared with the observed level ($H_{i,t}$), the counterfactual proportion of educated natives ($H_{i,t}^{NM}$) varies when migration rates are set equal to zero. Focusing on the short-run human capital response in country i belonging to the income group k, we have:

$$\ln H_{i,t}^{NM} = \ln H_{i,t} - \left(\gamma_2 + \gamma_4^k D_i^k\right)(m_{i,h,t} - m_{i,l,t}),$$

while the long-term human capital response to selective emigration is given by:

$$\ln H_{i,t}^{NM} = \ln H_{i,t} - \frac{\left(\gamma_2 + \gamma_4^k D_i^k\right)}{-\gamma_1}(m_{i,h,t} - m_{i,l,t}).$$

Under the stability condition ($\gamma_1 \in]-1, 0[$), the counterfactual no-migration share of educated natives is smaller (larger) than the observed one when the migration differential is positive (negative) and an incentive effect is present. This is the case for lower-middle and low-income countries, where the incentive effect is significant and positive ($\gamma_2 + \gamma_4^k D_i^k > 0$). The absence of an incentive effect in the upper-middle and high-income countries implies that $H_{i,t}^{NM} = H_{i,t}$. Then, from Eq. (1.19), we have

$$h_{i,t}^{NM} \equiv \frac{H_{i,t}^{NM} N_{i,t} + I_{i,h,t}}{N_{i,t} + I_{i,h,t} + I_{i,l,t}} \tag{1.20}$$

in the no-migration scenario.

For the 174 countries included in our sample, we simulate the counterfactual proportions of college graduates obtained in the no-migration scenario, and define the human capital response to selective emigration as the difference between the observed and counterfactual proportions of college graduates in the labor force: $\Delta h_{i,t} \equiv h_{i,t} - h_{i,t}^{NM}$. The results are shown in Figure A.2. The three figures in the left-hand panel show the effects observed within a decade (when $H_{i,t}^{NM}$ is computed using short-term semi-elasticities), while figures in the right-hand panel depict the long-term human capital responses (using long-term semi-elasticities).

[36] Since we are interested in determining the effect of emigration on human capital accumulation, we assume that the stock of immigrants ($I_{i,s,t}$) remains unchanged. In our calculations, immigrants are assimilated to natives. We relax this assumption in the last section of the paper.

Panels (a) and (b) show the variation in human capital ($\Delta h_{i,t}$ on the vertical axis) as a function of the no-migration level of human capital ($h_{i,t}^{NM}$ on the horizontal axis). Selective emigration induces a short-run increase in human capital in 78 countries, and a short-run decrease in 96 countries (compared with 101 winners and 73 losers when using the microfounded approach in Figure A.3). Using the long-run semi-elasticity level, a gain is obtained in exactly half of the sample (i.e. 87 out of 174 countries, compared to 128 winners and 46 losers when using the microfounded approach). Compared to the microfounded approach depicted in Figure 1.1, the gains are smaller and the losses are larger. A negative effect is found in upper-middle and high-income countries where the emigration differential is positive. The emigration differential is negative (i.e., emigrants are negatively selected) in only ten countries (Bolivia, Bulgaria, Finland, Georgia, Ireland, Kazakhstan, Lithuania, Mexico, Macedonia, and Portugal).

Panels (c) and (d) compare the predictions of the cross-country and microfounded approaches under both scenarios. We find *three major differences*. First, the microfounded approach predicts a positive effect in some upper-middle and high-income countries, while the empirical approach predicts a loss of human capital, at least when the emigration differential is positive. Second, a few upper-middle and high-income countries that benefited from negative emigration differentials in the empirical setting suffer from reduced incentives to acquire human capital under the microfounded approach. This is the case for Finland, Georgia, Ireland, Kazakhstan, Lithuania, and Mexico. Third, small states lose less or gain more in the microfounded framework.

Panels (e) and (f) compare the kernel density of the migration-driven change in human capital under the two approaches. While the density is left-skewed under the empirical approach, it is nearly symmetric under the microfounded approach.

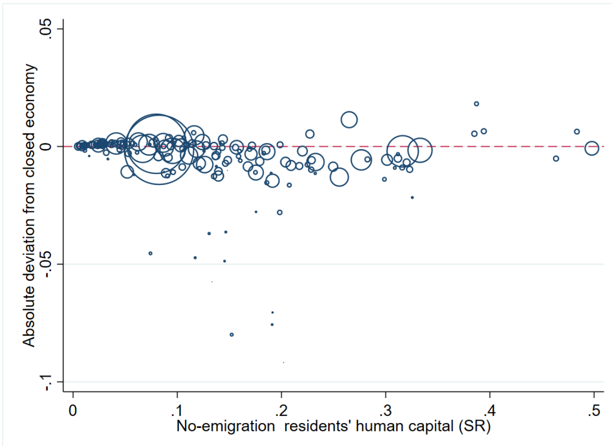
1.B.3 Effect on Human Capital under a Conservative Variant

In the main text (Section 1.2.3), the parameterization of the model uses the long-term effect of selective emigration on human capital accumulation (see section 1.2.3) and intermediate elasticity values from the existing literature. Here, we consider a conservative parameter set based on the short-term human capital response to emigration discussed in Section 1.A.4.

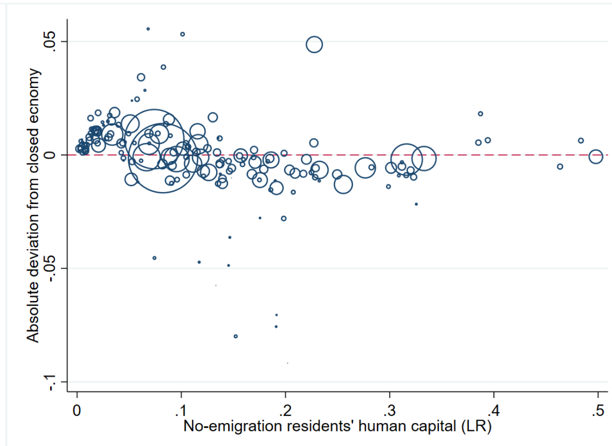
In the conservative variant, Panel (a) of Figure A.3 shows that selective emigration increases human capital in 101 countries (58% of our sample), and decreases it in 73 countries. The short-run gain is greater than one percentage point (p.p.) in 23 countries. These include small upper-middle and high-income countries where the emigration differential is limited

Figure A.2: Effect of selective emigration on human capital accumulation (h_i)
Insights from the empirical model

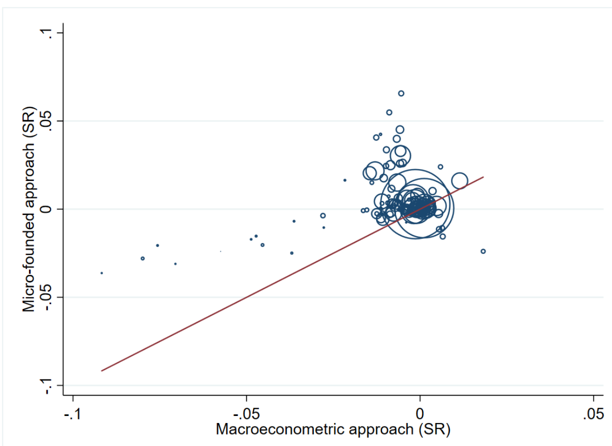
(**a**) Short-term (SR) effect (Δh_i)



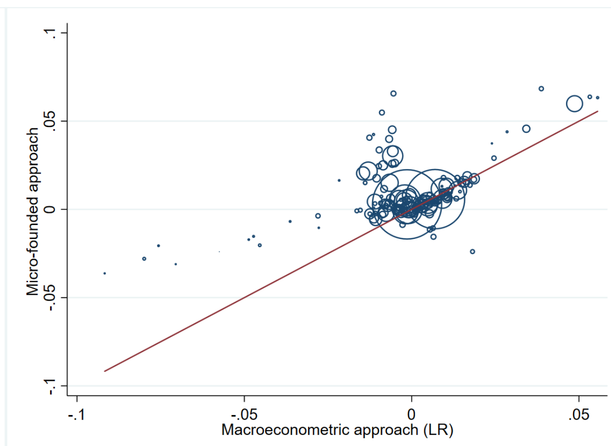
(**b**) Long-term (LR) effect (Δh_i)



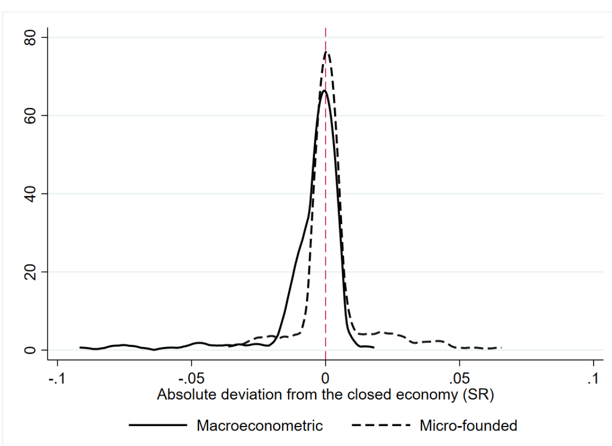
(**c**) Generalized vs. Empirical (Δh_i in SR)



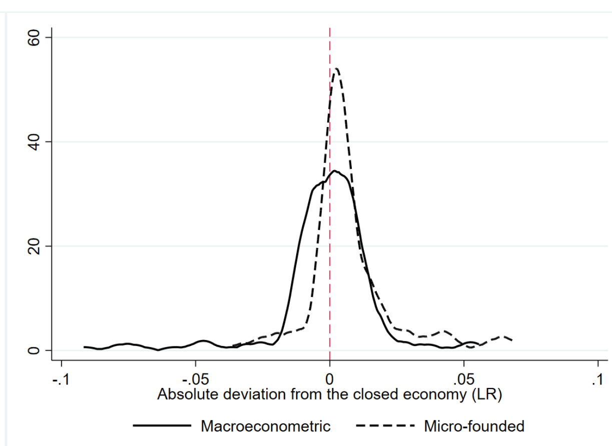
(**d**) Generalized vs. Empirical (Δh_i in LR)



(**e**) Density of Δh_i (SR)



(**f**) Density of Δh_i (LR)



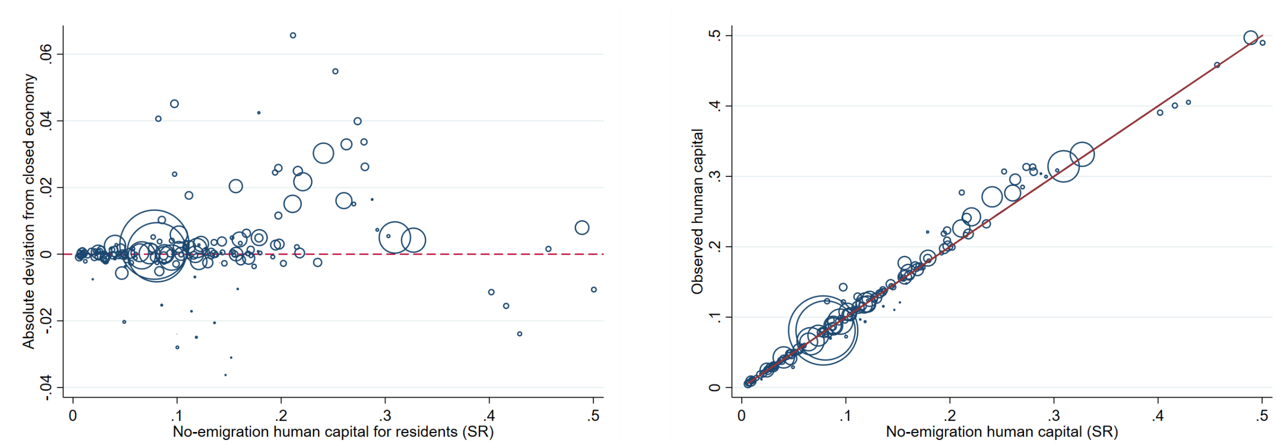
Note: Panels (a) and (b) compare the variation in resident human capital, Δh_i, (i.e. the difference between the observed proportion of college graduates, h_i, and the no-migration proportion, h_i^{NM}) as a function of the no-migration counterfactual human capital level (h_i^{NM}). Panels (c) and (d) compare the variation in resident human capital, Δh_i, obtained with the cross-country empirical approach (X-axis, labeled as "Macroeconometric approach") and with the structural approach (Y-axis, labeled as "microfounded approach"). Panels (e) and (f) compare the density of Δh_i obtained with the two approaches. Panels (a), (c), and (e) present the results obtained with the short-term (SR) elasticity, $\gamma_2 + \gamma_4^k D_i^k$. Panels (b), (d), and (f) present the results obtained with the long-term (LR) elasticity $(\gamma_2 + \gamma_4^k D_i^k)/(-\gamma_1)$.

(Norway, New Zealand, Czech Republic, Luxembourg, Israel, etc.). A gain is observed in 44 lower-middle and low-income countries, out of 58 in our sample. The short-run loss is greater than 1 p.p. in 14 countries. These include Guyana, a lower-middle-income country characterized by a high degree of positive selection, and 13 upper-middle and high-income countries where the emigration differential is either negative (e.g. Georgia, Finland, Ireland, Lithuania) or positive and very large (Grenada, Trinidad and Tobago, Tonga, Barbados, Mauritius, etc.). The effects are identical to those of the benchmark scenario in upper-middle and high-income countries, and are entirely driven by the change in population structure – since the same uniform distribution of ability ($z^*_{UMI} = z^*_{HIC} = 0$) is assumed in both scenarios.

In Panel (b) of Figure A.3, we compare the observed and counterfactual levels of human capital. All the observations are close to the 45-degree line, suggesting that the human capital responses to selective emigration are rather limited in the short run.

Figure A.3: Effect of selective emigration on human capital accumulation (h_i)
Generalized approach with conservative parameter set

(**a**) Short-term (SR) effect (Δh_i) (**b**) Observed vs. no-migration (SR)



Note: Panel (a) compares the variation Δh_i (i.e. the difference between the observed proportion of college graduates (h_i) and the no-migration proportion (h_i^{NM})) as a function of the no-migration counterfactual level (h_i^{NM}). Panels (b) compares the observed proportion of college graduates h_i with the no-migration proportion h_i^{NM}. Results are obtained with the conservative scenario. Each circle represents a country, and its size represents the size of the labor force.

1.B.4 Quantitative Results by Country

Tables A.3, A.4 and A.5 provide country-level human capital responses to selective emigration for the no-migration simulations obtained with the empirical estimations and the micro-founded model respectively. Results are shown for the benchmark and conservative scenarios. Tables A.6, A.7 and A.8 detail the welfare implications at the country-level. They show the country-level change in net income for the benchmark and conservative scenarios. In addition, they disentangle the relative impact of each externality for the simulations under the benchmark scenario.

1.C Development Accounting: Parameterization and Additional Results

In this section, we provide additional estimates of the effect of skill-biased emigration prospects on disposable income per worker. We explain the parameterization of the development accounting framework and its extensions in Section 1.C.1. In Section 1.C.2, we first use a conservative parameter set, where we consider the short-term human capital response to emigration and double or halve the elasticity levels to produce smaller income gains or larger income losses. Neutralizing the size of the emigrant stock, we isolate the effect of positive selection on income per worker in Section 1.C.3. Finally, we examine the robustness of our results to two key elasticities in Section 1.C.4.

1.C.1 Parameterization of the Economic Block

We calibrate the general equilibrium model to exactly match the world income distribution, and the estimated elasticities from the existing empirical literature. The calibration of technological externalities requires selecting three common elasticities $(\sigma, \epsilon, \kappa)$ and two country-specific parameters $(\overline{\Gamma}_i, \overline{A}_i)$. The common elasticities are taken from the empirical literature, while the country-specific parameters are calibrated to match two moments for the year 2010, namely the observed level of GDP per worker and the wage ratio between college graduates and the less educated.

The CES technology determines the aggregate real output/income level in country i:[37]

$$Y_i = \frac{A_i}{P_i}\left[\frac{\Gamma_i}{1+\Gamma_i}L_{i,h}^{\frac{\sigma-1}{\sigma}} + \frac{1}{1+\Gamma_i}L_{i,l}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{1.21}$$

where $L_{i,s}$ denotes the number of workers of type s (such that $L_i = L_{i,h} + L_{i,l}$).

The aggregate externality in Eq. (1.11) formalizes a simple Lucas-type effect of human capital on TFP [see][]lucas1988jme; it assumes that the scale of the TFP is a concave function of the skill ratio in the resident labor force with an elasticity ϵ, while $\overline{\overline{A}}_i$ is a scale factor. The skill-biased technical change in Eq. (1.12) affects the relative productivity of high-skilled workers with an elasticity κ, while $\overline{\Gamma}_i$ is a residual scale factor [see][]Acemoglu2002jel, restuc-

[37] We choose the CES production function because it allows to account for imperfect substitution between low and highly-educated workers. It is quite standard in development accounting settings [see e.g.,][]jones2014human as well as in the literature analyzing the effects of migration [see e.g.,][]ottaviano2012rethinking. In Appendix 1.C.4, we show that results are robust to an alternative value of the elasticity of substitution between the two types of worker skills, σ.

cia2013evolution, autor2003skill. As the supply of highly skilled labor increases, the relative labor demand for non-routine tasks increases at the expense of the demand for routine and manual tasks. The observed relative shift in demand favors highly educated workers over their less educated counterparts.[38]

We first calibrate (Γ_i, A_i) to match two country-specific moments, the ratio of wage rates $(w_{i,h}/w_{i,l})$ and nominal income per worker (y_i). An analytical expression for the ratio of wage rates can be obtained by assuming that firms maximize profits and the labor market is competitive. The equilibrium wage rate for workers of type-s in country i is equal to their marginal productivity of labor. The nominal wage rates of college graduates and less educated workers are given by:

$$w_{i,h} = A_i \frac{\Gamma_i}{1+\Gamma_i} \left(\frac{Q(\Gamma_i, h_i)}{L_{i,h}} \right)^{1/\sigma}, \tag{1.22}$$

$$w_{i,l} = A_i \frac{1}{1+\Gamma_i} \left(\frac{Q(\Gamma_i, h_i)}{L_{i,l}} \right)^{1/\sigma}. \tag{1.23}$$

This implies that the ratio of wage rates is given by:

$$\frac{w_{i,h}}{w_{i,l}} = \Gamma_i \left(\frac{L_{i,h}}{L_{i,l}} \right)^{-1/\sigma} = \Gamma_i \left(\frac{h_i}{1-h_i} \right)^{-1/\sigma}. \tag{1.24}$$

Data on the wage ratios are obtained from Hendricks (2004). Data on income per worker are obtained by dividing nominal per capita income in PPP terms (values from Bolt et al. (2018)) by the share of the working age population in the total population, obtained from the World Development Indicators. In the labor market literature [e.g.,][]ottaviano2012rethinking, angrist1995aer, the elasticity of substitution between skill groups varies between 1.3 and 3. We assume $\sigma = 2$ and we use the share of college graduates in the labor force (h_i) as defined in the previous section.[39] Assuming a competitive labor market, the ratio of wage rates is given by the ratio of marginal productivities. In practice, we use Eq. (1.24) and calibrate Γ_i to match the average wage ratio. When Γ_i is known, we compute $Q(\Gamma_i, h_i)$.

An additional contribution of human capital to productivity can be obtained by assuming positive technological externalities. Recent studies show that college-educated workers are instrumental in supporting democratization [e.g.,][]castello2013mass, bobba2007el,

---

[38] When comparing low-, middle-, and high-income countries, skill-biased technical change also captures the transition from agriculture to non-agriculture, or from the traditional to the modern sector [see][]ciccone2009restat, vollrath2009jde, gollin2014qje.

[39] In a robustness check, we show that $\sigma = 1.5$ does not affect our results; see Figure A.5.

murtin2014joeg, docquier2016emigration, and in facilitating innovation and technology diffusion when knowledge becomes economically useful [e.g.,][]benhabib1994jme, caselli2006aer, ciccone2009restat.

We consider two education-related externalities: an aggregate productivity externality and directed technical change:

$$A_i = \overline{\overline{A}}_i \left(\frac{h_i}{1-h_i}\right)^{\epsilon}, \tag{1.25}$$

$$\Gamma_i = \overline{\Gamma}_i \left(\frac{h_i}{1-h_i}\right)^{\kappa}. \tag{1.26}$$

We assume the elasticity of directed technical change with respect to the ratio of skilled-to-unskilled workers, $\kappa = 0.10$, in line with Burzyński et al. (2020). The scaling parameter $\overline{\Gamma}_i$ is such that the skill bias in the current state of the world matches the observed ratio of wages in 2010. To calibrate the elasticity of TFP with respect to the skill ratio in the resident labor force, ϵ, Caselli and Ciccone (2013) argue that for an average poor country, raising college attainment to the level of the U.S. (a share of college graduates equal to 0.31 in 2010) would induce a 30% increase in TFP. The average human capital of low-income countries in 2010 was equal to 0.075. This implies that $\epsilon = 0.10$.

With regard to diaspora externalities, we assume that the TFP is affected by the average proportion of migrants abroad. To calibrate the size of the diaspora externality, we combine two strands of literature. The first one has identified a causal impact of migration on trade and FDI, with elasticities of 0.1 and 0.2, respectively [e.g.,][]iranzo2009jie, felbermayr2010aes, parsons2018ej, kugler2007el, javorcik2011jde. The other strand of literature has identified a causal effect of trade and FDI on TFP, with elasticities of 0.3 and 0.01, respectively [see][]larch2017wp, feyrer2019aej. Combining these findings yields a conservative elasticity of total factor productivity to emigration of approximately 0.032. In Eq. (1.13), we also assume that $\overline{m} = 0.10$ as a benchmark. The scaling parameter $\overline{A}_i$ is calibrated as a residual from Eq. (1.13) and is such that the TFP level in the current state of the world allows us to match the observed level of income per worker in 2010.

In a monopolistic competition context, the aggregate demand determines the entry and exit decisions of firms, and thus the number of entrepreneurs and the amount of goods available to consumers. Market size and country size are uncorrelated in a world of perfect free trade. In practice, trade is costly and the magnitude of the market size effect depends on both country size and trade openness. As far as the market size externality is concerned, we assume $\lambda = 8.0$ as a benchmark value, which implies that the model predicts conservative market size effects feenstra1994aer. The scale parameter $\overline{P}_i$ is such that the price index in the current state of the world equals unity. Under the conservative scenario, the market size externality is halved ($\lambda = 4.0$), implying that an emigration-related decrease in market size has a greater impact on the ideal price index.

Regarding the elasticity of government consumption with respect to population size, we assume that $\eta = 0.056$, in line with Alesina and Wacziarg (1998) who suggest that a 10% decrease in the population leads to a 0.56% increase in public consumption per capita. In addition, public consumption (x_i) is country-specific and proxied by the ratio of government consumption to the GDP from the World Development Indicators. Furthermore, the average education cost per worker (c_i) is calibrated to match the skill-specific education cost per student from the UNESCO Institute of Statistics and education expenditure as a percentage of GDP from the World Development Indicators. Assuming a balanced budget, the baseline income tax rate (τ_i) is obtained, as a sum of the two components: government consumption (x_i) and education expenditure (v_i). Under the conservative scenario, the market size externality is doubled ($\eta = 0.112$), which means that a 10% decrease in population leads to a 1.12% increase in government consumption per capita.

1.C.2 Effect on Income under the Conservative Variant

In the main text, the parameterization of the model uses the long-term effect of selective emigration on human capital accumulation (see Section 1.2.3) and intermediate elasticity values from the existing literature. In this section, the *development accounting* block is used to estimate the relative variations in disposable income per worker due to selective emigration, $(y_i - y_i^{NM})/y_i^{NM}$, for each country under a conservative variant. The conservative parameter set is based on the short-term human capital response to emigration (as in Section 1.B.3), and we double or halve the elasticity levels to generate smaller income gains or larger income losses. Table A.1 compares the consensus parameter values used in the benchmark simulations with the conservative values.

Figure A.1 presents the results obtained under the conservative scenario. This scenario considers the human capital effect of moving from the current state of the world to a no-migration scenario in only ten years, together with a parameter set that minimizes the income gains and/or maximizes the income losses due to emigration and changes in education. Panel (a) shows that the density of the net impact of emigration is right-skewed. The unweighted average income response to selective emigration equals 3.6 percent, somewhate mitigated relative to the benchmark scenario (+5.7 percent).

We identify 151 winners and only 23 losers. The losses are in the same order of magnitude as in the benchmark scenario and exceed 5 percent in seven small island states with large emigration differentials: Barbados (-5.7%), Sao Tome and Principe (-7.2%), Mauritius (-8.1%), Saint Vincent and the Grenadines (-8.4%), Trinidad and Tobago (-9.3%), Grenada (-9.6%), and Suriname (-12.0%). By contrast, the gains are lower than in the benchmark scenario. They exceed 15 percent in eleven countries: Lebanon (32.2%), Comoros (29.9%), Madagascar (25.8%), Tajikistan (21.8%), Haiti (21.0%), Slovenia (21.0%), Lesotho (18.8%), Jamaica (17.0%), Serbia and Montenegro (16.4%), and Zimbabwe (15.0%).[40]

Unsurprisingly, Panel (b) shows that the magnitude of neo-classical effects and, to a lesser extent, of schooling externalities is mitigated relative to the benchmark scenario.

Panel (c) compares the income response to emigration with the no-migration counterfactual income level (in logs). The negative slope implies that the income response is larger in poor countries (around +5 percent in the least developed countries) than in countries at the top end of the distribution (around +1 percent). The convergence forces is weaker than in the benchmark scenario: the absolute value of the slope of the fitted curve – driven by selective emigration – is half as large as in the benchmark case.

The effect on income per natural, which is mostly governed by emigrants' income gains (i.e. income disparities between countries), is less dependent on parameter values. Panel (d) shows that the distribution of income per natural is comparable to the one observed for the benchmark scenario in Figure 1.2.

[40] We also find a large gain in Luxembourg (20.2%) but this result rings false. It is driven by a large amount of recorded remittances, which are likely to include financial transfers to individual bank accounts whose owners do not physically reside in the country, thereby inflating the amount of remittances received per worker. In the data, remittances represent more than 10 percent of the average worker's net income, while in reality the flows of migration-related transfers are presumably low.

Table A.3: Human capital response to skill biased emigration (1/3)

	Observation				NM (Econometric approach)				NM (Micro-founded approach)				
					Long run		Short run			Long run		Short run	
ISO	Λ	H	h	$m_h - m_l$	h	Δh	h	Δh	Λ	h	Δh	h	Δh
AFG	3.141	0.083	0.078	0.057	0.069	0.009	0.077	0.002	2.960	0.069	0.009	0.077	0.002
AGO	3.338	0.036	0.030	0.187	0.020	0.010	0.029	0.001	2.699	0.022	0.008	0.030	0.000
ALB	2.601	0.091	0.078	0.108	0.091	-0.012	0.091	-0.012	2.212	0.081	-0.003	0.081	-0.003
ARE	2.085	0.157	0.157	0.002	0.157	0.000	0.157	0.000	2.081	0.157	0.000	0.157	0.000
ARG	1.923	0.121	0.114	0.066	0.121	-0.007	0.121	-0.007	1.795	0.112	0.002	0.112	0.002
ARM	2.443	0.207	0.191	0.094	0.207	-0.016	0.207	-0.016	2.205	0.192	-0.001	0.192	-0.001
AUS	1.213	0.301	0.296	0.026	0.301	-0.006	0.301	-0.006	1.181	0.263	0.033	0.263	0.033
AUT	1.243	0.229	0.223	0.031	0.229	-0.006	0.229	-0.006	1.203	0.197	0.026	0.197	0.026
AZE	2.349	0.136	0.132	0.035	0.136	-0.004	0.136	-0.004	2.266	0.133	0.000	0.133	0.000
BDI	3.736	0.015	0.011	0.218	0.007	0.004	0.011	0.000	2.917	0.007	0.004	0.011	0.001
BEL	1.238	0.312	0.307	0.022	0.312	-0.005	0.312	-0.005	1.209	0.280	0.026	0.280	0.026
BEN	3.581	0.017	0.014	0.181	0.009	0.004	0.013	0.001	2.931	0.011	0.003	0.014	0.000
BFA	3.266	0.010	0.009	0.085	0.008	0.002	0.009	0.000	2.988	0.008	0.001	0.010	0.000
BGD	2.887	0.076	0.074	0.030	0.069	0.005	0.073	0.001	2.801	0.070	0.004	0.074	0.000
BGR	1.271	0.199	0.199	-0.004	0.199	0.001	0.199	0.001	1.278	0.202	-0.003	0.202	-0.003
BHR	2.105	0.183	0.180	0.019	0.183	-0.003	0.183	-0.003	2.065	0.180	0.000	0.180	0.000
BHS	2.919	0.147	0.110	0.256	0.147	-0.036	0.147	-0.036	2.106	0.117	-0.007	0.117	-0.007
BIH	2.586	0.096	0.085	0.102	0.096	-0.011	0.096	-0.011	2.266	0.087	-0.002	0.087	-0.002
BLR	1.632	0.179	0.173	0.041	0.179	-0.006	0.179	-0.006	1.563	0.167	0.006	0.167	0.006
BLZ	3.713	0.145	0.097	0.297	0.145	-0.049	0.145	-0.049	2.337	0.114	-0.017	0.114	-0.017
BOL	1.607	0.142	0.143	-0.008	0.145	-0.003	0.143	0.000	1.621	0.151	-0.009	0.145	-0.003
BRA	3.567	0.095	0.094	0.021	0.095	-0.002	0.095	-0.002	3.493	0.095	-0.001	0.095	-0.001
BRB	3.812	0.191	0.115	0.339	0.191	-0.076	0.191	-0.076	2.106	0.136	-0.021	0.136	-0.021
BRN	2.021	0.137	0.129	0.069	0.137	-0.008	0.137	-0.008	1.879	0.127	0.002	0.127	0.002
BTN	3.077	0.055	0.052	0.052	0.046	0.006	0.051	0.001	2.915	0.048	0.004	0.052	0.000
BWA	3.086	0.044	0.043	0.032	0.044	-0.001	0.044	-0.001	2.988	0.044	-0.001	0.044	-0.001
CAF	3.891	0.013	0.010	0.246	0.006	0.004	0.009	0.000	2.931	0.006	0.004	0.009	0.000
CAN	1.172	0.498	0.497	0.003	0.498	-0.001	0.498	-0.001	1.168	0.489	0.008	0.489	0.008
CHE	1.552	0.217	0.209	0.045	0.217	-0.008	0.217	-0.008	1.478	0.197	0.012	0.197	0.012
CHL	2.033	0.137	0.133	0.032	0.137	-0.004	0.137	-0.004	1.967	0.133	0.001	0.133	0.001
CHN	1.360	0.082	0.081	0.018	0.082	-0.001	0.082	-0.001	1.336	0.078	0.003	0.078	0.003
CIV	3.339	0.042	0.038	0.104	0.030	0.008	0.037	0.001	2.988	0.033	0.005	0.038	0.000
CMR	3.779	0.038	0.030	0.207	0.019	0.011	0.029	0.001	2.988	0.023	0.007	0.031	-0.001
COG	3.147	0.051	0.049	0.050	0.044	0.005	0.048	0.001	2.988	0.046	0.003	0.049	0.000
COL	2.974	0.171	0.168	0.022	0.171	-0.003	0.171	-0.003	2.908	0.169	-0.001	0.169	-0.001
COM	3.838	0.049	0.038	0.202	0.025	0.013	0.037	0.001	2.988	0.025	0.013	0.037	0.002
CPV	4.569	0.049	0.028	0.291	0.019	0.009	0.033	-0.005	2.567	0.015	0.013	0.031	-0.003
CRI	2.048	0.159	0.155	0.030	0.159	-0.004	0.159	-0.004	1.985	0.154	0.001	0.154	0.001
CUB	2.808	0.121	0.096	0.210	0.061	0.034	0.092	0.004	2.152	0.050	0.046	0.085	0.010
CYP	1.825	0.309	0.300	0.036	0.309	-0.009	0.309	-0.009	1.748	0.292	0.007	0.292	0.007
CZE	1.139	0.148	0.143	0.044	0.148	-0.006	0.148	-0.006	1.087	0.097	0.045	0.097	0.045
DEU	1.222	0.277	0.271	0.027	0.277	-0.006	0.277	-0.006	1.188	0.241	0.030	0.241	0.030
DJI	3.432	0.029	0.022	0.231	0.014	0.009	0.021	0.001	2.633	0.015	0.007	0.022	0.000
DNK	1.387	0.228	0.219	0.053	0.228	-0.010	0.228	-0.010	1.311	0.194	0.025	0.194	0.025
DOM	1.823	0.146	0.139	0.049	0.146	-0.007	0.146	-0.007	1.720	0.136	0.004	0.136	0.004
DZA	2.757	0.112	0.104	0.073	0.088	0.016	0.101	0.002	2.544	0.088	0.016	0.102	0.002
ECU	1.916	0.173	0.172	0.006	0.170	0.002	0.172	0.000	1.904	0.167	0.005	0.171	0.001
EGY	2.290	0.130	0.126	0.037	0.116	0.010	0.124	0.002	2.205	0.113	0.013	0.123	0.003
ERI	4.072	0.031	0.022	0.276	0.013	0.010	0.021	0.001	2.916	0.013	0.009	0.021	0.001
ESP	1.379	0.186	0.184	0.014	0.186	-0.002	0.186	-0.002	1.359	0.179	0.005	0.179	0.005
EST	1.547	0.312	0.309	0.014	0.312	-0.003	0.312	-0.003	1.524	0.303	0.005	0.303	0.005
ETH	3.270	0.027	0.025	0.086	0.021	0.004	0.024	0.001	2.988	0.021	0.004	0.024	0.001
FIN	1.520	0.385	0.391	-0.022	0.385	0.005	0.385	0.005	1.555	0.402	-0.011	0.402	-0.011
FJI	4.133	0.191	0.124	0.317	0.068	0.056	0.126	-0.002	2.480	0.060	0.063	0.121	0.003
FRA	1.407	0.233	0.226	0.036	0.233	-0.007	0.233	-0.007	1.355	0.211	0.015	0.211	0.015
FSM	2.698	0.148	0.138	0.058	0.148	-0.010	0.148	-0.010	2.484	0.141	-0.003	0.141	-0.003
GAB	2.795	0.054	0.044	0.187	0.030	0.015	0.042	0.002	2.266	0.028	0.017	0.042	0.003
GBR	1.529	0.256	0.243	0.064	0.256	-0.013	0.256	-0.013	1.426	0.221	0.022	0.221	0.022

Table A.4: Human capital response to skill biased emigration (2/3)

	Observation				NM (Econometric approach)				NM (Micro-founded approach)				
					Long run		Short run			Long run		Short run	
ISO	Λ	H	h	$m_h - m_l$	h	Δh	h	Δh	Λ	h	Δ h	h	Δ h
GEO	1.716	0.483	0.490	-0.024	0.483	0.006	0.483	0.006	1.760	0.500	-0.011	0.500	-0.011
GHA	2.916	0.058	0.048	0.171	0.033	0.015	0.046	0.002	2.408	0.033	0.015	0.046	0.002
GIN	3.344	0.028	0.025	0.105	0.020	0.005	0.024	0.001	2.988	0.020	0.005	0.024	0.001
GMB	3.769	0.050	0.039	0.221	0.024	0.014	0.037	0.001	2.898	0.029	0.010	0.040	-0.001
GNB	4.968	0.018	0.011	0.381	0.005	0.006	0.011	0.000	2.988	0.006	0.005	0.011	0.000
GNQ	3.045	0.056	0.047	0.215	0.058	-0.012	0.058	-0.012	2.489	0.050	-0.004	0.050	-0.004
GRC	1.294	0.185	0.183	0.009	0.185	-0.002	0.185	-0.002	1.281	0.179	0.005	0.179	0.005
GRD	4.795	0.202	0.110	0.303	0.202	-0.092	0.202	-0.092	2.348	0.147	-0.036	0.147	-0.036
GTM	3.522	0.053	0.050	0.053	0.053	-0.003	0.053	-0.003	3.316	0.052	-0.002	0.052	-0.002
GUY	7.049	0.210	0.094	0.361	0.065	0.029	0.131	-0.037	2.744	0.050	0.044	0.119	-0.025
HND	4.231	0.062	0.053	0.138	0.040	0.013	0.052	0.001	3.574	0.047	0.006	0.056	-0.003
HRV	2.285	0.139	0.137	0.016	0.139	-0.002	0.139	-0.002	2.243	0.137	0.000	0.137	0.000
HTI	6.158	0.059	0.029	0.466	0.013	0.016	0.032	-0.003	2.978	0.014	0.016	0.031	-0.002
HUN	1.469	0.139	0.129	0.084	0.139	-0.010	0.139	-0.010	1.342	0.111	0.018	0.111	0.018
IDN	2.694	0.067	0.066	0.015	0.067	-0.001	0.067	-0.001	2.653	0.066	0.000	0.066	0.000
IND	2.787	0.084	0.081	0.039	0.074	0.007	0.080	0.001	2.677	0.075	0.006	0.081	0.001
IRL	1.480	0.394	0.401	-0.022	0.394	0.007	0.394	0.007	1.521	0.416	-0.016	0.416	-0.016
IRN	2.698	0.126	0.119	0.068	0.126	-0.008	0.126	-0.008	2.513	0.121	-0.002	0.121	-0.002
IRQ	2.491	0.154	0.147	0.051	0.130	0.017	0.144	0.003	2.360	0.128	0.019	0.143	0.004
ISL	1.904	0.326	0.304	0.088	0.326	-0.022	0.326	-0.022	1.722	0.287	0.016	0.287	0.016
ISR	1.341	0.323	0.313	0.042	0.323	-0.010	0.323	-0.010	1.282	0.280	0.034	0.280	0.034
ITA	1.458	0.111	0.108	0.037	0.111	-0.004	0.111	-0.004	1.402	0.102	0.006	0.102	0.006
JAM	4.207	0.219	0.154	0.239	0.101	0.053	0.160	-0.006	2.733	0.091	0.064	0.155	0.000
JOR	2.045	0.225	0.217	0.043	0.225	-0.008	0.225	-0.008	1.956	0.215	0.002	0.215	0.002
JPN	1.408	0.333	0.331	0.007	0.333	-0.002	0.333	-0.002	1.398	0.327	0.004	0.327	0.004
KAZ	1.864	0.227	0.233	-0.028	0.227	0.005	0.227	0.005	1.921	0.235	-0.002	0.235	-0.002
KEN	3.772	0.037	0.030	0.208	0.019	0.011	0.028	0.001	2.983	0.023	0.007	0.031	-0.001
KGZ	1.927	0.111	0.110	0.014	0.106	0.004	0.109	0.001	1.900	0.103	0.007	0.108	0.002
KHM	3.859	0.026	0.020	0.248	0.012	0.008	0.019	0.001	2.871	0.014	0.005	0.021	-0.001
KWT	1.995	0.175	0.164	0.074	0.175	-0.011	0.175	-0.011	1.846	0.161	0.003	0.161	0.003
LAO	3.642	0.062	0.049	0.213	0.031	0.017	0.047	0.002	2.801	0.035	0.014	0.050	-0.001
LBN	2.671	0.198	0.170	0.153	0.198	-0.028	0.198	-0.028	2.217	0.174	-0.004	0.174	-0.004
LBR	7.684	0.025	0.010	0.602	0.004	0.006	0.011	-0.002	2.933	0.004	0.005	0.012	-0.002
LBY	2.339	0.105	0.099	0.065	0.085	0.014	0.097	0.002	2.184	0.081	0.018	0.095	0.004
LCA	3.310	0.176	0.148	0.143	0.176	-0.028	0.176	-0.028	2.696	0.158	-0.010	0.158	-0.010
LKA	3.300	0.089	0.078	0.134	0.089	-0.011	0.089	-0.011	2.848	0.083	-0.005	0.083	-0.005
LSO	3.019	0.044	0.043	0.010	0.042	0.001	0.043	0.000	2.988	0.043	0.001	0.043	0.000
LTU	1.673	0.387	0.405	-0.069	0.387	0.018	0.387	0.018	1.806	0.429	-0.024	0.429	-0.024
LUX	1.290	0.232	0.221	0.059	0.232	-0.011	0.232	-0.011	1.209	0.179	0.042	0.179	0.042
LVA	1.718	0.299	0.285	0.062	0.299	-0.014	0.299	-0.014	1.606	0.270	0.015	0.270	0.015
MAR	3.421	0.070	0.055	0.204	0.036	0.019	0.053	0.001	2.640	0.037	0.017	0.054	0.000
MDA	2.205	0.145	0.122	0.173	0.083	0.039	0.116	0.006	1.796	0.053	0.068	0.098	0.024
MDG	3.721	0.023	0.018	0.195	0.012	0.006	0.018	0.001	2.988	0.013	0.006	0.018	0.001
MDV	2.280	0.045	0.042	0.056	0.045	-0.002	0.045	-0.002	2.151	0.043	0.000	0.043	0.000
MEX	2.777	0.116	0.121	-0.040	0.116	0.005	0.116	0.005	2.906	0.119	0.002	0.119	0.002
MKD	1.893	0.106	0.110	-0.033	0.106	0.004	0.106	0.004	1.967	0.111	-0.001	0.111	-0.001
MLI	4.088	0.008	0.006	0.266	0.003	0.003	0.006	0.000	2.988	0.004	0.002	0.006	0.000
MLT	2.224	0.190	0.179	0.055	0.190	-0.011	0.190	-0.011	2.063	0.178	0.001	0.178	0.001
MMR	2.950	0.105	0.104	0.012	0.101	0.003	0.104	0.000	2.915	0.102	0.002	0.104	0.000
MNG	2.987	0.102	0.098	0.039	0.090	0.009	0.097	0.001	2.869	0.092	0.006	0.098	0.000
MOZ	4.961	0.008	0.005	0.395	0.002	0.003	0.005	0.000	2.988	0.004	0.002	0.006	-0.001
MRT	3.044	0.063	0.060	0.040	0.055	0.005	0.060	0.001	2.919	0.057	0.004	0.060	0.000
MUS	6.119	0.072	0.029	0.594	0.074	-0.045	0.074	-0.045	2.352	0.049	-0.020	0.049	-0.020
MWI	3.464	0.012	0.011	0.132	0.008	0.003	0.010	0.000	3.005	0.008	0.002	0.010	0.000
MYS	2.604	0.168	0.159	0.060	0.168	-0.008	0.168	-0.008	2.448	0.161	-0.002	0.161	-0.002
NAM	3.125	0.061	0.059	0.044	0.061	-0.003	0.061	-0.003	2.988	0.060	-0.001	0.060	-0.001
NER	3.316	0.008	0.007	0.099	0.006	0.001	0.007	0.000	2.988	0.006	0.001	0.007	0.000
NGA	3.139	0.092	0.088	0.048	0.079	0.009	0.086	0.002	2.988	0.082	0.006	0.088	0.000
NIC	2.802	0.098	0.082	0.165	0.058	0.025	0.079	0.003	2.304	0.053	0.029	0.077	0.005

Table A.5: Human capital response to skill biased emigration (3/3)

	Observation				NM (Econometric approach)				NM (Micro-founded approach)				
					Long run		Short run			Long run		Short run	
ISO	Λ	H	h	$m_h - m_l$	h	Δh	h	Δh	Λ	h	Δh	h	Δh
NLD	1.352	0.250	0.241	0.043	0.250	-0.009	0.250	-0.009	1.291	0.216	0.025	0.216	0.025
NOR	1.109	0.283	0.277	0.026	0.283	-0.005	0.283	-0.005	1.079	0.211	0.066	0.211	0.066
NPL	3.206	0.039	0.035	0.103	0.028	0.007	0.034	0.001	2.874	0.030	0.005	0.036	0.000
NZL	1.210	0.316	0.307	0.035	0.316	-0.009	0.316	-0.009	1.161	0.252	0.055	0.252	0.055
OMN	2.075	0.156	0.155	0.003	0.156	0.000	0.156	0.000	2.070	0.155	0.000	0.155	0.000
PAK	2.420	0.048	0.043	0.106	0.034	0.009	0.041	0.001	2.161	0.031	0.012	0.040	0.002
PAN	2.378	0.186	0.171	0.095	0.186	-0.015	0.186	-0.015	2.142	0.171	0.000	0.171	0.000
PER	1.919	0.204	0.197	0.039	0.204	-0.007	0.204	-0.007	1.841	0.195	0.003	0.195	0.003
PHL	2.444	0.294	0.276	0.079	0.228	0.049	0.265	0.011	2.245	0.216	0.060	0.260	0.016
PNG	2.892	0.147	0.144	0.022	0.137	0.007	0.143	0.001	2.827	0.139	0.005	0.144	0.001
POL	1.556	0.191	0.177	0.085	0.191	-0.015	0.191	-0.015	1.413	0.156	0.020	0.156	0.020
PRT	1.892	0.114	0.116	-0.011	0.114	0.001	0.114	0.001	1.916	0.116	0.000	0.116	0.000
PRY	2.092	0.112	0.110	0.022	0.104	0.005	0.109	0.001	2.046	0.101	0.008	0.108	0.002
QAT	1.992	0.169	0.168	0.007	0.169	-0.001	0.169	-0.001	1.978	0.168	0.000	0.168	0.000
ROM	2.604	0.139	0.127	0.091	0.139	-0.013	0.139	-0.013	2.336	0.129	-0.003	0.129	-0.003
RWA	4.470	0.010	0.007	0.325	0.003	0.003	0.006	0.000	3.014	0.005	0.002	0.007	-0.001
SAU	2.085	0.220	0.218	0.011	0.220	-0.002	0.220	-0.002	2.062	0.218	0.000	0.218	0.000
SDN	3.147	0.050	0.048	0.050	0.042	0.005	0.047	0.001	2.988	0.044	0.003	0.048	0.000
SEN	3.900	0.036	0.028	0.226	0.017	0.011	0.027	0.001	2.988	0.021	0.007	0.029	-0.001
SGP	2.441	0.463	0.458	0.020	0.463	-0.005	0.463	-0.005	2.391	0.457	0.002	0.457	0.002
SLB	3.032	0.146	0.143	0.023	0.135	0.007	0.141	0.001	2.963	0.138	0.005	0.142	0.000
SLE	4.248	0.036	0.025	0.292	0.014	0.011	0.024	0.001	2.988	0.015	0.010	0.024	0.001
SLV	2.425	0.094	0.087	0.060	0.077	0.010	0.087	0.000	2.228	0.069	0.018	0.083	0.004
SOM	4.158	0.037	0.027	0.267	0.016	0.011	0.026	0.001	2.988	0.016	0.011	0.026	0.001
SRB	2.378	0.129	0.128	0.010	0.125	0.003	0.128	0.000	2.352	0.124	0.004	0.127	0.001
STP	8.706	0.035	0.011	0.624	0.005	0.007	0.015	-0.004	2.988	0.008	0.003	0.019	-0.008
SUR	3.869	0.117	0.070	0.324	0.117	-0.047	0.117	-0.047	2.372	0.085	-0.015	0.085	-0.015
SVK	1.302	0.135	0.123	0.097	0.135	-0.013	0.135	-0.013	1.164	0.082	0.041	0.082	0.041
SVN	1.339	0.160	0.158	0.014	0.160	-0.002	0.160	-0.002	1.320	0.153	0.005	0.153	0.005
SWE	1.217	0.320	0.313	0.030	0.320	-0.007	0.320	-0.007	1.180	0.273	0.040	0.273	0.040
SWZ	2.741	0.077	0.074	0.031	0.069	0.005	0.073	0.001	2.655	0.070	0.004	0.074	0.000
SYR	2.295	0.091	0.087	0.055	0.091	-0.005	0.091	-0.005	2.167	0.087	0.000	0.087	0.000
TCD	2.224	0.011	0.010	0.081	0.009	0.002	0.010	0.000	2.044	0.007	0.003	0.009	0.001
TGO	3.241	0.063	0.059	0.077	0.049	0.009	0.057	0.001	2.988	0.050	0.009	0.057	0.002
THA	2.173	0.119	0.117	0.010	0.119	-0.001	0.119	-0.001	2.151	0.118	0.000	0.118	0.000
TJK	2.349	0.094	0.094	0.005	0.093	0.001	0.094	0.000	2.336	0.093	0.001	0.094	0.000
TKM	2.360	0.105	0.104	0.010	0.105	-0.001	0.105	-0.001	2.336	0.104	0.000	0.104	0.000
TON	4.532	0.133	0.076	0.269	0.133	-0.057	0.133	-0.057	2.483	0.100	-0.024	0.100	-0.024
TTO	4.822	0.152	0.072	0.506	0.152	-0.080	0.152	-0.080	2.266	0.100	-0.028	0.100	-0.028
TUN	2.838	0.105	0.096	0.086	0.105	-0.009	0.105	-0.009	2.577	0.099	-0.003	0.099	-0.003
TUR	2.390	0.088	0.088	0.007	0.088	-0.001	0.088	-0.001	2.372	0.088	0.000	0.088	0.000
TZA	3.803	0.012	0.009	0.214	0.006	0.003	0.009	0.000	2.988	0.006	0.003	0.009	0.000
UGA	3.526	0.029	0.024	0.152	0.018	0.007	0.024	0.001	2.988	0.020	0.004	0.025	-0.001
UKR	1.924	0.175	0.164	0.073	0.175	-0.011	0.175	-0.011	1.779	0.160	0.004	0.160	0.004
URY	1.894	0.121	0.112	0.082	0.121	-0.009	0.121	-0.009	1.731	0.109	0.004	0.109	0.004
USA	1.424	0.316	0.314	0.009	0.316	-0.002	0.316	-0.002	1.411	0.309	0.005	0.309	0.005
UZB	2.492	0.082	0.078	0.053	0.082	-0.004	0.082	-0.004	2.360	0.079	-0.001	0.079	-0.001
VCT	4.497	0.191	0.121	0.280	0.191	-0.071	0.191	-0.071	2.613	0.152	-0.031	0.152	-0.031
VEN	1.955	0.209	0.201	0.047	0.209	-0.008	0.209	-0.008	1.861	0.198	0.003	0.198	0.003
VNM	3.102	0.072	0.065	0.107	0.051	0.014	0.063	0.002	2.761	0.054	0.011	0.064	0.000
VUT	3.189	0.037	0.029	0.219	0.018	0.011	0.028	0.001	2.478	0.019	0.010	0.029	0.001
WSM	4.011	0.124	0.077	0.264	0.053	0.024	0.087	-0.011	2.477	0.039	0.037	0.076	0.000
YEM	2.930	0.136	0.135	0.003	0.134	0.001	0.135	0.000	2.920	0.135	0.001	0.135	0.000
ZAF	3.809	0.052	0.041	0.214	0.052	-0.011	0.052	-0.011	2.988	0.047	-0.006	0.047	-0.006
ZAR	3.895	0.036	0.028	0.232	0.017	0.011	0.027	0.001	2.988	0.018	0.010	0.027	0.001
ZMB	3.375	0.046	0.041	0.114	0.032	0.009	0.040	0.001	2.988	0.033	0.009	0.040	0.001
ZWE	4.398	0.056	0.039	0.316	0.020	0.019	0.037	0.002	2.988	0.022	0.017	0.037	0.001

Table A.6: Welfare implications for those left behind (1/3)

		Net dispo. income response		Channels under benchmark scenario					
ISO	$m_h - m_l$	Bench.	Pess. view	Hum cap.	Tech. ext.	Dias. ext.	Fis. ext.	Mkt. size	Rem.
AFG	5.7%	4.4%	1.6%	2.9%	0.6%	0.7%	-0.1%	-0.5%	0.9%
AGO	18.7%	3.8%	0.0%	2.5%	1.2%	0.9%	-0.1%	-0.7%	0.1%
ALB	10.8%	10.8%	11.5%	-0.5%	-0.2%	4.4%	-1.6%	-6.6%	15.2%
ARE	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ARG	6.6%	0.5%	0.6%	0.3%	0.1%	0.7%	-0.1%	-0.5%	0.2%
ARM	9.4%	5.5%	5.3%	-0.1%	0.0%	1.5%	-0.3%	-1.4%	5.8%
AUS	2.6%	2.8%	4.1%	1.0%	1.3%	0.6%	0.0%	-0.5%	0.5%
AUT	3.1%	3.8%	4.8%	0.9%	1.1%	1.2%	-0.3%	-1.1%	2.0%
AZE	3.5%	2.3%	2.2%	-0.1%	0.0%	0.4%	0.0%	-0.3%	2.4%
BDI	21.8%	4.5%	1.5%	1.6%	1.9%	0.2%	-0.1%	-0.2%	0.9%
BEL	2.2%	7.5%	8.2%	0.8%	1.0%	1.2%	-0.3%	-1.0%	5.8%
BEN	18.1%	3.6%	1.1%	1.1%	1.0%	0.2%	0.0%	-0.1%	1.5%
BFA	8.5%	1.9%	0.9%	0.4%	0.5%	0.1%	0.0%	-0.1%	1.0%
BGD	3.0%	8.3%	7.0%	1.0%	0.2%	0.2%	0.0%	-0.1%	7.1%
BGR	-0.4%	1.9%	1.8%	-0.1%	-0.1%	2.2%	-0.5%	-2.3%	2.7%
BHR	1.9%	0.1%	0.1%	0.0%	0.0%	0.2%	0.0%	-0.2%	0.0%
BHS	25.6%	-2.1%	-2.1%	-1.0%	-0.4%	2.5%	-0.4%	-2.8%	0.0%
BIH	10.2%	6.4%	6.4%	-0.4%	-0.1%	3.4%	-1.4%	-4.4%	9.4%
BLR	4.1%	1.4%	1.7%	0.5%	0.3%	0.8%	-0.2%	-0.7%	0.7%
BLZ	29.7%	-2.3%	-2.2%	-3.0%	-0.9%	3.9%	-2.7%	-5.7%	6.1%
BOL	-0.8%	2.6%	3.2%	-0.7%	-0.4%	1.2%	-0.5%	-1.1%	4.1%
BRA	2.1%	-0.1%	-0.2%	-0.3%	-0.1%	0.2%	-0.1%	-0.2%	0.3%
BRB	33.9%	-6.5%	-5.7%	-2.9%	-1.0%	4.4%	-3.3%	-7.2%	3.5%
BRN	6.9%	0.4%	0.4%	0.2%	0.1%	0.8%	-0.1%	-0.6%	0.0%
BTN	5.2%	2.0%	0.4%	1.2%	0.3%	0.4%	-0.1%	-0.3%	0.4%
BWA	3.2%	0.0%	0.0%	-0.2%	-0.1%	0.1%	0.0%	-0.1%	0.3%
CAF	24.6%	3.8%	0.6%	1.5%	2.2%	0.3%	0.0%	-0.2%	0.0%
CAN	0.3%	0.7%	1.0%	0.2%	0.3%	1.1%	-0.2%	-1.0%	0.2%
CHE	4.5%	2.7%	3.2%	0.8%	0.5%	1.7%	-0.4%	-1.6%	1.7%
CHL	3.2%	0.2%	0.2%	0.1%	0.0%	0.7%	-0.1%	-0.5%	0.0%
CHN	1.8%	1.0%	1.2%	0.1%	0.2%	0.1%	0.0%	-0.1%	0.6%
CIV	10.4%	3.9%	1.4%	1.7%	0.5%	0.5%	-0.1%	-0.3%	1.7%
CMR	20.7%	4.2%	0.1%	2.5%	0.9%	0.5%	-0.1%	-0.4%	0.8%
COG	5.0%	1.9%	0.5%	1.1%	0.3%	0.4%	-0.1%	-0.3%	0.5%
COL	2.2%	1.3%	1.1%	-0.3%	-0.1%	1.0%	-0.2%	-0.8%	1.7%
COM	20.2%	38.4%	29.9%	5.2%	1.4%	2.3%	-0.6%	-2.2%	32.4%
CPV	29.1%	14.8%	6.9%	4.3%	2.5%	5.3%	-4.2%	-8.1%	15.1%
CRI	3.0%	1.7%	1.7%	0.1%	0.0%	0.9%	-0.3%	-0.7%	1.7%
CUB	21.0%	10.2%	0.6%	10.3%	3.0%	3.0%	-3.1%	-2.9%	0.0%
CYP	3.6%	4.1%	4.6%	0.7%	0.3%	3.0%	-1.5%	-3.5%	5.2%
CZE	4.4%	5.1%	8.0%	1.1%	2.8%	1.0%	-0.2%	-0.8%	1.2%
DEU	2.7%	3.0%	4.2%	0.9%	1.2%	1.3%	-0.3%	-1.1%	1.0%
DJI	23.1%	7.6%	3.3%	2.3%	1.6%	0.5%	-0.1%	-0.4%	3.7%
DNK	5.3%	3.0%	4.0%	1.2%	1.0%	1.1%	-0.4%	-0.9%	1.1%
DOM	4.9%	9.6%	9.9%	0.4%	0.2%	2.9%	-0.4%	-3.3%	9.9%
DZA	7.3%	4.4%	0.6%	3.7%	0.8%	1.8%	-0.4%	-1.6%	0.2%
ECU	0.6%	5.4%	4.8%	0.6%	0.2%	2.1%	-0.5%	-2.1%	5.2%
EGY	3.7%	7.6%	5.1%	2.4%	0.7%	0.3%	0.0%	-0.2%	4.5%
ERI	27.6%	5.8%	0.7%	3.8%	2.0%	1.1%	-0.1%	-0.9%	0.0%
ESP	1.4%	1.8%	2.0%	0.3%	0.2%	0.5%	-0.1%	-0.4%	1.3%
EST	1.4%	2.2%	2.4%	0.4%	0.2%	1.4%	-0.4%	-1.3%	1.9%
ETH	8.6%	2.8%	1.1%	1.5%	0.6%	0.3%	0.0%	-0.2%	0.7%
FIN	-2.2%	-0.7%	-1.1%	-0.7%	-0.4%	1.5%	-0.5%	-1.4%	0.8%
FJI	31.7%	27.2%	5.7%	17.9%	3.4%	5.2%	-2.5%	-6.2%	9.5%
FRA	3.6%	3.4%	3.9%	0.8%	0.6%	0.8%	-0.1%	-0.6%	2.0%
FSM	5.8%	-3.9%	-2.5%	-0.5%	-0.1%	4.3%	-6.6%	-6.4%	5.4%
GAB	18.7%	6.6%	1.6%	4.1%	2.0%	0.7%	-0.1%	-0.5%	0.4%
GBR	6.4%	2.4%	3.3%	1.3%	0.9%	1.7%	-0.5%	-1.5%	0.5%

Table A.7: Welfare implications for those left behind (2/3)

ISO	$m_h - m_l$	Net dispo. income response		Channels under benchmark scenario					
		Bench.	Pess. view	Hum cap.	Tech. ext.	Dias. ext.	Fis. ext.	Mkt. size	Rem.
GEO	-2.4%	5.2%	4.5%	-0.8%	-0.4%	1.3%	-0.2%	-1.2%	6.5%
GHA	17.1%	8.2%	3.2%	4.0%	1.6%	0.8%	-0.2%	-0.6%	2.6%
GIN	10.5%	3.7%	1.5%	1.8%	0.8%	0.4%	0.0%	-0.3%	1.0%
GMB	22.1%	10.2%	4.5%	3.6%	1.0%	1.5%	-0.2%	-1.3%	5.6%
GNB	38.1%	11.1%	5.3%	2.3%	2.9%	1.4%	-0.1%	-1.2%	5.9%
GNQ	21.5%	-1.2%	-1.5%	-0.8%	-0.3%	1.3%	-0.1%	-1.1%	0.0%
GRC	0.9%	1.4%	1.6%	0.2%	0.2%	1.6%	-0.3%	-1.5%	1.2%
GRD	30.3%	-11.2%	-9.6%	-5.9%	-1.7%	5.3%	-3.5%	-10.9%	5.5%
GTM	5.3%	6.4%	6.2%	-0.6%	-0.1%	2.3%	-0.4%	-2.4%	7.6%
GUY	36.1%	33.3%	4.4%	14.6%	2.6%	6.8%	-5.8%	-11.3%	26.4%
HND	13.8%	19.1%	13.3%	2.6%	0.4%	2.6%	-1.0%	-2.7%	17.3%
HRV	1.6%	6.0%	6.0%	0.0%	0.0%	2.7%	-0.8%	-3.0%	7.2%
HTI	46.6%	34.6%	21.0%	6.9%	2.4%	2.9%	-0.5%	-2.9%	25.9%
HUN	8.4%	4.6%	5.5%	1.0%	1.0%	1.2%	-0.3%	-1.0%	2.7%
IDN	1.5%	0.6%	0.5%	-0.1%	0.0%	0.1%	0.0%	-0.1%	0.7%
IND	3.9%	3.5%	1.8%	1.5%	0.3%	0.2%	0.0%	-0.1%	1.7%
IRL	-2.2%	-3.5%	-3.2%	-0.9%	-0.6%	3.4%	-1.7%	-4.5%	0.7%
IRN	6.8%	-0.3%	-0.4%	-0.4%	-0.1%	0.5%	-0.1%	-0.4%	0.3%
IRQ	5.1%	5.2%	1.6%	3.6%	0.9%	1.1%	-0.2%	-0.9%	0.7%
ISL	8.8%	4.0%	4.7%	1.5%	0.6%	2.4%	-1.1%	-2.6%	3.1%
ISR	4.2%	8.1%	9.1%	1.4%	1.3%	1.2%	-0.2%	-1.0%	5.4%
ITA	3.7%	1.5%	1.9%	0.4%	0.4%	1.2%	-0.2%	-1.0%	0.9%
JAM	23.9%	42.8%	17.0%	18.3%	3.2%	6.2%	-5.8%	-8.6%	29.6%
JOR	4.3%	10.4%	10.0%	0.3%	0.1%	0.8%	-0.2%	-0.6%	10.1%
JPN	0.7%	0.5%	0.6%	0.2%	0.2%	0.2%	0.0%	-0.1%	0.1%
KAZ	-2.8%	-0.5%	-0.5%	-0.3%	-0.1%	1.8%	-0.3%	-1.8%	0.1%
KEN	20.8%	5.4%	1.3%	2.5%	0.9%	0.5%	-0.1%	-0.4%	2.1%
KGZ	1.4%	12.2%	10.8%	0.9%	0.4%	0.1%	0.0%	-0.1%	10.9%
KHM	24.8%	4.8%	0.8%	2.0%	1.3%	1.0%	-0.1%	-0.9%	1.4%
KWT	7.4%	0.5%	0.7%	0.4%	0.1%	0.7%	-0.1%	-0.6%	0.0%
LAO	21.3%	6.5%	0.3%	4.5%	1.2%	2.2%	-0.2%	-2.1%	0.9%
LBN	15.3%	33.6%	32.2%	-0.6%	-0.2%	2.7%	-0.3%	-3.0%	35.0%
LBR	60.2%	17.1%	7.1%	2.4%	3.7%	1.2%	-0.1%	-1.0%	10.8%
LBY	6.5%	4.5%	1.2%	3.4%	1.0%	0.8%	-0.1%	-0.6%	0.0%
LCA	14.3%	-3.2%	-2.4%	-2.1%	-0.5%	4.0%	-1.4%	-5.9%	2.7%
LKA	13.4%	3.0%	2.5%	-1.3%	-0.3%	1.0%	-0.1%	-0.9%	4.5%
LSO	1.0%	21.9%	18.8%	0.2%	0.1%	0.0%	0.0%	0.0%	21.6%
LTU	-6.9%	1.5%	0.5%	-2.0%	-0.9%	2.2%	-0.7%	-2.3%	5.2%
LUX	5.9%	18.9%	20.2%	1.6%	1.8%	2.0%	-0.3%	-1.9%	15.6%
LVA	6.2%	8.4%	8.7%	1.2%	0.6%	1.7%	-0.4%	-1.6%	6.9%
MAR	20.4%	13.1%	5.9%	5.3%	1.5%	2.7%	-0.9%	-2.8%	7.4%
MDA	17.3%	39.4%	25.8%	11.5%	4.3%	2.4%	-1.1%	-2.1%	24.3%
MDG	19.5%	6.3%	3.0%	2.4%	1.4%	0.4%	0.0%	-0.3%	2.5%
MDV	5.6%	0.1%	0.0%	-0.1%	0.0%	0.1%	0.0%	-0.1%	0.2%
MEX	-4.0%	2.2%	2.6%	0.5%	0.1%	2.8%	-1.0%	-3.2%	2.9%
MKD	-3.3%	3.9%	4.2%	-0.1%	0.0%	3.1%	-0.8%	-3.7%	5.5%
MLI	26.6%	6.2%	2.8%	0.6%	1.6%	0.5%	-0.1%	-0.4%	3.9%
MLT	5.5%	0.7%	1.8%	0.1%	0.0%	4.1%	-2.8%	-5.8%	5.1%
MMR	1.2%	0.7%	0.1%	0.5%	0.1%	0.1%	0.0%	-0.1%	0.1%
MNG	3.9%	12.6%	10.2%	1.6%	0.3%	0.3%	-0.1%	-0.2%	10.6%
MOZ	39.5%	3.0%	-1.7%	0.7%	2.0%	0.3%	-0.1%	-0.2%	0.3%
MRT	4.0%	1.4%	0.1%	1.1%	0.2%	0.5%	-0.1%	-0.4%	0.0%
MUS	59.4%	-6.1%	-8.1%	-3.6%	-2.6%	2.6%	-0.7%	-3.2%	1.4%
MWI	13.2%	2.4%	0.6%	1.0%	1.1%	0.1%	0.0%	-0.1%	0.2%
MYS	6.0%	0.1%	0.0%	-0.3%	-0.1%	0.5%	-0.1%	-0.4%	0.5%
NAM	4.4%	0.3%	0.2%	-0.4%	-0.1%	0.2%	-0.1%	-0.2%	0.8%
NER	9.9%	3.2%	2.0%	0.5%	1.0%	0.1%	0.0%	0.0%	1.7%
NGA	4.8%	11.1%	8.6%	1.7%	0.3%	0.2%	0.0%	-0.2%	9.0%
NIC	16.5%	19.4%	11.2%	6.8%	2.0%	2.2%	-0.6%	-2.1%	11.1%

Table A.8: Welfare implications for those left behind (3/3)

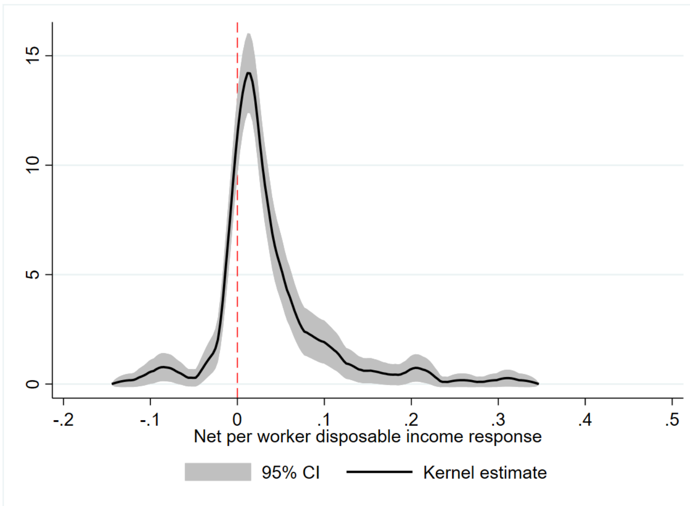
		Net dispo. income response		Channels under benchmark scenario					
ISO	$m_h - m_l$	Bench.	Pess. view	Hum cap.	Tech. ext.	Dias. ext.	Fis. ext.	Mkt. size	Rem.
NLD	4.3%	2.5%	3.5%	1.1%	1.0%	1.3%	-0.3%	-1.2%	0.6%
NOR	2.6%	4.6%	7.3%	1.4%	2.6%	1.0%	-0.2%	-0.8%	0.7%
NPL	10.3%	15.5%	12.5%	1.7%	0.5%	0.3%	0.0%	-0.2%	13.2%
NZL	3.5%	2.7%	5.3%	1.6%	2.1%	3.0%	-1.5%	-3.4%	0.8%
OMN	0.3%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
PAK	10.6%	6.8%	3.8%	2.4%	1.5%	0.4%	0.0%	-0.3%	2.9%
PAN	9.5%	1.5%	1.5%	-0.1%	0.0%	1.6%	-0.3%	-1.5%	1.7%
PER	3.9%	2.2%	2.3%	0.3%	0.1%	1.3%	-0.2%	-1.1%	1.8%
PHL	7.9%	21.7%	12.1%	9.6%	2.5%	1.7%	-0.2%	-1.4%	9.5%
PNG	2.2%	1.7%	0.3%	1.3%	0.3%	0.3%	0.0%	-0.2%	0.1%
POL	8.5%	4.1%	5.2%	1.3%	0.9%	2.2%	-0.7%	-2.3%	2.6%
PRT	-1.1%	1.7%	2.0%	0.0%	0.0%	2.9%	-1.1%	-3.3%	3.3%
PRY	2.2%	4.3%	3.0%	1.3%	0.5%	0.7%	-0.1%	-0.6%	2.5%
QAT	0.7%	1.0%	1.0%	0.0%	0.0%	0.1%	0.0%	-0.1%	1.0%
ROM	9.1%	-0.5%	-0.3%	-0.5%	-0.1%	2.6%	-0.6%	-2.9%	1.0%
RWA	32.5%	3.5%	-0.4%	0.8%	1.7%	0.2%	0.0%	-0.2%	1.0%
SAU	1.1%	0.2%	0.2%	0.0%	0.0%	0.1%	0.0%	-0.1%	0.1%
SDN	5.0%	3.8%	2.3%	1.1%	0.3%	0.2%	0.0%	-0.1%	2.4%
SEN	22.6%	12.9%	7.9%	2.6%	0.9%	1.2%	-0.3%	-1.0%	9.6%
SGP	2.0%	0.3%	0.3%	0.2%	0.1%	0.9%	-0.1%	-0.7%	0.0%
SLB	2.3%	3.3%	1.7%	1.2%	0.2%	0.3%	-0.1%	-0.2%	1.9%
SLE	29.2%	7.4%	1.7%	4.4%	1.8%	0.8%	-0.1%	-0.6%	1.2%
SLV	6.0%	25.4%	21.0%	3.6%	1.1%	4.5%	-2.0%	-6.4%	24.5%
SOM	26.7%	6.3%	0.7%	4.5%	1.7%	1.6%	-0.1%	-1.4%	0.0%
SRB	1.0%	18.1%	16.4%	0.7%	0.2%	1.5%	-0.4%	-1.4%	17.5%
STP	62.4%	1.4%	-7.2%	1.3%	1.4%	3.4%	-2.8%	-4.2%	2.3%
SUR	32.4%	-14.2%	-12.0%	-2.9%	-1.0%	5.0%	-6.4%	-9.1%	0.2%
SVK	9.7%	6.9%	10.0%	1.5%	2.8%	2.4%	-0.6%	-2.4%	3.2%
SVN	1.4%	1.2%	1.4%	0.2%	0.2%	1.2%	-0.3%	-1.1%	0.9%
SWE	3.0%	5.3%	6.7%	1.2%	1.5%	0.9%	-0.2%	-0.7%	2.6%
SWZ	3.1%	4.2%	2.8%	1.1%	0.3%	0.2%	0.0%	-0.1%	2.8%
SYR	5.5%	0.8%	0.8%	-0.1%	0.0%	0.5%	-0.1%	-0.4%	0.9%
TCD	8.1%	3.1%	1.7%	0.7%	2.4%	0.1%	0.0%	0.0%	0.0%
TGO	7.7%	13.2%	9.6%	3.0%	0.6%	0.5%	-0.1%	-0.3%	9.5%
THA	1.0%	0.8%	0.8%	0.0%	0.0%	0.2%	0.0%	-0.2%	0.8%
TJK	0.5%	22.7%	21.8%	0.3%	0.1%	0.0%	0.0%	0.0%	22.4%
TKM	1.0%	0.2%	0.1%	0.0%	0.0%	0.1%	0.0%	-0.1%	0.2%
TON	26.9%	1.8%	2.9%	-4.6%	-1.4%	5.5%	-4.8%	-11.5%	18.7%
TTO	50.6%	-9.0%	-9.3%	-4.5%	-1.7%	3.8%	-1.2%	-5.8%	0.4%
TUN	8.6%	2.3%	2.1%	-0.6%	-0.2%	1.8%	-0.6%	-1.8%	3.7%
TUR	0.7%	0.3%	0.3%	0.0%	0.0%	1.4%	-0.2%	-1.3%	0.4%
TZA	21.4%	4.0%	1.3%	1.3%	1.9%	0.2%	0.0%	-0.1%	0.8%
UGA	15.2%	5.0%	2.2%	1.6%	0.7%	0.3%	0.0%	-0.2%	2.6%
UKR	7.3%	4.2%	4.2%	0.5%	0.2%	1.1%	-0.3%	-0.9%	3.6%
URY	8.2%	0.7%	1.0%	0.4%	0.2%	1.6%	-0.4%	-1.5%	0.4%
USA	0.9%	0.6%	0.8%	0.3%	0.2%	0.2%	0.0%	-0.2%	0.1%
UZB	5.3%	2.4%	2.3%	-0.2%	-0.1%	0.3%	-0.1%	-0.2%	2.7%
VCT	28.0%	-9.5%	-8.4%	-5.9%	-1.4%	4.8%	-4.0%	-9.0%	6.0%
VEN	4.7%	0.4%	0.6%	0.3%	0.1%	0.7%	-0.2%	-0.6%	0.1%
VNM	10.7%	7.3%	3.4%	3.2%	0.7%	0.9%	-0.2%	-0.8%	3.4%
VUT	21.9%	7.3%	2.7%	3.0%	1.8%	0.7%	-0.2%	-0.6%	2.6%
WSM	26.4%	29.4%	14.4%	11.0%	2.7%	6.4%	-6.7%	-10.7%	26.8%
YEM	0.3%	3.4%	3.1%	0.2%	0.0%	0.3%	-0.1%	-0.2%	3.2%
ZAF	21.4%	-1.8%	-2.3%	-1.7%	-0.5%	0.5%	-0.1%	-0.4%	0.5%
ZAR	23.2%	8.4%	3.4%	4.0%	1.5%	0.5%	0.0%	-0.3%	2.8%
ZMB	11.4%	4.5%	1.3%	3.1%	0.8%	0.3%	0.0%	-0.2%	0.5%
ZWE	31.6%	24.9%	15.0%	6.9%	1.8%	1.0%	-0.1%	-0.8%	16.0%

Table A.1: Calibration of the income block: benchmark and conservative parameter sets

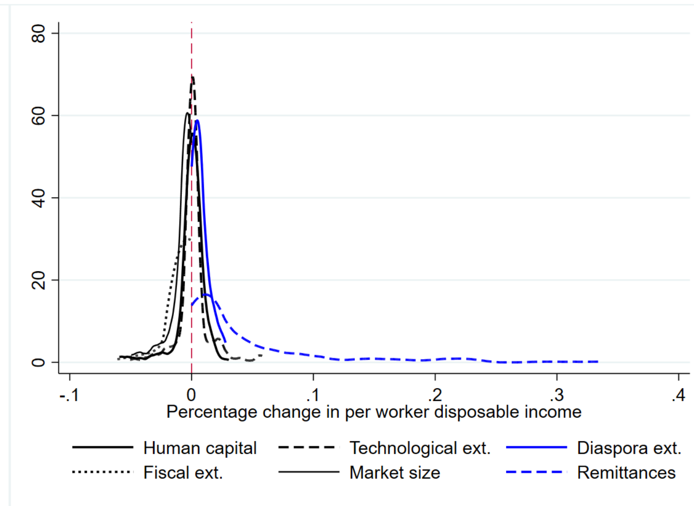
Parameter		Conservative	Benchmark	Source
Change in human capital	Δh_i	**SR**	LR	Section 1.2.3
Substitution HS/LS	σ	**2.0**	2.0	Ottaviano and Peri (2012)
Migration-income elasticity	$1/\mu$	**0.7**	0.7	Bertoli and Moraga (2013)
Schooling ext. aggregate	ϵ	**0.05**	0.10	Caselli and Ciccone (2013)
Schooling ext. skill-biased	κ	**0.05**	0.10	Burzyński et al. (2020)
Diaspora externality	ρ	**0.016**	0.032	Larch et al. (2017); Feyrer (2019)
Substitution between goods	λ	**4.0**	8.0	Feenstra (1994)
Fiscal externality	η	**0.112**	0.056	Alesina and Spolaore (1997)

Figure A.1: Effect of selective emigration on disposable income (y_i)
Results obtained under the conservative scenario (short-term human capital responses and conservative elasticity values)

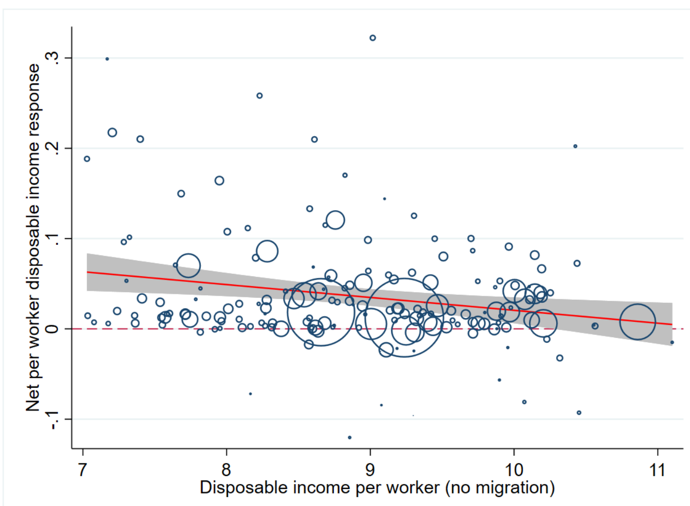
(a) Density of $(y_i - y_i^{NM})/y_i^{NM}$



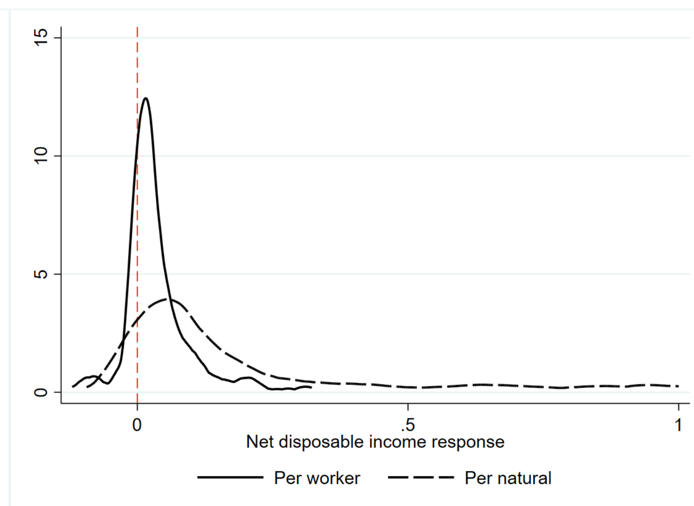
(b) Decomposition by channel



(c) Convergence: $(y_i - y_i^{NM})/y_i^{NM}$ vs. y_i^{NM}



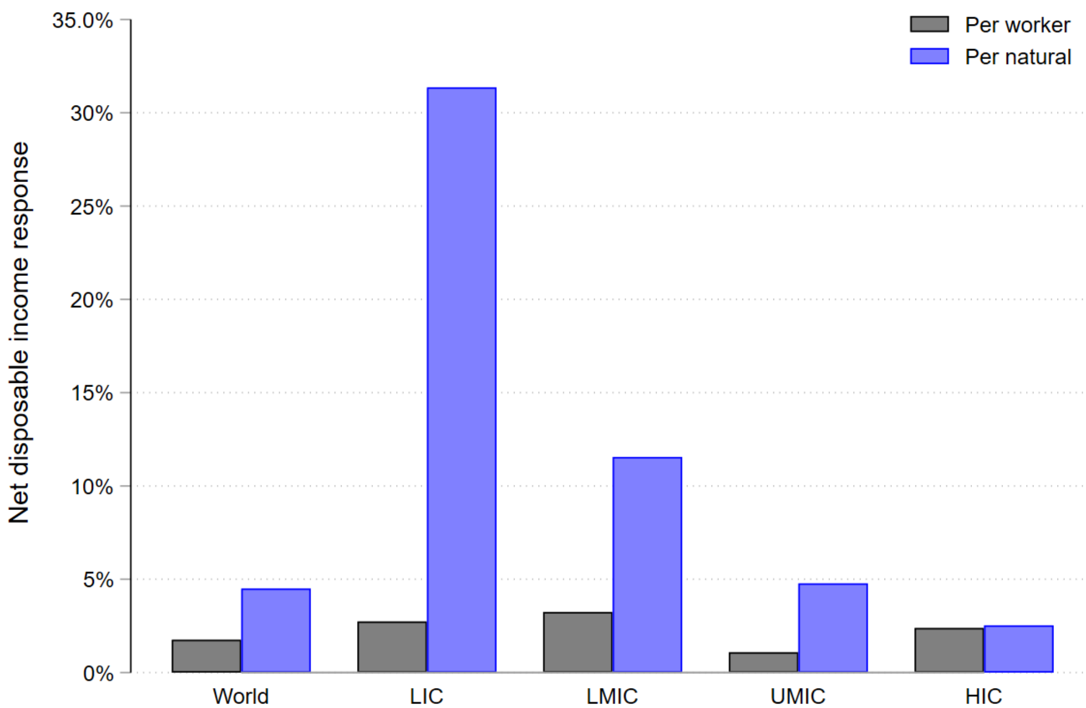
(d) Impact on income per natural vs. income per worker



Note: Each circle represents a country, and its size represents the size of the labor force.

Figure A.2 shows, for the conservative scenario, the population-weighted average disposable income response to selective emigration per worker (left-hand bars), and per natural (right-hand bars) worldwide. The average income per worker increases by 1.7 percent while the average income per natural increases by 4.5 percent. Average income per capita increases between 1.0% in upper-middle income countries and 3.2% in lower-middle income countries. When we account for emigrants' income gains, using the income per natural measure, gains from migration are substantially higher. Income per natural increases by 31.4 percent in low-income countries and 11.6 percent in lower-middle income countries. The average gain is below 5 percent in upper-middle and high-income countries.

Figure A.2: Average disposable income responses to selective emigration (conservative variant)



1.C.3 Effect of Selection *per se* on Economic Development

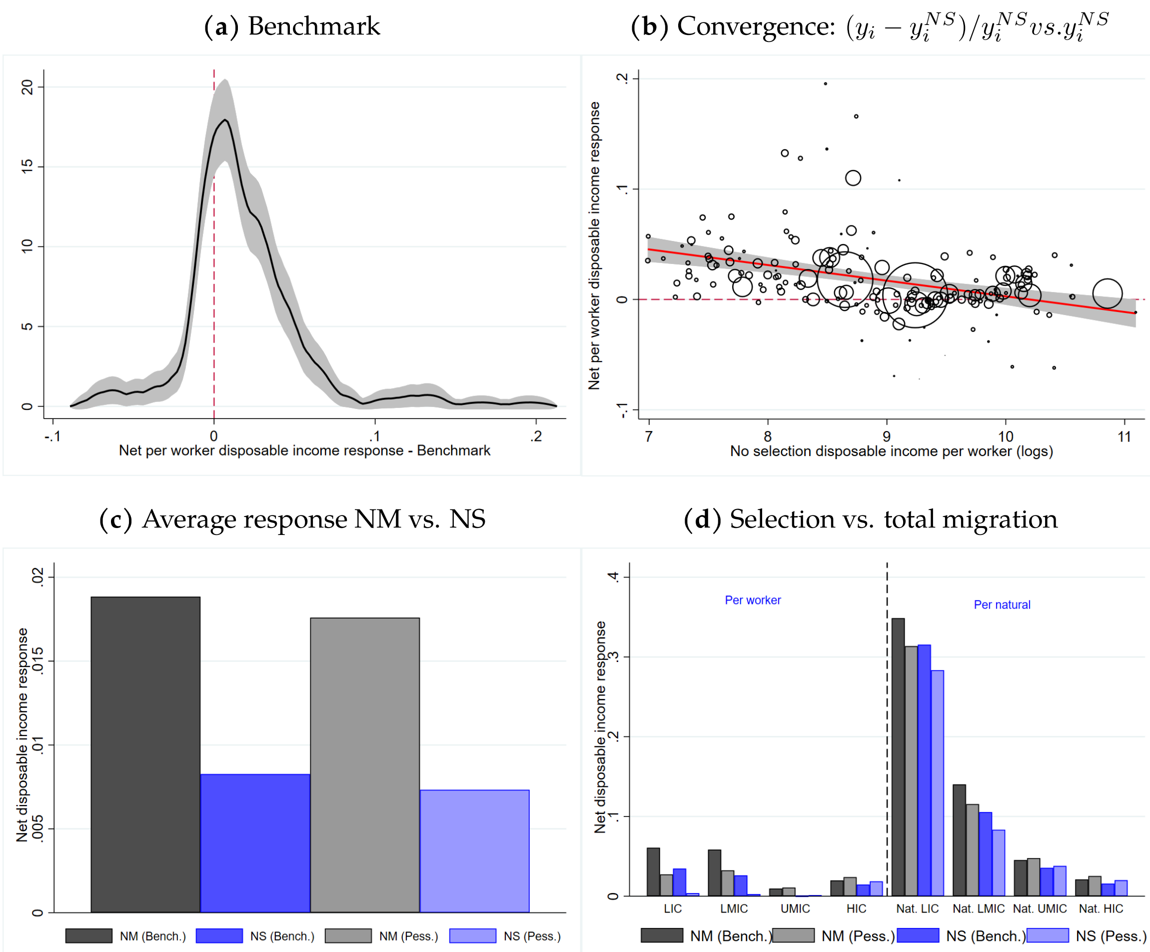
In Figure A.3, we isolate the effect of positive selection. We consider a new counterfactual scenario (labeled as NS) with the same migration intensity, but without positive selection. Assuming constant wage rates, migration costs are re-calibrated so as to have $m_{ij,h} = m_{ij,l} = \overline{m}_{ij}$ over all corridors j, where $\overline{m}_{ij}$ is the average emigration rate from country i to country j. Keeping total bilateral migration levels constant, the NS counterfactual scenario allows us to isolate the impact of positive selection in migration on the average net income per worker.

The effect of selection is positive in a large majority of countries. Its distribution, shown in Panel A.3a, is right skewed which implies that a majority of individuals benefit somewhat from the selection in emigration. The peak of the density is around 0.7% and below the one observed in Figure 1.2 (which combines the effect of the size and skill-composition of emigration). The lower positive effects of selection are driven by market size and fiscal externalities. The skill bias in emigration reduces market size and decreases the tax base, thus increasing the ideal price index and tax rates. Schooling externalities only depend on human capital differentials between emigrants and non-leavers and hence this channel generates similar effects in the NS and NM scenarios. In contrast, diaspora externalities are not affected in the no-selection scenario because they are insensitive to the selection of migrants and only depend on the size of emigrant flows (which remain constant in the NS counterfactual). By assumption, selection alone does not impact remittances either, as we assume that college-educated and less educated migrants send the same amount of remittances, in line with Bollard et al. (2011). Hence, in comparison to the no-migration scenario, selection by itself generate similar "brain gain" responses but does not affect diaspora externalities nor remittances.

Panel A.3b compares the income response of the observed selection with the counterfactual no-selection income level (in logs), in a setting where only the origin country wages are assumed to be endogenous. The fitted line is decreasing and intersects with zero at an income level around USD 8,000. With some exceptions, this implies that emigrants' selection increases the level of income per worker at low levels of development, and is detrimental in richer countries. The average gain for poor countries is smaller than the gain from migration (around one third of the total effect of migration), and can only be due to the greater incentive to acquire human capital. The income loss at higher levels of development is governed by the human capital flight and the negative fiscal and market size externalities. There is more variability in the response to selection on disposable income per worker. By contrast, the isolated effect of migrant selection on income per natural is similar to that of the no-migration scenario, as shown in Panel A.3d.

Overall, the average effect of selection is positive, but smaller than the effect of migration intensity (see panel A.3c). This result is highly robust to the parameter set of the conservative variant of our model. Panel A.3c shows that selection alone generates more than one-third (0.8%) of the total effects of migration (1.9%). Contrary to the NM scenario, the changes in income generated in our NS scenario are only governed by the reallocation of college graduates and less educated workers, given that population sizes do not change. The pure income effects are smaller given that population sizes remain constant and the NS scenario only affects part of the channels that drive the total effect of the NM scenario. In particular, remittances and diaspora externalities are not affected by selection per se. Market size and fiscal externalities vary between the NM and NS scenarios whereas schooling externalities are identical. Our results differ somewhat from those in Biavaschi et al. (2020). They use a different modelling framework with lower human capital responses and find that selection increases average welfare of never-migrants by 0.63%, which represents roughly 1/6 of their average total migration effect. The fact that they focus on never-migrants, which is a constant reference population, also disregards population composition effects that our *per worker* measure takes into account. The NS counterfactual gives a rough proxy of the share of the total effect that is generated by the human capital mechanism. This share is low in the short-term, and larger in the long-term (between one fourth and one half depending on the income group). The residual share of the long-term gains from migration is governed by the diaspora and remittance mechanisms, which are independent of the skill selection of emigrants. Panel A.3d details the average effects of the NM and NS scenarios on income per worker and income per natural by country income group.

Figure A.3: Impact of selection per se (NS)



(**a**) Benchmark

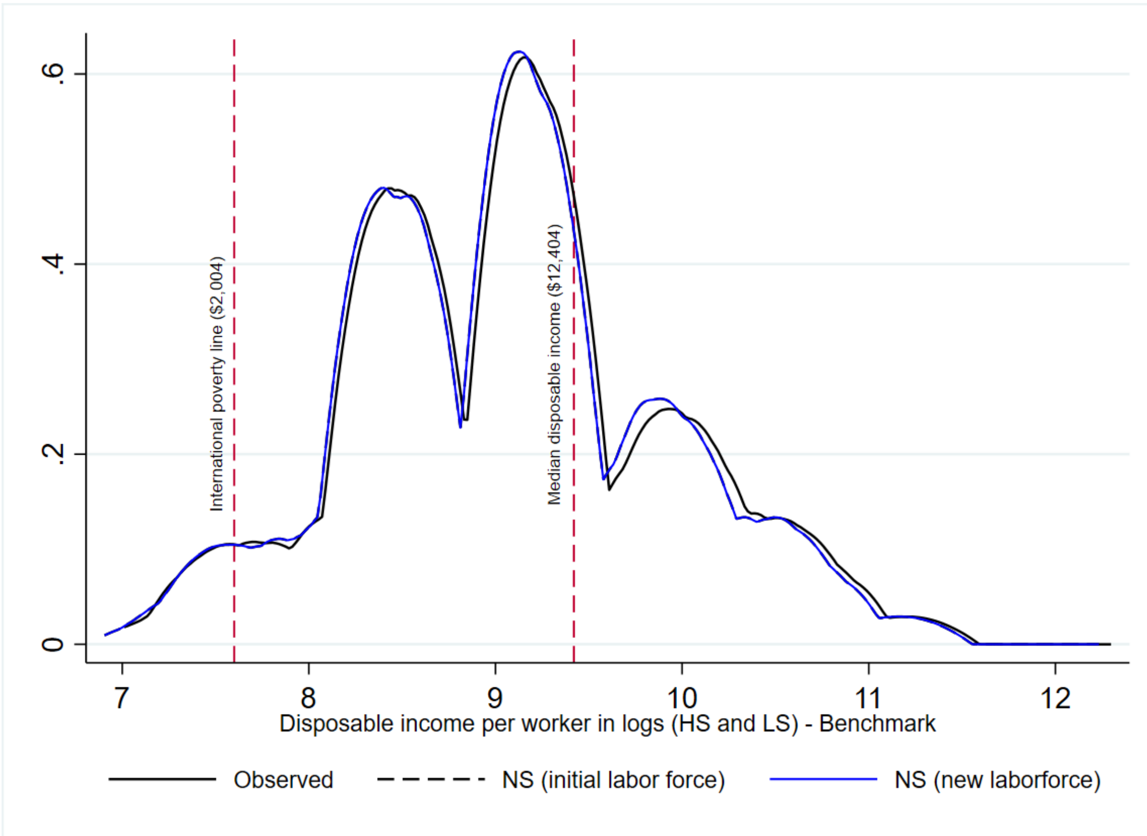
(**b**) Convergence: $(y_i - y_i^{NS})/y_i^{NS} vs. y_i^{NS}$

(**c**) Average response NM vs. NS

(**d**) Selection vs. total migration

Figure A.4 compares the observed world distribution of income to the one obtained under the counterfactual no-selection (NS) scenario. Selection by itself shifts the density to the right, both at low income levels and at levels above the median.

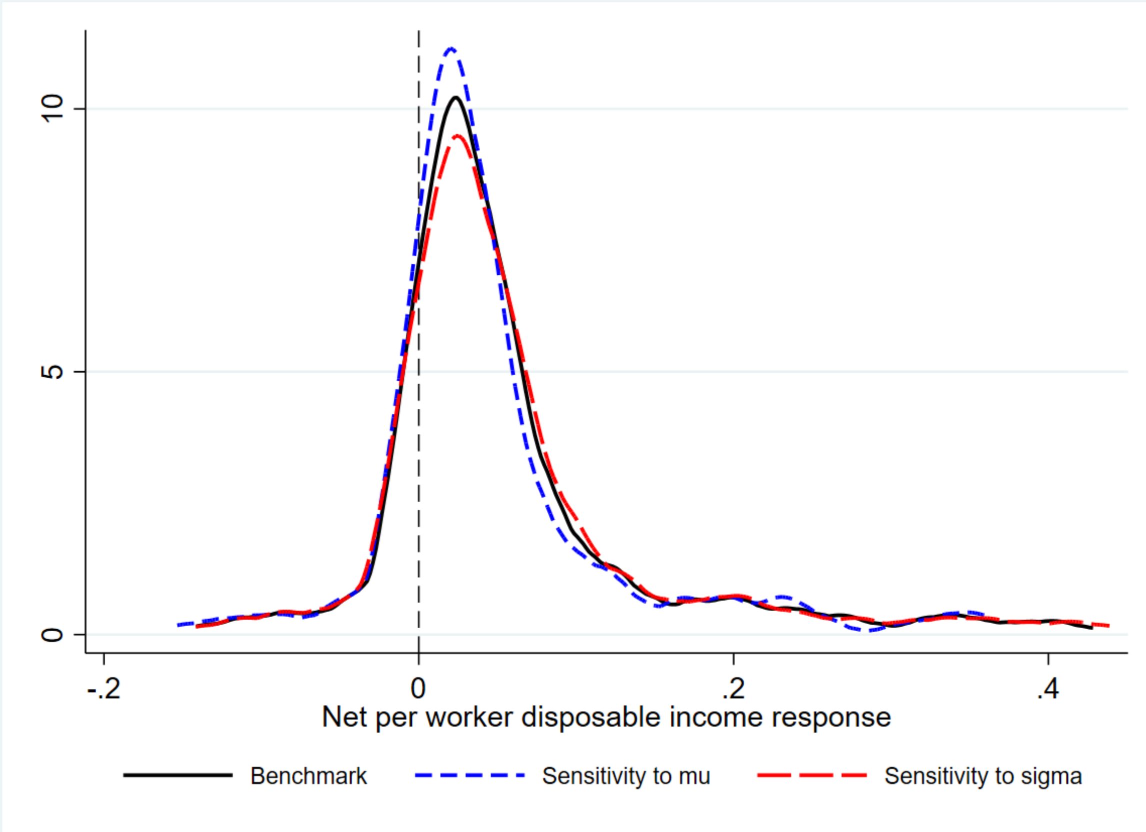
Figure A.4: Selection and world distribution of income



1.C.4 Robustness of results to key parameter values

Figure A.5 shows that our benchmark results are robust to re-calibrating the model after changing the elasticity of bilateral migration to the wage ratio (using μ=0.8), or the elasticity of substitution between skill groups (using σ=1.5).

Figure A.5: Sensitivity to μ and σ



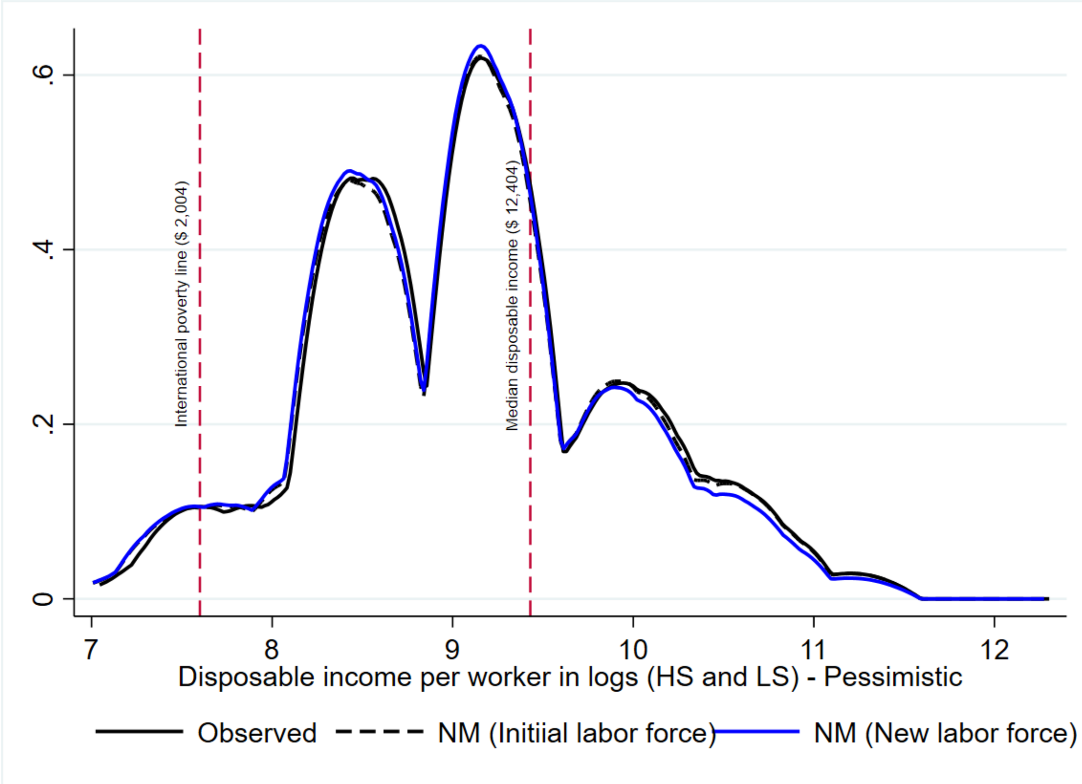
1.D Global Inequality: Additional Results

In Section 1.D.1, we estimate the effect of positive selection on the world distribution of income under the conservative variant defined in Section 1.C.2. We provide additional measures of the inequality effect of global migration in Section 1.D.2.

1.D.1 Effect on Inequality under the Conservative Variant

Figure A.1 replicates Figure 1.4 under the conservative scenario. The shift of the income distribution to the right is qualitatively similar to the benchmark scenario, albeit unsurprisingly less pronounced. Under the conservative scenario, the proportion of people living below the poverty line decreases by 5.3 percent, which represents 66.7 million people.

Figure A.1: Emigration and the world income distribution: Conservative variant



1.D.2 Theil Index

Relying on the general equilibrium setting introduced in Section 1.4, we measure global income inequality using the Theil index:

$$T = \sum_i \sum_s \frac{y_{i,s} L_{i,s}}{\bar{y} L} \ln \left(\frac{y_{i,s}}{\bar{y}} \right) \tag{1.27}$$

Where $L \equiv \sum_i \sum_s L_{i,s}$ and $\bar{y} \equiv \left(\sum_i \sum_s y_{i,s} L_{i,s} \right) / L$ denote the total working-age population of the world and the worldwide average level of disposable income, respectively. The ratio $y_{i,s} L_{i,s} / \bar{y} L$ is the proportion of world income that is earned by type s workers living in country i. This index can be expressed as the sum of two components:

(i) an across-country component: $T_A \equiv \sum_i \frac{y_i L_i}{\bar{y} L} \ln \left(\frac{y_i}{\bar{y}} \right)$, where y_i and L_i stand for the average level of disposable income and working-age population in country i, respectively;

(ii) a within-country component: $T_W \equiv \sum_i \frac{y_i L_i}{\bar{y} L} \sum_s \frac{y_{i,s} L_{i,s}}{y_i L_i} \ln \left(\frac{y_{i,s}}{y_i} \right)$.

Table A.1 compares the observed and counterfactual levels of the Theil index under the conservative and benchmark scenarios. Col. (1) reports the observed levels in income disparities. These levels are smaller than the usual estimates because we focus on the working-age population, and we only distinguish between two types of workers by country. We thus disregard the residual (or unexplained) heterogeneity within these broad groups of workers. In Cols. (2) and (3), we compute the Theil index in the no-migration (NM) counterfactual under the conservative scenario. Changes are driven by the income responses to global migration, as well as by the geographic reallocation of the world labor force ($L_{i,s}$ is endogenous). Col. (2) abstracts from population reallocation and isolates the income effects. It shows that global migration reduces the across-country component of the Theil index (reflecting the convergence in disposable income per worker between countries, as highlighted in Figures A.1 and 1.2), and increases the within-country component (as it increases the income gap between high-skilled and low-skilled workers in receiving countries). Overall, these pure income mechanisms tend to generate a decrease in global inequality of approximately 0.5 percent.

When accounting for the reallocation effects, the results are inverted. Global migration increases the across-country component of the Theil index. This is generated by the huge "place premium" effect: migrants' income gains tend to increase the worldwide average income level more rapidly than the income level of those remaining behind, as illustrated in Figure 1.3. This is partly attenuated by a decrease in the within-country component of the Theil index, and is driven by the fact that migrants move from high-inequality to low-inequality countries. Overall, the Theil index increases by 1.94 percent due to the composition effect. In Cols. (4) and (5), we conduct the same exercise under the benchmark scenario. The changes are magnified but qualitatively similar. The Theil index increases by 2.5 percent, spurred by the across-country component. This may appear to be a small effect; however, it is worth emphasizing that international migrants represent about 2.25 percent of the world's working-age population. Hence, the elasticity of the Theil index to migration slightly exceeds unity.

Table A.1: Theil index

	Obs.	NM Conservative		NM Benchmark	
		Cst. pop	New pop	Cst. pop	New pop
Total	0.355	0.357	0.349	0.363	0.351
Across	0.294	0.299	0.284	0.303	0.287
Within	0.061	0.059	0.064	0.059	0.064
		Rel. dev.		Rel. dev.	
Total		-0.51%	+1.94%	-0.68%	+2.50%
Across		-1.49%	+3.51%	-1.28%	+4.17%
Within		+4.51%	-5.00%	+2.40%	-4.96%
		Acr/With		Acr/With	
Across	82.8%	83.6%	81.5%	83.6%	81.8%
Within	17.2%	16.4%	18.5%	16.4%	18.2%

Bibliography

Abarcar, P. and C. Theoharides (2021). “Medical Worker Migration and Origin-Country Human Capital: Evidence from U.S. Visa Policy”. In: *Review of Economics and Statistics* forthcoming, pp. 1–46.

Acemoglu, D. (2002). “Technical Change, Inequality, and the Labor Market”. In: *Journal of Economic Literature* 40(1), pp. 7–72.

Acemoglu, D., F. F.A. Gallego, and J. Robinson (2014). “Institutions, Human Capital and Development”. In: *Annual Review of Economics* 6, pp. 875–912.

Alesina, A. and E. Spolaore (1997). “On the number and size of nations”. In: *The Quarterly Journal of Economics* 112(4), pp. 1027–1056.

Alesina, A. and R. Wacziarg (1998). “Openness, country size and government”. In: *Journal of Public Economics* 69(3), pp. 305–321.

Antman, F. M. (2011). “The intergenerational effects of paternal migration on schooling and work: What can we learn from children’s time allocations?” In: *Journal of Development Economics* 96(2), pp. 200–208.

Arslan, C., J.-C. Dumont, Z. Kone, Y. Moullan, C. Ozden, C. Parsons, and T. Xenogiani (2015). “A new profile of migrants in the aftermath of the recent economic crisis”. In: *OECD Social Employment and Migration Working Papers* 160.

Artuc, E., F. Docquier, Ç. Özden, and C. Parsons (2014). *A global assessment of human capital mobility: the role of non-OECD destinations*. The World Bank.

Aubry, A., M. Burzyński, and F. Docquier (2016). “The welfare impact of global migration in OECD countries”. In: *Journal of International Economics* 101(C), pp. 1–21.

Autor, D. H., F. Levy, and R. J. Murnane (2003). “The skill content of recent technological change: An empirical exploration”. In: *The Quarterly journal of economics* 118(4), pp. 1279–1333.

Bahar, D. and H. Rapoport (2018). “Migration, Knowledge Diffusion and the Comparative Advantage of Nations”. In: *Economic Journal* 128(612), F273–F305.

Batista, C., A. Lacuesta, and P. C. Vicente (2012). “Testing the ’brain gain’ hypothesis: Micro evidence from Cape Verde”. In: *Journal of Development Economics* 97(1), pp. 32–45.

Beine, M., F. Docquier, and H. Rapoport (2008). “Brain drain and human capital formation in developing countries: winners and losers”. In: *The Economic Journal* 118(528), pp. 631–652.

Beine, M., F. Docquier, and C. Oden-Defoort (2011). “A panel data analysis of the brain gain”. In: *World Development* 39(4), pp. 523–532.

Beine, M., F. Docquier, and H. Rapoport (2001). “Brain drain and economic growth: theory and evidence”. In: *Journal of Development Economics* 64(1), pp. 275–289.

Beine, M., F. Docquier, and H. Rapoport (2010). “On the robustness of brain gain estimates”. In: *Annals of Economics and Statistics/Annales d’Économie et de Statistique*, pp. 143–165.

Belot, M. V. and T. J. Hatton (2012). “Immigrant Selection in the OECD”. In: *The Scandinavian Journal of Economics* 114(4), pp. 1105–1128.

Bencek, D. and C. Schneiderheinze (2020). *Higher economic growth in poor countries, lower migration flows to the OECD: Revisiting the migration hump with panel data*. Kiel Working Papers 2145. Kiel Institute for the World Economy (IfW).

Benhabib, J. and M. M. Spiegel (1994). “The role of human capital in economic development evidence from aggregate cross-country data”. In: *Journal of Monetary Economics* 34(2), pp. 143–173.

Bertoli, S. and J. F.-H. Moraga (2013). “Multilateral resistance to migration”. In: *Journal of development economics* 102, pp. 79–100.

Bertoli, S., J. Moraga, and F. Ortega (2013). “Crossing the border: self-selection, earnings and individual migration decisions”. In: *Journal of Development Economics* 101(1), pp. 75–91.

Bhagwati, J. and K. Hamada (1974). “The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis”. In: *Journal of Development Economics* 1(1), pp. 19–42.

Biavaschi, C., M. Burzyński, B. Elsner, and J. Machado (2020). “Taking the skill bias out of global migration”. In: *Journal of Development Economics* 142, p. 102317.

Bobba, M. and D. Coviello (2007). “Weak instruments and weak identification, in estimating the effects of education, on democracy”. In: *Economics Letters* 96(3), pp. 301–306.

Bollard, A., D. McKenzie, M. Morten, and H. Rapoport (2011). “Remittances and the Brain Drain Revisited: The Microdata Show That More Educated Migrants Remit More”. In: *World Bank Economic Review* 25(1), pp. 132–156.

Bolt, J., R. Inklaar, H. de Jong, and J. L. van Zanden (2018). “Rebasing ’Maddison’: new income comparisons and the shape of long-run economic development”. In: *Maddison Project Working Paper* 10.

Bolt, J. and J. L. Van Zanden (2014). “The Maddison Project: collaborative research on historical national accounts”. In: *The Economic History Review* 67(3), pp. 627–651.

Boustan, L. (2010). “Was Postwar Suburbanization “White Flight”? Evidence from the Black Migration”. In: *Quarterly Journal of Economics* 125(1), pp. 417–443.

Brauw, A. de and J. Giles (2017). “Migrant Opportunity and the Educational Attainment of Youth in Rural China”. In: *Journal of Human Resources* 52(1), pp. 272–311.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014). “Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh”. In: *Econometrica* 82, pp. 1671–1748.

Burzyński, M., C. Deuster, and F. Docquier (2020). “Geography of skills and global inequality”. In: *Journal of Development Economics* 142, p. 102333.

Caballero, M. E., B. Cadena, and B. K. Kovak (2021). *The International Transmission of Local Economic Shocks Through Migrant Networks*. NBER Working Papers 28696. National Bureau of Economic Research, Inc.

Caselli, F. and A. Ciccone (2013). “The contribution of schooling in development accounting: Results from a nonparametric upper bound”. In: *Journal of Development Economics* 104(C), pp. 199–211.

Caselli, F. and W. J. I. Coleman (2006). “The World Technology Frontier”. In: *American Economic Review* 96(3), pp. 499–522.

Castelló-Climent, A. and A. Mukhopadhyay (2013). “Mass education or a minority well educated elite in the process of growth: The case of India”. In: *Journal of Development Economics* 105, pp. 303–320.

Chand, S. and M. A. Clemens (2008). “Skilled emigration and skill creation: a quasi-experiment”. In: *Available at SSRN 1299135*.

Ciccone, A. and E. Papaioannou (2009). “Human Capital, the Structure of Production, and Growth”. In: *Review of Economics and Statistics* 91(1), pp. 66–82.

Clemens, M., C. Ozden, and H. Rapoport (2014). “Migration and Development Research is Moving Far Beyond Remittances”. In: *World Development* 64, pp. 121–124.

Clemens, M. and L. Pritchett (2008). “Income per Natural: Measuring Development for People Rather Than Places”. In: *Population and Development Review* 34(3), pp. 395–434.

Clemens, M. and E. R. Tiongson (2017). “Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work”. In: *Review of Economics and Statistics* 99(3), pp. 531–543.

Clemens, M. A. (2020). *The Emigration Life Cycle: How Development Shapes Emigration from Poor Countries*. IZA Discussion Papers 13614. Institute of Labor Economics (IZA).

Clemens, M. A. and M. Mendola (2020). *Migration from Developing Countries: Selection, Income Elasticity, and Simpson's Paradox*. IZA Discussion Papers 13612. Institute of Labor Economics (IZA).

Commander, S., M. Kangasniemi, and L. A. Winters (2004). "The Brain Drain: Curse or Boon? A Survey of the Literature". In: *Challenges to Globalization: Analyzing the Economics*. NBER Chapters. National Bureau of Economic Research, Inc, pp. 235–278.

Dao, T. H., F. Docquier, C. Parsons, and G. Peri (2018). "Migration and development: Dissecting the anatomy of the mobility transition". In: *Journal of Development Economics* 132, pp. 88–101.

Delogu, M., F. Docquier, and J. Machado (2018). "Globalizing labor and the world economy: the role of human capital". In: *Journal of Economic Growth* 23(2), pp. 223–258.

Devesh, K., J. McHale, and K. Rogers (2009). "The Fiscal Impact of High-Skilled Emigration: Flows of Indians to the U.S." In: *Journal of Development Economics* 88(1), pp. 32–44.

Dinkelman, T. and M. Mariotti (2016). "The Long-Run Effects of Labor Migration on Human Capital Formation in Communities of Origin". In: *American Economic Journal: applied Economics* 8(4), pp. 1–35.

Djajic, S. (1989). "Skills and the pattern of migration: the role of qualitative and quantitative restrictions on international labor mobility". In: *International Economic Review*, pp. 795–809.

Djajić, S., F. Docquier, and M. S. Michael (2019). "Optimal education policy and human capital accumulation in the context of brain drain". In: *Journal of Demographic Economics* 85(4), pp. 271–303.

Docquier, F., O. Faye, and P. Pestieau (2008). "Is migration a good substitute for education subsidies?" In: *Journal of Development Economics* 86(2), pp. 263–276.

Docquier, F., E. Lodigiani, H. Rapoport, and M. Schiff (2016). "Emigration and democracy". In: *Journal of Development Economics* 120, pp. 209–223.

Docquier, F., B. L. Lowell, and A. Marfouk (2009). "A gendered assessment of highly skilled emigration". In: *Population and Development Review* 35(2), pp. 297–321.

Docquier, F. and J. Machado (2016). "Global Competition for Attracting Talents and the World Economy". In: *The World Economy* 39(4), pp. 530–542. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/twec.12267.

Docquier, F. and H. Rapoport (2012). "Globalization, brain drain, and development". In: *Journal of Economic Literature* 50(3), pp. 681–730.

Egger, H., J. Falkinger, and V. Grossmann (2012). "Brain drain, fiscal competition, and public education expenditure". In: *Review of International Economics* 20(1), pp. 81–94.

Feenstra, R. C. (1994). "New Product Varieties and the Measurement of International Prices". In: *American Economic Review* 84(1), pp. 157–177.

Felbermayr, G. J., B. Jung, and F. Toubal (2010). "Ethnic Networks, Information, and International Trade: Revisiting the Evidence". In: *Annals of Economics and Statistics* 97-98, pp. 41–70.

Fernández Sánchez, M. (2022). *Mass Emigration and Human Capital over a Century: Evidence from the Galician Diaspora*. Tech. rep. Luxembourg Institute of Socio-Economic Research (LISER).

Feyrer, J. (2009). *Distance, trade, and income - the 1967 to 1975 closing of the Suez canal as a natural experiment*. Tech. rep. National Bureau of Economic Research.

Feyrer, J. (2019). "Trade and Income — Exploiting Time Series in Geography". In: *American Economic Journal: Applied Economics* 11(4), pp. 1–35.

Gibson, J. and D. McKenzie (2009). *The microeconomic determinants of emigration and return migration of the best and brightest: Evidence from the Pacific*. The World Bank.

Gibson, J., D. McKenzie, and S. Stillman (2011). "The Impacts of International Migration on Remaining Household Members: Omnibus Results from a Migration Lottery Program". In: *The Review of Economics and Statistics* 93(4), pp. 1297–1318.

Giovanni, J. di, A. A. Levchenko, and F. Ortega (2015). "A global view of cross-border migration". In: *Journal of the European Economic Association* 13(1), pp. 168–202.

Glaeser, E. L., R. La Porta, F. Lopez-de-Silanes, and A. Shleifer (2004). "Do institutions cause growth?" In: *Journal of Economic Growth* 9(3), pp. 271–303.

Grogger, J. and G. H. Hanson (2011). "Income maximization and the selection and sorting of international migrants". In: *Journal of Development Economics* 95(1), pp. 42–57.

Haque, N. U. and S.-J. Kim (1995). ""Human capital flight": Impact of migration on income and growth". In: *Staff Papers* 42(3), pp. 577–607.

Hendricks, L. (2004). *A database of Mincerian earnings regressions*.

Hsieh, C.-T. and P. J. Klenow (2010). "Development accounting". In: *American Economic Journal: Macroeconomics* 2(1), pp. 207–223.

Iranzo, S. and G. Peri (2009). "Migration and trade: Theory with an application to the Eastern-Western European integration". In: *Journal of International Economics* 79(1), pp. 1–19.

Javorcik, B. S., C. Ozden, M. Spatareanu, and C. Neagu (2011). "Migrant networks and foreign direct investment". In: *Journal of Development Economics* 94(2), pp. 231–241.

Jones, B. F. (2014). "The human capital stock: a generalized approach". In: *American Economic Review* 104(11), pp. 3752–77.

Justman, M. and J.-F. Thisse (1997). "Implications of the mobility of skilled labor for local public funding of higher education". In: *Economics Letters* 55(3), pp. 409–412.

Kerr, S. P., W. Kerr, Ç. Özden, and C. Parsons (2016). "Global talent flows". In: *Journal of Economic Perspectives* 30(4), pp. 83–106.

Khanna, G. and N. Morales (2017). *The IT Boom and Other Unintended Consequences of Chasing the American Dream*. Working Paper 460. Center for Global Development.

Khanna, G., E. Murathanoglu, C. Theoharides, and D. Yang (2022). *Abundance from abroad: migrant income and long-run economic development*. Working Paper 29862. NBER.

Kleemans, M. and J. Magruder (2018). "Labour Market Responses To Immigration: Evidence From Internal Migration Driven By Weather Shocks". In: *The Economic Journal* 128(613), pp. 2032–2065.

Kosack, E. (2021). "Guest Worker Programs and Human Capital Investment – The Bracero Program in Mexico, 1942–1964". In: *Journal of Human Resources* 56(2), pp. 570–592.

Krugman, P. (1980). "Scale Economies, Product Differentiation, and the Pattern of Trade". In: *American Economic Review* 70(5), pp. 950–959.

Kugler, M. and H. Rapoport (2007). "International labor and capital flows: Complements or substitutes?" In: *Economics Letters* 94(2), pp. 155–162.

Larch, M., J. E. Anderson, and Y. V. Yotov (2017). *Trade Liberalization, Growth, and FDI: A Structural Estimation Framework*. Annual Conference 2017 (Vienna): Alternative Structures for Money and Banking 168071. German Economic Association.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior". In: *Frontiers in econometrics*. Ed. by P. Zarembka. Academic Press: New York. Chap. 4, pp. 105–142.

McKenzie, D. and H. Rapoport (2011). "Can Migration Reduce Educational Attaintment? Evidence from Mexico". In: *Journal of Population Economics* 24(4), pp. 1331–1358.

Miyagiwa, K. (1991). "Scale economies in education and the brain drain problem". In: *International Economic Review*, pp. 743–759.

Monras, J. (2020). "Immigration and Wage Dynamics: Evidence from the Mexican Peso Crisis". In: *Journal of Political Economy* 128(8), pp. 3017–3089.

Mountford, A. (1997). "Can a brain drain be good for growth in the source economy?" In: *Journal of Development Economics* 53(2), pp. 287–303.

Munshi, K. (2003). "Networks in the Modern Economy: Mexican Migrants in the U.S. Labor Market". In: *Quarterly Journal of Economics* 118(2), pp. 549–599.

Murtin, F. and R. Wacziarg (2014). "The democratic transition". In: *Journal of Economic Growth* 19(2), pp. 141–181.

Ottaviano, G. I. and G. Peri (2012). "Rethinking the effect of immigration on wages". In: *Journal of the European Economic Association* 10(1), pp. 152–197.

Ozden, C. and H. Rapoport (2018). "Cross-country Perspectives on Migration and Development". In: *The Economic Journal* 128(612), pp. 174–178.

Palma, A. de and K. Kilani (2007). "Invariance of conditional maximum utility". In: *Journal of Economic Theory* 132(1), pp. 137–146.

Pan, Y. (2017). "The Impact of Removing Selective Migration Restrictions on Education: Evidence from China". In: *Journal of Human Resources* 52(3), pp. 859–885.

Parsons, C. R. and P.-L. Vezina (2018). "Migrant Networks and Trade: The Vietnamese Boat People as a Natural Experiment". In: *The Economic Journal* 128(612), pp. 210–234.

Restuccia, D. and G. Vandenbroucke (2013). "The evolution of education: A macroeconomic analysis". In: *International Economic Review* 54(3), pp. 915–936.

Shrestha, S. A. (2017). "No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants". In: *The Economic Journal* 127(600), pp. 495–521.

Silva, J. S. and S. Tenreyro (2011). "Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator". In: *Economics Letters* 112(2), pp. 220–222.

Stark, O., C. Helmenstein, and A. Prskawetz (1997). "A brain gain with a brain drain". In: *Economics letters* 55(2), pp. 227–234.

Stark, O. and Y. Wang (2002). "Inducing human capital formation: migration as a substitute for subsidies". In: *Journal of Public Economics* 86(1), pp. 29–46.

Teferra, D. (2007). "Higher education in sub-Saharan Africa". In: *International handbook of higher education*. Springer, pp. 557–569.

Theoharides, C. (2018). "Manila to Malaysia, Quezon to Qatar International Migration and Its Effects on Origin-Country Human Capital". In: *Journal of Human Resources* 53(4), pp. 1022–1049.

Theoharides, C. (2020). "The unintended consequences of migration policy on origin-country labor market decisions". In: *Journal of Development Economics* 142, p. 102271.

UNESCO (2023). *Global Education Monitoring Report 2023: Technology in education – A tool on whose terms?* Tech. rep. Paris.

Vidal, J.-P. (1998). "The effect of emigration on human capital formation". In: *Journal of Population Economics* 11(4), pp. 589–600.

Wong, K.-y. and C. K. Yip (1999). "Education, economic growth, and brain drain". In: *Journal of Economic Dynamics and Control* 23(5-6), pp. 699–726.

World Bank (2010). *Financing higher education in Africa*. The World Bank.

Yang, D. (2008). "International Migration, Remittances and Household Investment: Evidence from Philippine Migrants' Exchange Rate Shocks". In: *Economic Journal* 118(528), pp. 591–630.

Chapter 2

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

Abstract

Existing empirical literature provides converging evidence that selective emigration boosts human capital accumulation in the world's poorest countries. However, the within-country distribution of such *brain gain* effects has been largely disregarded. Focusing on Senegal, we provide evidence that the *brain gain* mechanism benefits the richest regions that are internationally connected and have better access to education. Human capital responses are negligible in regions lacking international connectivity, and even negative in better connected regions with poor access to education. These results also pertain to internal migration, suggesting that highly vulnerable populations are trapped in the least developed areas.

2.1 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 boosts domestic human capital accumulation, turning the brain drain into a brain gain. The main reason is that selective emigration prospects raise the expected returns to education and stimulate pre-migration human capital formation. This *incentive effect* dominates the pure *composition effect* (i.e. the fact that the propensity to emigrate increases with the level of education) in most of the world's poorest countries. Although exposure to international migration varies drastically across regions – e.g. 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 – the within-country distribution of these human capital responses has been largely disregarded.

In this paper, we focus on Senegal and investigate the effect of international and internal migration exposure on human capital and welfare disparities between regions. Senegal is an interesting case study. The country has shifted from a traditional country of destination in the Western Africa region to a country of emigration.[41] In addition, internal migration has significantly increased since the late 1990s due to the combined impact of underemployment, urbanization and degradation of natural resources, among others (Ba et al., 2017). Our analysis relies on the Senegalese census of 2013, which provides exceptionally rich data on households' exposure to international and internal migration. We use the data to calibrate a Random Utility Model (RUM) that jointly endogenizes migration and education decisions in the 45 *départements* of the country. The parameterization is such that the model exactly matches existing data as well as some relevant elasticities estimated in existing empirical literature. We use the model to identify populations that suffer from a lack of international and internal connectivity, and quantify the effect of exposure to mobility on welfare and upper-tail human capital disparities between regions, as proxied by the share of college graduates in the regional labor force.

While there is converging evidence that selective emigration to wealthier countries boosts upper-tail human capital accumulation in a majority of low-income and lower-middle income countries, we show that selective emigration to wealthier countries is beneficial to the country as a whole, but mostly benefits the richest regions that are internationally connected

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

and have better access to education. The welfare gains from international mobility are limited by the fact that highly vulnerable, trapped populations are too poor to migrate or have a poor access to education due to a persistent lack of economic development. International emigration thus increases gaps in human capital accumulation and welfare between the richest and poorest regions. We also find that internal labor mobility from poorer to richer regions can mitigate these effects, but the poorest regions of the country also lack internal connectivity and hardly benefit from inter-departmental migration opportunities. Hence, the *brain gain* outcome found at the national level is mostly driven by the net human capital gains experienced by the richest *départements* situated in the region of Dakar (Pikine, Guédiawaye, Ruffisque and Dakar) and in the surrounding areas (regions of Thiès and Diourbel). The human capital response to international migration is negligible in *départements* lacking international connectivity, or even negative in better connected *départements* with poor access to education. Overall, the region of Dakar enjoys a double dividend linked to both incentives driven by selective international migration prospects and inflows of human capital from the rest of the country.

Our paper speaks to the literature on human capital, migration and economic development. First, it is undisputed that human capital accumulation, economic growth and welfare are closely interrelated. The empirical literature suggests that the size and significance of the growth impact of human capital are stronger when human capital is not just measured as the average years of schooling or literacy rates, but with more exclusive and elitist measures such as the average stock of cognitive skills or knowledge capital, that Hanushek and Woesmann (2008); Hanushek and Woesmann (2021) suggest to proxy with international measures of math and science skills, or as the stock of upper-tail human capital – say, the share of tertiary educated workers – as evidenced in several studies focusing on the industrial revolution (e.g. Squicciarini and Voigtländer, 2015; Mokyr, 2005; Mokyr and Voth, 2009) or today's developing countries (e.g. Castelló-Climent and Mukhopadhyay, 2013). Our paper contributes to this literature by modeling the determinants of upper-tail human capital disparities between regions within a developing country.

Second, we contribute to the literature on brain drain, pre-migration human capital formation, and post-migration human capital accumulation. From a theoretical perspective, early contributions have underlined the effect of higher returns to education provided by the emigration option on human capital accumulation (Mountford, 1997; Stark et al., 1997; Vidal, 1998). Beyond higher expected returns, the emigration option could also provide a protection mechanism and incentivize a shift in investments from less-mobile (physical) capital to more mobile human capital in a context where economic uncertainty is higher in origin countries (Katz and Rapoport, 2005). Our model links endogenous education and emigration decisions in a multi-region (both in terms of origin and destination) context, but abstracts from economic uncertainty. Identifying the causal effect of selective emigration on human capital accumulation is a complex task because skill-specific emigration rates are endogenous. Cross-country regressions with instrumental-variable techniques show that selective migration is likely to boost education and post-migration human capital accumulation in developing countries (Beine et al., 2001; Beine et al., 2008; Beine et al., 2010), and even more so when focusing on the poorest countries of the world – i.e. low-income and lower-middle income countries (Cha'ngom et al., 2023). Case studies exploiting quasi-experimental settings show that shocks affecting skill-specific emigration prospects translate into greater levels of human capital after a few years – see Shrestha (2017) on Nepal, Abarcar and Theoharides (2021) on the Philippines, Khanna and Morales (2021) on India, and Chand and M. A. Clemens (2019) on the Fiji.[42] Similar results are obtained in studies exploiting long-lasting spatial variations in exposure to emigration between regions (Batista et al., 2012; Theoharides, 2018).[43] We use here an alternative micro-founded approach that jointly endogenizes migration and education decisions as a function of regional characteristics.

We focus on the within-country responses to selective emigration. Large regional disparities in human capital accumulation are observed in low-income and lower-middle income countries. For example, Gollin et al. (2014) and Vollrath (2009) document that the urban/rural ratio of years of schooling varies between 2.0 or 1.5 in poor countries. In addition, existing case studies reveal that exposure to selective migration varies drastically across regions in developing countries (Batista et al., 2012; Abarcar and Theoharides, 2021; Theoharides, 2018). Given huge heterogeneity in international connectivity and access to education between regions, we investigate whether selective migration flows across Senegalese regions increase or decrease regional disparities in human capital.

Finally, we also contribute to the literature on internal migration and education decisions. Bryan et al. (2014a) use randomized controlled trials to study the effect of rural-to-urban migration in rural Bangladesh during the lean season. They find that having a migrant in the household significantly increases the households' expenditure on children's education.[44] Other contributions investigate the effect of the Hukou system in China. Pan (2017) and

[42] Exploiting a government lottery that randomly allocated visas to Bangladeshis for low-skilled temporary labor contracts in Malaysia, Mobarak et al. (2023) highlight that the increase in pre-departure investments are largely focused on skills (partially required by Malaysia, the destination country) that generate no returns on the domestic labor market.

[43] Other mechanisms of transmission have been identified in the literature, such as remittances (Khanna et al., 2022; M. Clemens and Tiongson, 2017; Dinkelman and Mariotti, 2016; Dinkelman et al., 2021), 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.

[44] Relying on the same context, Lagakos et al. (2023) develop a dynamic incomplete-markets model in which seasonal migration acts as an insurance mechanism for vulnerable households that own little assets and are financially constrained. Meghir et al. (2022) further find that the temporary migration subsidies in the Bangladeshi context can have spillover effects beyond the benefiting household and improve risk sharing within the migrant's village.

Brauw and Giles (2017) find that negatively selected migration reduces the probability of transition from middle to high school in rural areas. Some related studies find that improving the connectivity of poor regions impacts education choices in both developed and developing countries.[45] Our micro-founded model allows to compare the effects of international and internal movements on human capital disparities between Senegalese regions.

The rest of this paper is organized as follows. Section 2.2 describes our data sources and characterizes regional disparities in exposure to international and internal migration in Senegal. In Section 2.3, we develop a Random Utility Model (RUM) that jointly endogenizes mobility and education decisions, and we parameterize it to match the data as well as empirical estimates from existing literature. Section 2.4 presents our quantitative analysis. Finally, Section 2.5 concludes.

2.2 Context, Data and Facts

Context. – Migration patterns from Senegalese regions result from both historical events and the increasing demographic share of the Dakar region. At the beginning of the 20th century,[46] the first Senegalese migrants were sailors, traders and demobilised soldiers. Sailors departed due to the decline in traffic on the Senegal River and joined the merchant navy and the French war navy (Robin, 2000). Yet, international emigration did not really take off until the 1960s, when the French *Office National de l'Immigration* opened recruitment centers in Senegal at the initiative of French firms (supported by the French Ministry of Labour and Population). The French automobile industry recruited massively in the Senegal River valley, in the Tambacounda region and in Casamance (including all *départments* south of the Gambia), at a time when rural Senegal was affected by a succession of droughts (Robin, 1996). As for African destinations, the economic success of Ivory Coast and Ghana directed Senegalese migrant farmers and traders to these countries, but also to Gabon, Zaire and Cameroon. However, the crisis in groundnut cultivation, caused in particular by the successive droughts from the 1970s onward, reinforced international emigration towards Europe. Until the 1980s, most of these migrants came from the Senegal River valley, and increasingly settled in France despite the official end to immigration programs in 1974. The immigration policy of 1975 and 1976 in France transformed traditional labor immigration, composed essentially of single men, into family immigration (Robin, 2000).

[45] 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.

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

Since the 1980s, the capital has been an important pole of international emigration, especially because of the increasing share of Dakar in the national population. Despite a progressive rise in the share of young adults taking at least some steps towards emigrating internationally (1 out of 3 young adults in Dakar in 2000-2008), their probability of actually emigrating from Dakar changed little until the late 2000s (approximately 1 in 10 young adults; Beauchemin et al. (2020); Lessault and Flahaux (2013)). From the 1990s onwards, Senegalese emigration was also affected by emigration from the regions of Diourbel, Thiès and Louga (formerly Baol, Cayor and Djambour). African destinations gradually declined to the benefit of a more diversified range of high-income countries.[47] Two new destinations emerged: Italy and Spain (Robin, 1996). Senegalese immigration to the United States dates back to the early 1980s and reflects a certain loss of momentum in Senegalese immigration to Africa.

Data sources. – We use data from the 2013 Senegalese census. The data cover the universe of the population (about 13.2 million individuals), and include a rich set of individual characteristics such as age, educational attainment and the administrative regions of birth and residence, among others. We only consider individuals aged 15 and more, and divide this population into two skill groups, college graduates (i.e. individuals with tertiary/higher education degrees and the less educated). We thus focus on the accumulation of upper-tail human capital, which has proven to be relevant for modeling growth and productivity differentials across countries and periods (Mokyr and Voth, 2009; Castelló-Climent and Mukhopadhyay, 2013).

Senegal is subdivided into four levels of administrative divisions, 14 *régions*, 45 *départements*, 133 *arrondissements*, and 548 *communes* or municipalities. Our quantitative analysis in Section 2.4 is conducted at the *département* level. This choice is guided by the availability of income data by education level as well as by its relevance to formalize residential mobility between administrative units and spatial disparities in the access to tertiary education. Commuting flows between *départements* are limited, with the exception of the region of Dakar, where the mean *département* size is smaller and the transport infrastructure is better.

A key feature of the Senegalese census is that it provides exceptionally rich information on households' migratory background and exposure to international migration:

- First, it includes detailed questions on the department of birth of each respondent. By comparing places of birth and residence, we can accurately measure the stock of (lifetime) internal migrants between *départements*. By using the concept of lifetime migration (i.e. people living in a *département* that differs from their *département* of birth) rather than migration flows, we approach migration as a life-course trajectory, and

[47] Trans-Saharan migrations were reactivated, notably via Morocco which has become a transit country.

focus on the long-term location choices of individuals. By 2013, there were 1,546,378 internal migrants in Senegal, which corresponds to about 24.1% of the working-age population.[48] These include 106,747 college graduates, representing about 47.2% of the college-educated working-age Senegalese population.

- Second, the census includes questions on household members who have left the country over the last five years. This allows us to generate flow data by place of residence, country of destination and education level. Between 2008 and 2013, the census records 150,370 working age international emigrants (among whom 11.1% were college graduates). We use the information on these emigrant flows to proxy the structure of the stock of international Senegalese migrants by *départements* of origin. More precisely, we use the five-year flows to compute the skill-specific shares of emigrants to OECD countries by department of origin, and then multiply the total stock of Senegalese migrants living in an OECD member state in the year 2015 by these shares. Data on immigration to OECD countries are taken from Arslan et al. (2015), who document the characteristics of 311,066 Senegalese migrants.

Table A.1 provides the country codes used throughout this paper and some descriptive statistics on the population structure for the 45 Senegalese *départements*.

Stylized facts. – The 2013 census allows us to proxy the skill-specific stocks of lifetime internal and international migrants by *département* of origin and by *département* or country of destination. Aggregating dyadic mobility at the *région* level, Figure 2.2.1 describes lifetime movements of international (top Panel) and internal (bottom Panel) migrants, respectively. Panels (a) and (c) depict the movements of college graduates, while Panels (b) and (d) focus on the less educated.

The role of Dakar as a main source of international migrants, and a main destination for internal movers is well illustrated. This is particularly the case for college-educated migrants. Most of high-skilled international migrants originate from the Dakar region (followed by the neighboring region of Thiès), and are living in one of the OECD members states. Focusing on internal migrants, Dakar is by far the main destination, and movers originate from all over the country. For both international and internal, college-educated migration, the largest *régions* of origin are Thiès, Saint-Louis, Ziguinchor, Diourbel, Kaolack and Fatick.

Focusing on less educated migrants, the region of Dakar remains the main region of origin. Nevertheless, due to the persistence of ancient 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 account for a

[48] Among them, 471,527 internal migrants moved over the last five years.

significant fraction of the total stock of international migrants. With regard to low-skilled internal migrants, Dakar hosts 349,610 of them. Thiès and Diourbel are also attractive regions, attracting together 377,275 movers.

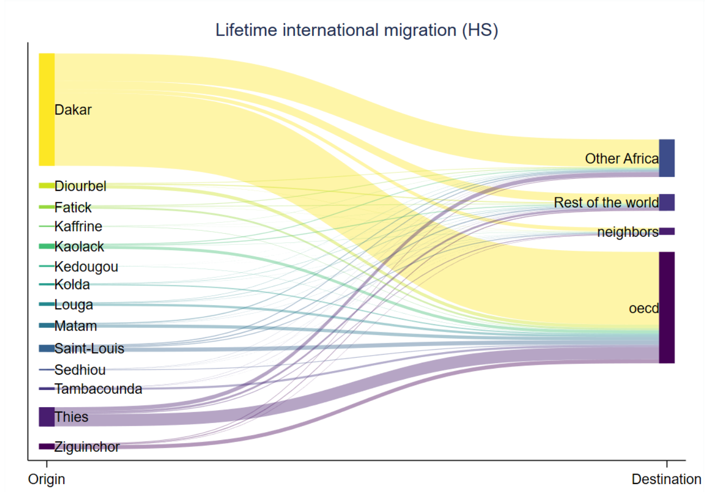
These disparities in the size of lifetime movements are partly due to differences in native population size between regions. In particular, the four *départements* of the Dakar region (Dakar, Rufisque, Pikine, and Guédiawaye) account for 18% of the Senegalese adult population but 45% of the college-educated population. To better illustrate heterogeneity in exposure to international and internal movements, we express each skill-specific emigration stock as percentage of the corresponding native population, what we refer to as an emigration rate. The spatial distribution of these emigration rates reflects differences in international and internal connectivity of the high- and low-skilled populations. Figure 2.2.2 below maps those disparities in connectivity between *départements*.

With regard to international migration (top panels), the largest emigration rates of college-educated people are observed in five *départements*, namely Dakar, Guédiawaye, Pikine and Rufisque (all belonging to the Dakar region), and Kanel (in the Matam region). Moderate emigration rates are also observed in the poorer *départements* of Mbacké, Matam, Goudiry and Bakel. The other regions lack international connectivity. The largest emigration rates of less-educated people are observed in the same *départements* and in the Senegal river regions at the border with Mali and Mauritania, which are still relatively well connected internationally. These are, however, much lower than the emigration rates of college-educated people.

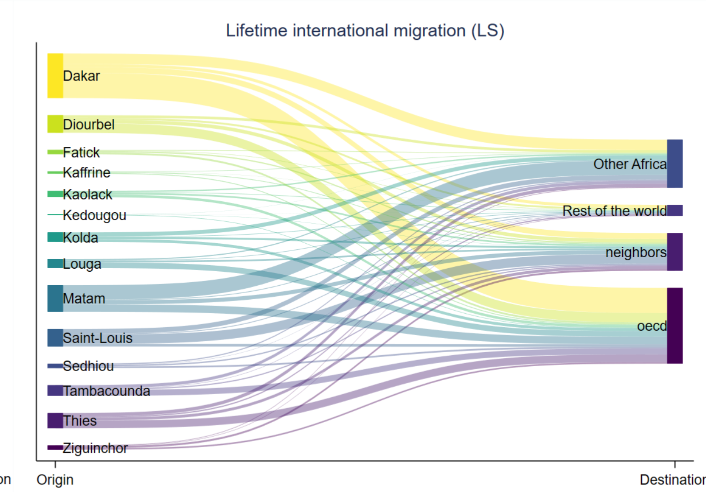
Focusing on internal movements (bottom panels), the distribution of high-skilled emigration rates is more uniform across the country, although the Eastern *départements* are less connected internally (contrary to international migration). The *département* of Salémata (in Kédougou region) exhibits high emigration rates. In contrast, the distribution of low-skilled emigration rates indicates a lack of internal connectivity in many *départements*. With the exception of Salémata, distance from Dakar appears to be an excellent predictor of this isolation.

Figure 2.2.1: Stock of international and internal migrants by education level, *département* of origin and destination

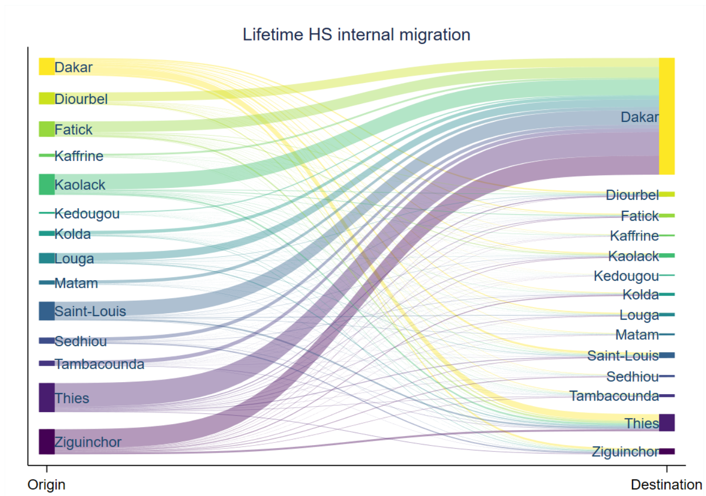
(**a**) International – College graduates



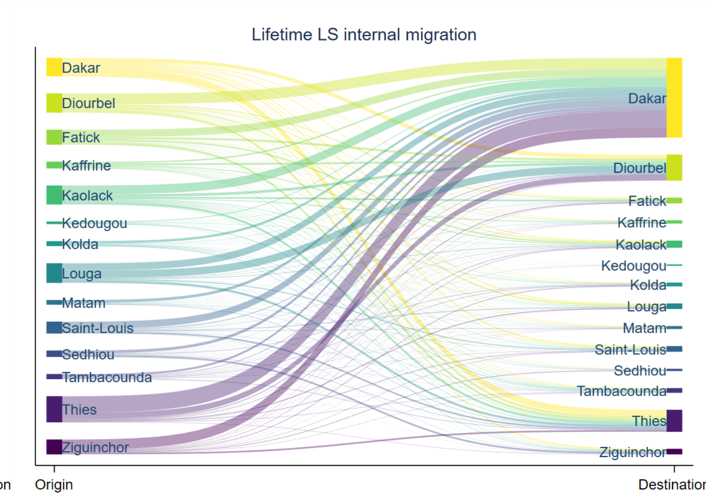
(**b**) International – Less educated



(**c**) Internal – College graduates

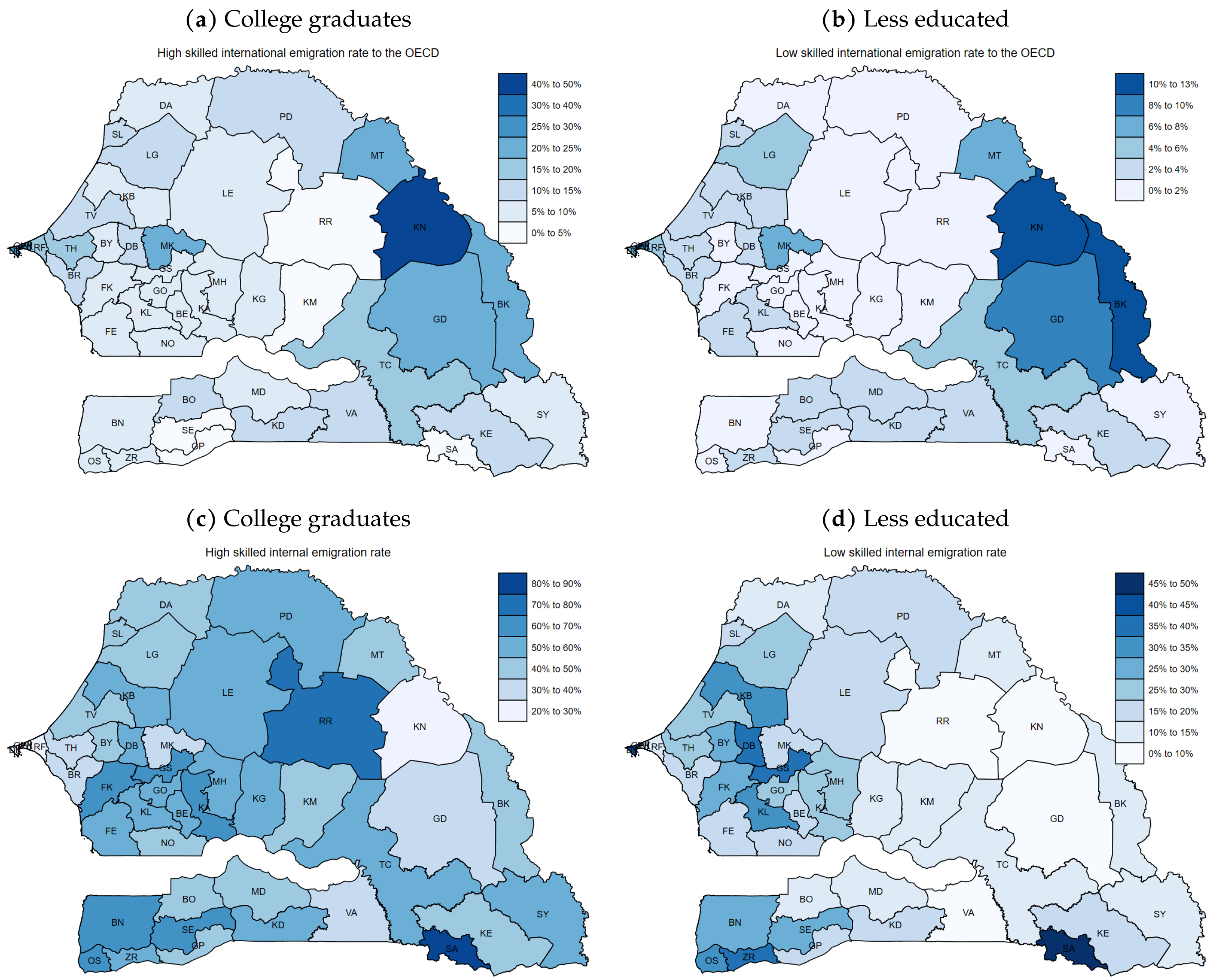


(**d**) Internal – Less educated



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

Figure 2.2.2: International and internal emigration rates by education level and *département* of origin



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

2.3 Model

To investigate the impact of international and internal mobility on human capital disparities in Senegal, we build and parameterize a model that jointly endogenizes the fraction of the (native) population from each *départments* i choosing to acquire college education (H_i),[49] the skill-specific share of people choosing to emigrate to another (international or internal) destination j ($m_{ij,s}$), and the share of college graduates in the regional labor force (h_i).[50] Individuals can choose between two skill types $s = (h, l)$, with $s = h$ for college graduates and $s = l$ for the less-educated, and the set of possible locations $\mathbb{J}$ includes a subset J of internal destinations ($j = 1, ..., J$), the *départments* of Senegal, as well as a subset J^* of F foreign destinations ($j = J + 1, ..., J + F$). Our model accounts for region-specific factors influencing the dyadic structure of mobility flows (such as dyadic migration costs, income disparities with easily accessible regions and foreign countries) as well as access to education (such as the education policy, the distribution of individual ability to educate). We abstract from general equilibrium effects (wages are constant), and from the temporal dimension.[51] We characterize decisions made by a given cohort over its active life and do not model fertility decisions.[52]

RUM structure. – Migration and education decisions are modeled as outcomes of a Random Utility Model (RUM) with two sources of heterogeneity between individuals – in the ability to acquire higher education and in preferences for various destinations (as in Cha'ngom et al., 2023; Delogu et al., 2018). The utility of an individual λ born in region i, choosing education type-s and moving to a destination j is given by:

$$U_{ij,s}^{\lambda} = \left[\ln \omega_i^{\lambda} + \ln\left(1 - \frac{e_s^{\lambda}}{G_i}\right)\right] + \left[\ln w_{j,s} + \ln(1 - c_{ij,s}) + \varepsilon_{ij,s}^{\lambda}\right], \tag{2.1}$$

49 A (pre-migration) process that we refer to as human capital formation.

50 A (post-migration) process that we refer to as human capital accumulation.

51 Endogenous wages would affect the magnitude of the effects depending on the interplay of the substitution and complementarity channels between educated and less-educated workers (in a context where natives and internal migrants are likely close to perfect substitutes). If substitution effects dominate, competition by additional educated immigrant workers would decrease high-skilled wages at destination and increase them at origin, thereby mitigating incentives to emigrate. The same would occur in the presence of congestion effects. In contrast, strong complemenarities between highly- and less-educated workers, increasing returns to scale and/or agglomeration effects would reinforce incentives to emigrate towards high-productivity areas, in particular under skill-biased externalities (see Delogu et al. (2018) for a quantification of these channels in the context of international migration).

52 A growing literature accounts for endogenous population growth and stresses that migration opportunities (Delogu et al., 2018) in particular if they are skill-biased (Mountford and Rapoport, 2011; Mountford and Rapoport, 2016; Docquier and Machado, 2016) can affect the quantity-quality trade-off in the fertility decision, reducing population growth and increasing education in origin countries. These population dynamics can reinforce inequality by further fostering human capital dynamics in the destination regions (where the more educated population has less and more educated children) relative to origin regions.

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).[53] 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):

$$\mathbb{E}\left(U_{i,s}^\lambda\right) = \left[\ln \omega_i^\lambda + \ln\left(1 - \frac{e_s^\lambda}{G_i}\right)\right] + \ln \sum_{j=1}^{\mathbb{J}} \left(w_{j,s}\right)^{1/\mu} \left(1 - c_{ij,s}\right)^{1/\mu}, \tag{2.2}$$

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 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

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

born in department i, the expected value of post-migration maximum utility (i.e. the second term in Eq. (2.2)) can be rewritten as:

$$\Omega_{i,s} = \ln\left[(w_{i,s})^{1/\mu} + (W_{i,s})^{1/\mu} + (W^*_{i,s})^{1/\mu}\right], \tag{2.3}$$

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 $\Omega^{NM}_{i,s} \equiv (1/\mu)\ln w_{i,s}$.[54] 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 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. (2.2), this condition holds if the cost of acquiring higher education is not too large:

$$e^{\lambda}_h \leq G_i\left[\frac{\Lambda_i - 1}{\Lambda_i}\right], \tag{2.4}$$

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:

$$\Lambda_i \equiv \frac{\exp(\Omega_{i,h})}{\exp(\Omega_{i,l})} \equiv \frac{(w_{i,h})^{1/\mu} + (W_{i,h})^{1/\mu} + (W^*_{i,h})^{1/\mu}}{(w_{i,l})^{1/\mu} + (W_{i,l})^{1/\mu} + (W^*_{i,l})^{1/\mu}}, \tag{2.5}$$

[54] 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:

$$H_i = G_i^{1+z} \left[\frac{\Lambda_i - 1}{\Lambda_i} \right]^{1+z}. \tag{2.6}$$

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) and Vidal (1998). 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. – 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. Under the Type I Extreme Value distribution, the probability that a type-s individual born in region i moves to destination j is governed 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 $\frac{W^*_{i,h}}{W^*_{i,l}}$).

Again, the model has desired properties in line with empirical work. 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). Finally, in line 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., McKenzie and Rapoport, 2011; Brauw and Giles, 2017; Pan, 2017; Kosack, 2021). This establishes the micro-foundations for the link between mobility prospects and pre-migration human capital formation in a dyadic framework with 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.

Finally, it is worth noting that under the Type I extreme-value distribution for ε, the conditional (on the chosen alternative) and the unconditional distributions of maximum post-migration utility coincide, whatever the chosen alternative (Palma and Kilani, 2007). This means that:

$$\Omega_{i,s} = \mathbb{E}\left[\ln w_{j,s} + \ln(1 - c_{ij,s}) + \varepsilon_{ij,s} | U_{i,j,s} = \max_{k \in \mathbb{J}} U_{i,k,s}\right] \; \forall j, \tag{2.7}$$

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 ($I_{i,s}$):

$$h_i \equiv \frac{(1 - m_{i,h}) H_i N_i + I_{i,h}}{(1 - m_{i,h}) H_i N_i + I_{i,h} + (1 - m_{i,l})(1 - H_i) N_i + I_{i,l}}, \tag{2.8}$$

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); Beine et al. (2008); Beine et al. (2010) and Cha'ngom et al. (2023).

Parameterization. – We parameterize our model to exactly fit 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 produce estimates of the skill-specific wages, we use data from the Senegalese Labor Force Survey. We compute the average monthly salary of college graduates and less educated workers in each *département*, adjusted for workers' participation rates and rescaled to match the annual level of GDP in PPP value. Hence, our income data are compatible with those observed in the OECD countries, taken from Cha'ngom et al. (2023). We only consider labor income, leaving aside non labor income. On average, college graduates earn about 3 times more than the less educated in Senegal. With regard to migration, we use the data on dyadic emigration stocks ($M_{ij,s}$), including the population of non-movers ($M_{ii,s}$), by education level described in Section 2.2. In our set of destinations, we distinguish between the 45 *départements* of Senegal, a single foreign entity gathering all OECD member states, and another one aggregating the rest of the world (which mostly, but not only, includes contiguous African countries). From Eq. (2.3), the ratio of movers to non-movers is given 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 between 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)). Dyadic migration costs ($c_{ij,s}$) are then obtained as a residual to exactly match the ratio of movers to non-movers from the data.

As a validation exercise, Table 2.3.1 shows that the calibrated levels of internal migration costs are positively correlated with the geodesic distance between *départements*, and the effect of distance barely varies across skill groups. Moving costs for college graduates decrease with cultural proximity and the mean distance to road within the *départements*. Although weakly significant, moving costs for the less educated are positively correlated to access to cities, which may suggest that a better mobility within the *départements* for low-skilled workers – including from rural to urban areas – reduces the need to move to a different location. Mobility costs are negatively correlated with the average income per worker at the *département* level, and the more so for college graduates. This suggests that migration costs are less difficult to bear when the local economic conditions at origin are better.

Figure 2.3.1 maps the calibrated levels of international and internal migration cost. For exposition purpose, the latter are restricted to migration costs to Dakar. To a large extent, these costs mirror disparities in emigration rates depicted in Figure 2.2.2. With regard to international migration costs, they are large for college-educated people with the exception of the Dakar region and Kanel (Matam region) as well as, to a lesser extent, some *départements* such as Saint-Louis and Louga (Saint-Louis region), Thiès and M'bour (Thiès region), Foundiougne (Fatick region), Ziguinchor, Sédhiou and the Eastern part of the country. With exception of Dakar, Guédiawaye and Pikine, low-skilled people face very high emigration costs. Focusing on internal migration costs, mobility of college graduates is relatively high in the whole

Table 2.3.1: 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.

country, with the exception of the *départements* located in the North of the country (Dagana and Podor), in the region of Kaffrine and in Koumpentoum, or in border areas with the Gambia (Bounkiling, Médina Yoro Foulah). Internal migration costs for the low skilled are much higher, except in the *départements* of Thiès, Djourbel and Fatick, as well as in Ziguinchor, Sédhiou and Salémata.

With regard to the education technology, we parameterize two unknown parameters, z and G_i to match data on emigration stocks and human capital levels. Parameter z determines the sensitivity of pre-migration human capital levels to selective migration prospects. Cha'ngom et al. (2023) calibrate it to match the semi-elasticities estimated empirically for four broad country income groups. We set $z = 3.8$, which matches the long-run semi-elasticity that they estimate for the group of lower-middle income countries (equal to 3.2).[55] Given z, the scale variable G_i is then calibrated as a residual from Eq. (2.6) in order to match the pre-migration human capital levels, H_i, observed in the data.

As a validation exercise, Table 2.3.2 shows that the calibrated values of G_i are positively correlated with the share of population living in urban areas, with the average income per worker, and with the number of schools at the level of the *departement*. Although these variables exhibit high levels of collinearity, they all remain significant and explain more than 3/4 of the variability in G_i when included jointly. Figure 2.3.2 maps the calibrated level of access to education in Senegal. Apart from the four *départements* of the Dakar region (i.e. Dakar, Guédiawaye, Pikine and Rufisque) and Bambey (Diourbel region), access to education is low to very low in the rest of the country. This means that selective emigration prospects are likely to induce large effects on human capital formation.

Table 2.3.2: Validation of calibrated provision of public education

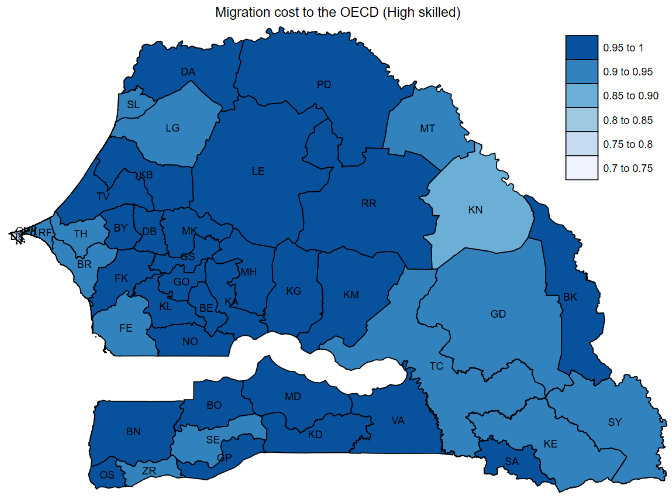
	(1)	(2)	(3)
Urban (as %)	0.261***		0.148**
	(0.040)		(0.059)
Nb. schools (logs)		0.043***	0.026***
		(0.005)	(0.008)
Income p.w. (logs)	0.069***	0.106***	0.078***
	(0.019)	(0.018)	(0.020)
Nb. Obs.	45	45	45
R-Sq.	0.70	0.71	0.76

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

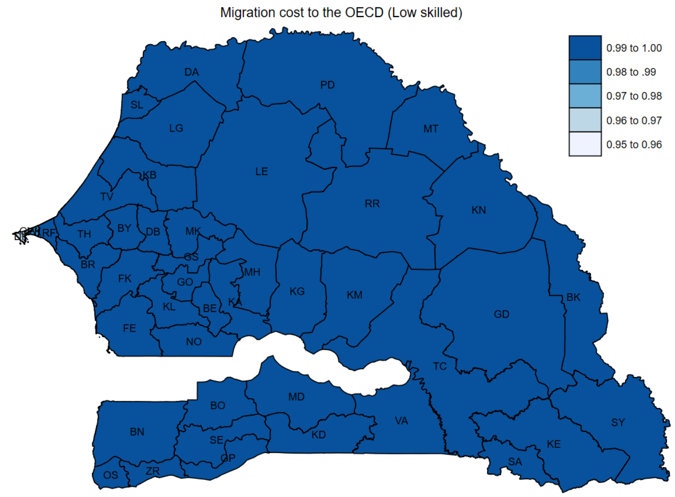
[55] This means that a 10 percentage-point gap between high and low-skilled emigration rates stimulates pre-migration human capital levels by 32% (e.g. increases the share of college graduates from 3.00 to 3.96%).

Figure 2.3.1: Calibrated migration costs $(c_{ij,s})$ by *département*

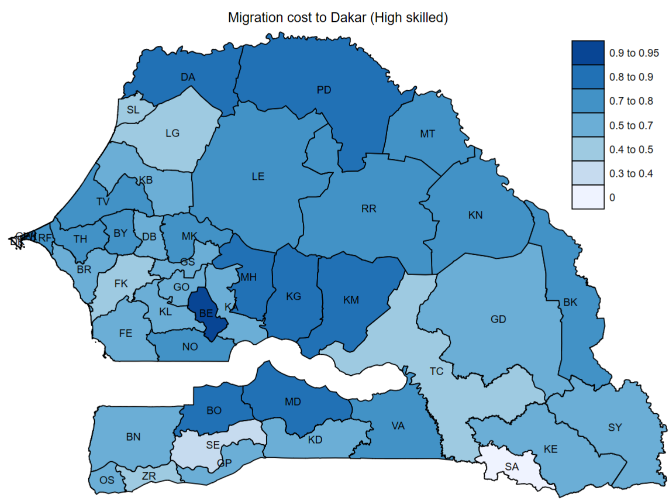
(**a**) International – College graduates



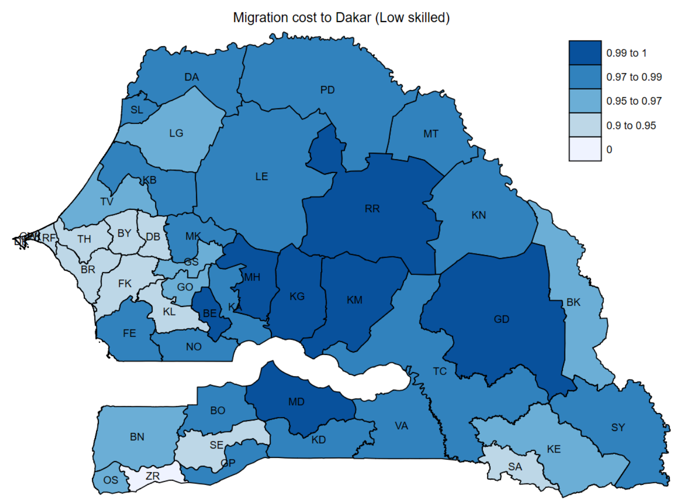
(**b**) International – Less educated



(**c**) Internal – College graduates

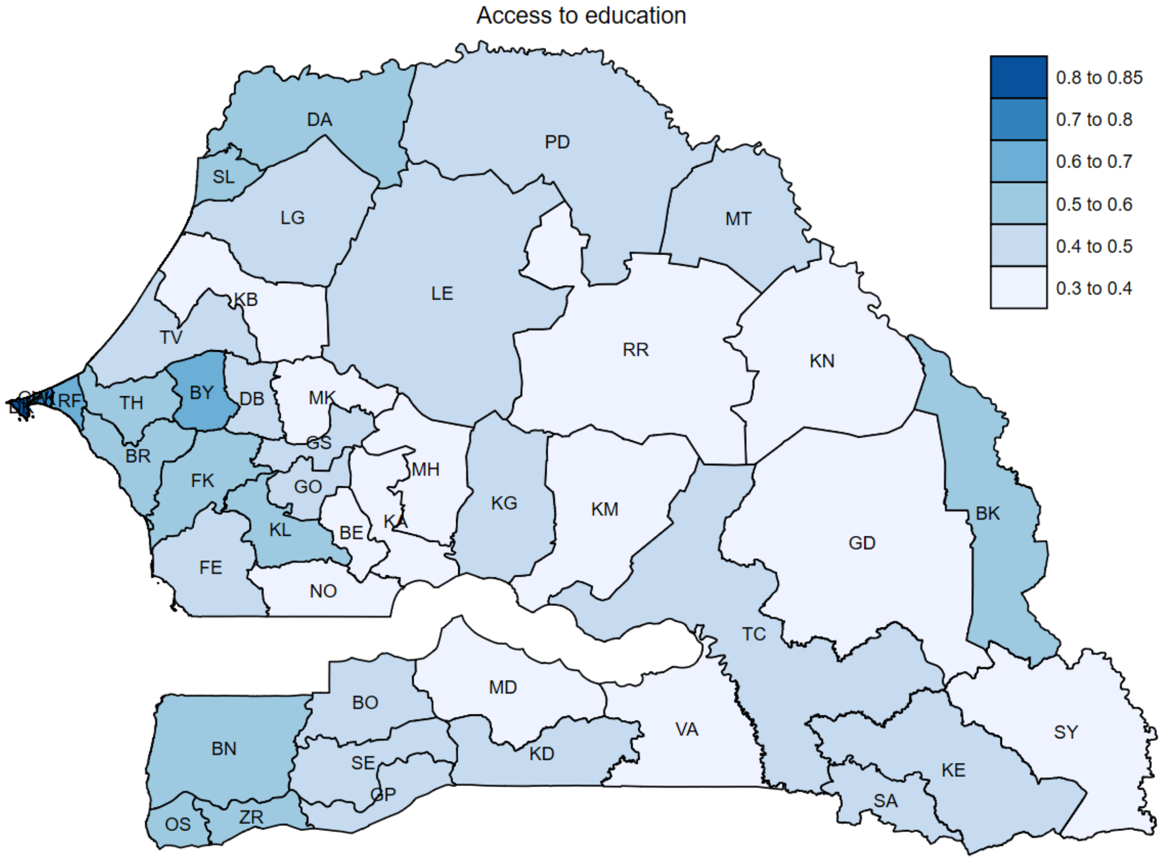


(**d**) Internal – Less educated



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

Figure 2.3.2: Calibrated access to education (G_i) by *département*



Note: Authors' computations.

2.4 Quantitative Results

We use our parameterized model to compare the current equilibrium with no-emigration scenarios, assuming constant wages. We first compare the current situation with a counterfactual without international migration opportunities (i.e. $c_{ij,s} = 1, \forall j \in J^*$ and $\forall s$). We focus on emigration to the OECD member states, as these countries are likely to have the strongest effects on selective migration prospects.[56] We then consider a second counterfactual without internal migration opportunities (i.e. $c_{ij,s} = 1, \forall j \in J \setminus \{i\}$ and $\forall s$), and a third counterfactual combing the first two scenarios (i.e. without international and internal migration opportunities).

We first investigate how international and internal mobility affect average welfare

[56] Senegalese migration to the rest of the world mostly includes migration to other African countries (contiguous countries, South Africa, and Northern African countries). Although our calibrated model also accounts for international migration to the rest of the world, our estimates for skill-specific wages are much more imprecise for these countries. We hence abstract from changing migration costs to the rest of the world.

disparities between birthplaces. Second, we quantify the effect of international and internal mobility on the expected return to higher education. Third, we examine how mobility impacts the post-migration share of college graduates in the regional labor force. In all cases, we compare the observed level of the variables of interest with the one obtained in the no-migration scenario.

Effects on welfare. – To estimate the welfare gains from emigration opportunities, we use the expected value of post-migration utility, as measured by $\Omega_{i,s}$ defined in Eq. (2.3). Remember that this variable captures both unconditional and conditional (on the chosen alternative) mean values of maximum utility for individuals born in region i. In Figure 2.4.1, 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 counterfactual, labeled as NM. Results for college graduates are presented in the left panel, while those for the less educated are shown 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 driven by selective emigration (expressed as a percentage of the NM counterfactual level).

The top panel of Figure 2.4.1 shows the welfare effects generated by international migration opportunities. Unsurprisingly, the latter boost the welfare of college graduates by more than 30% in the *départments* exhibiting the largest emigration rates (Dakar, Guédiawaye, Pikine, Mbacké, Matam, Goudiry, Bakel and Kanel). In Kanel, welfare even increases by 85%. In the rest of the country, welfare is less strongly affected by international migration. This is particularly the case of Salémata, a *départment* benefiting a lot from internal migration opportunities (see below), but lacking international connectivity. Overall, the correlation between the welfare effects from international migration and the no-migration level is rather low, indicating that high-skilled emigration prospects hardly influence inter-*départment* disparities in welfare among college-educated individuals. Things are different when looking at the welfare effects for the less educated. With the exception of a few *départments* (Eastern regions at the border with Mauritania and Mali in general, and Kanel in particular), international connectivity is drastically biased towards the richest *départments* of the Dakar region. The welfare of the less educated increases by 5 to 13% in these *départments*. This is significantly smaller than the welfare response to high-skilled migration. In poorer *départments*, the welfare effects from low-skilled migration is very low. Overall, this implies that international migration prospects increase inter-*départment* disparities in welfare within the low-skilled population.

The welfare effects generated by internal migration prospects are depicted in the middle panel of Figure 2.4.1. As shown in Figure 2.2.2, internal connectivity is rather high for college graduates from all regions. Contrary to international migration, the richest *départments* of the Dakar region benefit less from high-skilled internal emigration than the poorer *départments*.

While the welfare gains for college graduates are around 25% in the Dakar region, they are close to 100% in most other regions. The *départment* of Salémata is particularly well connected internally (+240% in welfare). This implies that internal migration reduces inter-*département* disparities in welfare among the highly educated. In contrast, with the exception of Salémata (+75% in welfare), internal connectivity is low (or very low) for less educated individuals born in regions that are distant from Dakar (see Figure 2.3.1). The least internally connected *départments* are located in the regions of Matam (Ranérou Ferlo, Kanel, Matam), Tambacounda (Goudiry, Koumpentoum, Tambacounda), Kolda (Vélingara, Médina Yoro Foulah) and Sédhiou (Bounkiling), and exhibit limited welfare gains around 10%. Overall, internal migration prospects increase inter-*département* disparities in welfare among the less educated, who account for the overwhelming majority of the Senegalese population.

Looking at the combined effects of internal and international migration in the bottom panel of Figure 2.4.1, it appears that mobility slightly decreases welfare disparities within the college-educated population, and induces large welfare effects in the vicinity of 100% in many *départements*. In contrast, mobility strongly increases welfare disparities within the less educated population, inducing large gains in the vicinity of 60% in the richest *départements* and smaller gains around 15% in the least connected ones.

Effects on expected skill premium. – We now turn our attention to human capital formation. Migration prospects affect individual incentives to invest in higher education. In the top panels of Figure 2.4.2, we focus on the expected skill premium, as measured by λ_i defined in Eq. (2.5). 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}. The skill-premium responses are closely related to the differential in welfare effects between college graduates and the less educated. Due to positive selection in international and internal migration, this differential is positive in almost all *départements*. Yet, its magnitude is very heterogeneous.

In Panel (a), we find that the greatest skill-premium responses to international migration prospects are observed in the richest *départements* where human capital is already abundant and no-migration skill premia are low. The skill premium is boosted by 30 to 60% in the Dakar region and by more than 100% in Kanel (Matam region), while it increases by less than 10% in the *départements* where human capital is scarce and no-migration skill premia are large. Hence, international migration tends to increase incentives to acquire human capital in the richest regions, implying that the national *brain gain* is strongly driven by these *départements*.[57]

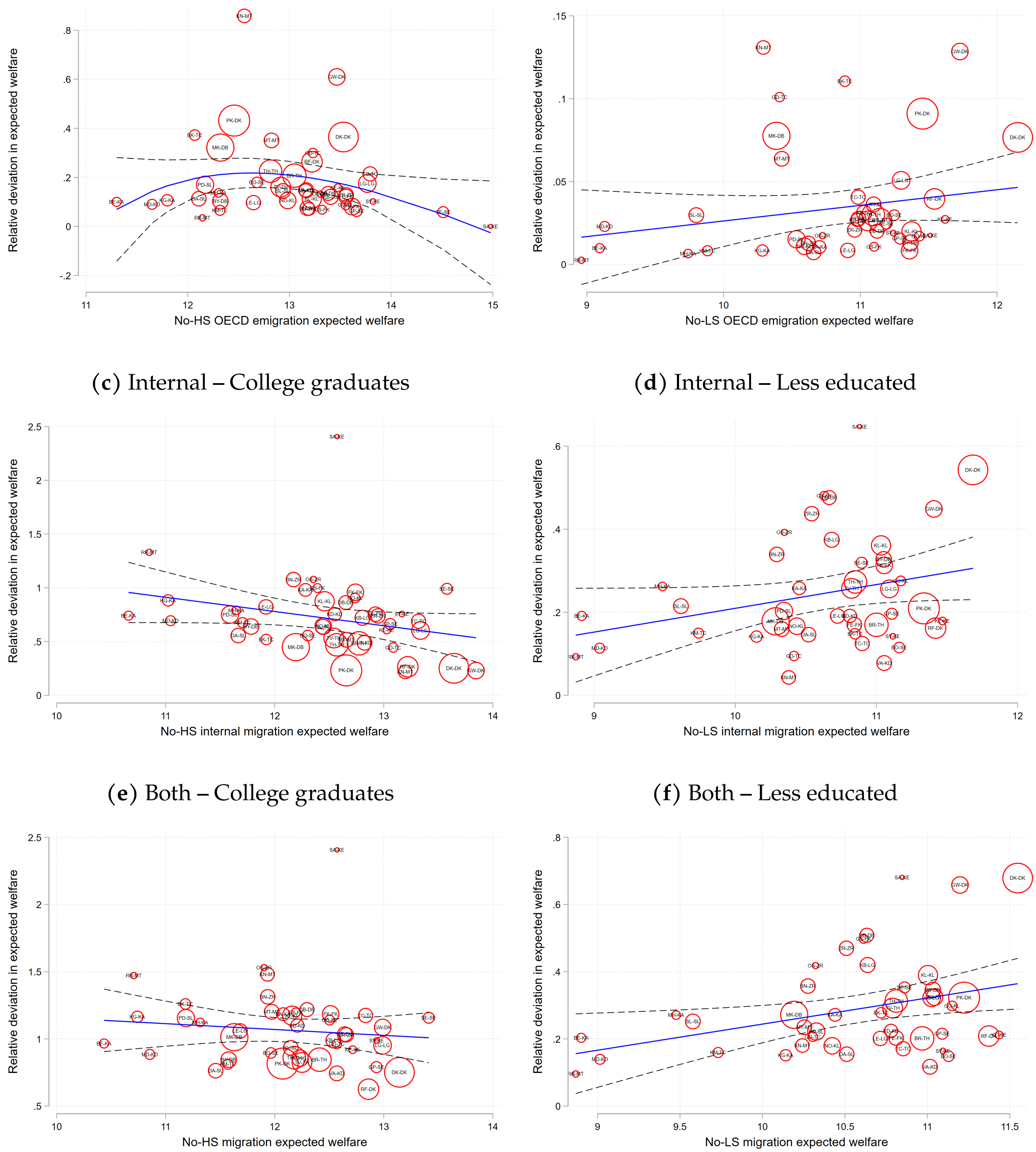
[57] The country-wide average share of college graduates in 2010 is around 3.0%. Cha'ngom et al. (2023) estimate that this share would be one percentage point lower without selective international migration prospects.

Figure 2.4.1: 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*.

Panel (b) shows that internal migration prospects drive qualitatively similar effects, although the correlation is less strong. With the exception of Dakar, internal connectivity is larger than international connectivity. Hence, in the Dakar region, internal migration prospects have only little positive or even a negative impact on the expected skill premium, while in most other regions, the positive effect varies between 40 and 100%. The largest responses are observed in *départements* at the middle of the no-migration counterfactual distribution. The skill premium almost increases threefold in the *départements* of Kanel and Ranérou Ferlo (Matam region).

Combining internal and international migration in Panel (c), we find that the total effect of mobility on incentives to acquire human capital is primarily governed by internal migration prospects. Expected skill premia are boosted by 100 to 200% in many regions, with the highest effects in Salémata, Ranérou Ferlo, Kanel and Oussouye. The smallest effects are in the richest regions: Dakar (Pikine, Rufisque, Guédiawaye and Dakar), Thiès (Tivaouane, M'bour and Thiès) or Diourbel (Bambey).

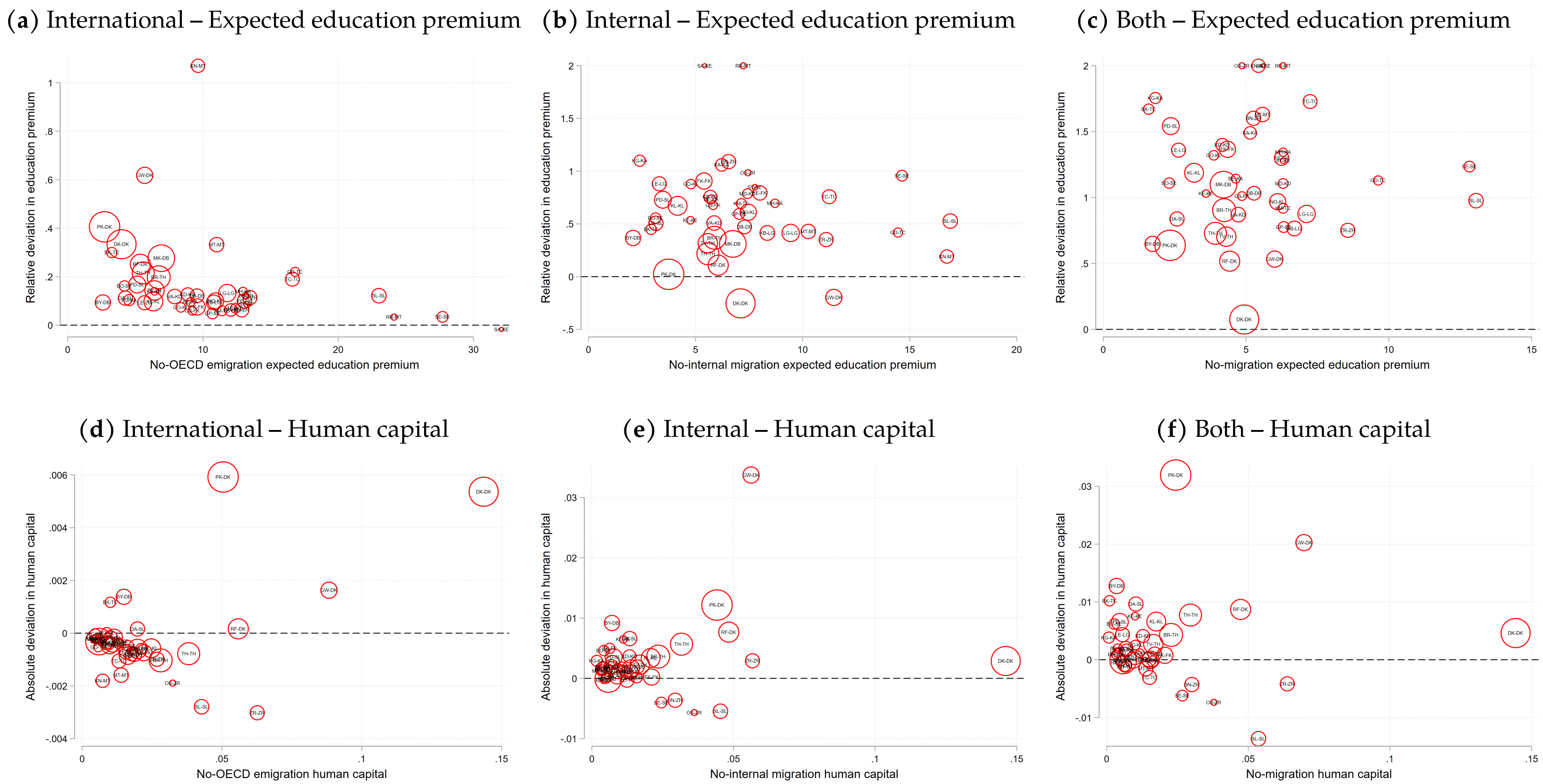
Effect on human capital accumulation. – We finally investigate the net effect of migration prospects on (post-migration) human capital accumulation, measured by h_i and defined in Eq. (2.8). In the bottom panels of Figure 2.4.2, we plot the migration-driven change in human capital, $\Delta h_i \equiv h_i - h_i^{NM}$ (expressed as a percentage point deviation), against the no-migration counterfactual level, h_i^{NM}. It is worth emphasizing that human capital responses result from natives' responses to emigration prospects (pre-migration incentive and post-migration composition effects) and from migrant inflows from other *départements*. However, as illustrated in Figure 2.2.1, inflows of college graduates are negligible in most *départements*, with the exception of Dakar and Thiès, joined by Diourbel when focusing on the less educated.

Panel (d) shows that selective international migration prospects increase domestic human capital accumulation in the region of Dakar – by about 2 percentage points in Dakar, Guédiawaye and Pikine and by roughly 1 percentage point in Ruffisque. Domestic human capital also increases in Ziguinchor, Salemata, Thies and Saint-Louis, four other *départements* where international migration prospects boost skill premia and access to education is not too low. In many other regions, the human capital response is small and close to zero.

In Panel (e), we find that internal migration prospects increase human capital in the *départements* of the Dakar region, and in Guédiawaye in particular. This net gain is mostly due to inflows of college graduates from the rest of the country, as there are relatively few internal movements from Dakar. Moreover, the latter are negatively selected and therefore do not generate domestic incentive effects. The average net effect is positive but small in the poorest *départements* of the country, with the exception of Bambey and Thiès, which exhibit larger gains. Four *départements* with low access to education (Saint-Louis, Oussouye, Bignona and Sédhiou) exhibit net losses of human capital due to internal migration.

Finally, Panel (f) combines the effects of internal and international migration. Overall, our analysis reveals that migration prospects mostly benefit the richest *départements* of Senegal, located in the region of Dakar. These gains are due to large incentive effects driven by selective emigration prospects to OECD countries, and by inflows of college graduates from the rest of the country. The effect is also beneficial in *départements* with good access to education and connection with Dakar – such as Thiès and Bambey. In the other *départements*, the effect is negligible or nil, which confirms our presumption that the brain gain mechanism is strongly governed by the effect observed in a few well-connected areas. Net losses of human capital are even experienced for (internationally or internally) connected *départements* with a lower access to education, such as Saint-Louis, Oussouye, Bignona and Sédhiou.

Figure 2.4.2: Skill premium and human capital effects by *département*



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.

2.5 Conclusion

The question on how emigration affects upper-tail human capital accumulation in poor countries is of prime importance for reaching the United Nations Sustainable Development Goals. Fears of human capital losses arise because emigrants are positively selected along the observable schooling (and unobservable skill) dimension. However, selective emigration can also boost human capital formation through greater incentives to acquire education, transfers of norms and values, or financial remittances, implying that its net effect on origin communities is ambiguous. A number of case studies, cross-country regressions and microfounded models provide converging evidence that selective international emigration plausibly boosts upper-tail human capital accumulation in the world's poorest countries, thereby reducing their human capital gap with wealthier countries. Nevertheless, the within-country distribution of these *brain gain* effects has been largely disregarded. Furthermore, while the number of inter-regional migrants in the world is more than threefold the number of international migrants (United Nations, 2000),[58] the role of internal migration opportunities in the education-migration nexus has received little attention.

Focusing on the case of Senegal, we provide suggestive evidence that the *brain gain* mechanism largely benefits the richest regions that are internationally connected and have better access to education. Human capital responses to international migration are negligible in regions lacking international connectivity, or even negative in better connected regions with poor access to education. These results also apply to internal migration, given that highly vulnerable populations are trapped in the least developed areas. Our main findings are likely to hold in many other developing countries where the high-skilled labor force and high-productivity activities are largely concentrated in one or very few mega-cities. Our study makes a clear case for studying human capital and economic responses to labor migration at a finer spatial level than the national one, accounting for internal mobility and heterogeneity in access to education. We show that the connectivity of places substantially defines the opportunities of its residents. From a policy perspective, our study thus highlights the urgency of designing policies to improve connectivity and access to education in remote areas of the developing world.

[58] 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).

Bibliography

Abarcar, P. and C. Theoharides (2021). "Medical Worker Migration and Origin-Country Human Capital: Evidence from U.S. Visa Policy". In: *Review of Economics and Statistics* forthcoming, pp. 1–46.

Aggarwal, S. (2018). "Do Rural Roads Create Pathways Out of Poverty? Evidence from India". In: *Journal of Development Economics* 133, pp. 375–395.

Ahlfeldt, G. M., S. J. Redding, D. M. Sturm, and N. Wolf (2015). "The economics of density: Evidence from the Berlin Wall". In: *Econometrica* 83(6), pp. 2127–2189.

Albert, C. and J. Monras (2022). "Immigration and spatial equilibrium: the role of expenditures in the country of origin". In: *American Economic Review* 112(11), pp. 3763–3802.

Angrist, J. D. and J.-S. Pischke (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

Antman, F. M. (2011). "The intergenerational effects of paternal migration on schooling and work: What can we learn from children's time allocations?" In: *Journal of Development Economics* 96(2), pp. 200–208.

Arslan, C., J.-C. Dumont, Z. Kone, Y. Moullan, C. Ozden, C. Parsons, and T. Xenogiani (2015). "A new profile of migrants in the aftermath of the recent economic crisis". In: *OECD Social Employment and Migration Working Papers* 160.

Ba, C., J. Bourgoin, and D. Diop (2017). "The fluidity of internal migration as an answer to local constraints". In: *In: Mercandalli, S. and Losch, B. (eds.). Rural Africa in motion: Dynamics and drivers of migration South of the Sahara*, pp. 32–33.

Bah, T. L., C. Batista, F. Gubert, and D. McKenzie (2023). "Can information and alternatives to irregular migration reduce "backway" migration from The Gambia?" In: *Journal of Development Economics* 165, p. 103153.

Barro, R. J. (2001). "Human capital and growth". In: *American economic review* 91(2), pp. 12–17.

Baseler, T. (2023). "Hidden income and the perceived returns to migration". In: *American Economic Journal: Applied Economics* 15(4), pp. 321–352.

Batista, C., A. Lacuesta, and P. C. Vicente (2012). "Testing the 'brain gain' hypothesis: Micro evidence from Cape Verde". In: *Journal of Development Economics* 97(1), pp. 32–45.

Beauchemin, C., M.-L. Flahaux, and B. Schoumaker (2020). "Three sub-Saharan migration systems in times of policy restriction". In: *Comparative Migration Studies* 8(19).

Beine, M., F. Docquier, and H. Rapoport (2008). "Brain drain and human capital formation in developing countries: winners and losers". In: *The Economic Journal* 118(528), pp. 631–652.

Beine, M., F. Docquier, and Ç. Özden (2011). "Diasporas". In: *Journal of Development Economics* 95(1), pp. 30–41.

Beine, M., F. Docquier, and H. Rapoport (2001). "Brain drain and economic growth: theory and evidence". In: *Journal of Development Economics* 64(1), pp. 275–289.

Beine, M., F. Docquier, and H. Rapoport (2010). "On the robustness of brain gain estimates". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 143–165.

Beine, M. and C. Parsons (2015). "Climatic factors as determinants of international migration". In: *The Scandinavian Journal of Economics* 117(2), pp. 723–767.

Bell, M., E. Charles-Edwards, A. Bernard, and P. Ueffing (2018). "Global trends in internal migration". In: *Internal migration in the developed world: are we becoming less mobile?* Ed. by T. C. T. Champion and I. Shuttleworth. Routledge: United Kingdom.

Belot, M. V. and T. J. Hatton (2012). "Immigrant Selection in the OECD". In: *The Scandinavian Journal of Economics* 114(4), pp. 1105–1128.

Benavente, A. and C. Panchaud (2008). "Lutte contre la pauvreté et éducation pour l'inclusion: transformer l'école en Afrique subsaharienne". In.

Bergman, P., R. Chetty, S. DeLuca, N. Hendren, L. F. Katz, and C. Palmer (2024). "Creating moves to opportunity: Experimental evidence on barriers to neighborhood choice". In: *American Economic Review* 114(5), pp. 1281–1337.

Berthélemy, J.-C., M. Beuran, and M. Maurel (2009). "Aid and migration: Substitutes or complements?" In: *World Development* 37(10), pp. 1589–1599.

Bertoli, S. and J. F.-H. Moraga (2013). "Multilateral resistance to migration". In: *Journal of development economics* 102, pp. 79–100.

Bhagwati, J. and K. Hamada (1974). "The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis". In: *Journal of Development Economics* 1(1), pp. 19–42.

Biavaschi, C., M. Burzyński, B. Elsner, and J. Machado (2020). "Taking the skill bias out of global migration". In: *Journal of Development Economics* 142, p. 102317.

Bocquier, P., N. Cha'ngom, F. Docquier, and J. Machado (2023). "The within-country distribution of brain drain and brain gain effects: A case study on Senegal". In: *Journal of Demographic Economics*, pp. 1–28.

Bouche, D. (1974). "The French school and Muslims in Senegal from 1850 to 1920". In: *Revue d'histoire* 61, pp. 218–235.

Brauw, A. de and J. Giles (2017). “Migrant Opportunity and the Educational Attainment of Youth in Rural China”. In: *Journal of Human Resources* 52(1), pp. 272–311.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014a). “Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh”. In: *Econometrica* 82, pp. 1671–1748.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014b). “Underinvestment in a profitable technology: The case of seasonal migration in Bangladesh”. In: *Econometrica* 82(5), pp. 1671–1748.

Bryan, G. and M. Morten (2019). “The aggregate productivity effects of internal migration: Evidence from Indonesia”. In: *Journal of Political Economy* 127(5), pp. 2229–2268.

Burzyński, M., C. Deuster, and F. Docquier (2020). “Geography of skills and global inequality”. In: *Journal of Development Economics* 142, p. 102333.

Burzyński, M., C. Deuster, F. Docquier, and J. De Melo (2022). “Climate change, inequality, and human migration”. In: *Journal of the European Economic Association* 20(3), pp. 1145–1197.

Caballero, M. E., B. Cadena, and B. K. Kovak (2021). *The International Transmission of Local Economic Shocks Through Migrant Networks*. NBER Working Papers 28696. National Bureau of Economic Research, Inc.

Caiumi, A. and G. Peri (2024). *Immigration's Effect on US Wages and Employment Redux*. Tech. rep. National Bureau of Economic Research.

Castelló-Climent, A. and A. Mukhopadhyay (2013). “Mass education or a minority well educated elite in the process of growth: The case of India”. In: *Journal of Development Economics* 105, pp. 303–320.

Cha'ngom, N., C. Deuster, F. Docquier, and J. Machado (2023). “Selective Migration and Economic Development: A Generalized Approach”. In.

Chand, S. and M. A. Clemens (2019). *Human Capital Investment under Exit Options: Evidence from a Natural Quasi-Experiment*. IZA Discussion Papers 12173. Institute of Labor Economics (IZA).

Clemens, M. and E. R. Tiongson (2017). “Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work”. In: *Review of Economics and Statistics* 99(3), pp. 531–543.

Clemens, M. A. (2014). “Does development reduce migration?” In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Clemens, M. A. and H. M. Postel (2018). “Deterring emigration with foreign aid: An overview of evidence from low-income countries”. In: *Population and Development Review* 44(4), p. 667.

Clemens, M. A., S. Radelet, R. R. Bhavnani, and S. Bazzi (2012). "Counting chickens when they hatch: Timing and the effects of aid on growth". In: *The Economic Journal* 122(561), pp. 590–617.

Conte, B. (2022). "Climate change and migration: the case of africa". In.

Cucu, F. (2019). "Roads, Internal Migration and the Spatial Sorting of US High-Skilled Workers". In: *Manuscript, Université Libre de Bruxelles (ECARES)*.

De Mesquita, B. B. and A. Smith (2009). "A political economy of aid". In: *International Organization* 63(2), pp. 309–340.

Delogu, M., F. Docquier, and J. Machado (2018). "Globalizing labor and the world economy: the role of human capital". In: *Journal of Economic Growth* 23(2), pp. 223–258.

Desmet, K., D. K. Nagy, and E. Rossi-Hansberg (2018). "The geography of development". In: *Journal of Political Economy* 126(3), pp. 903–983.

Diamond, R. (2016). "The determinants and welfare implications of US workers' diverging location choices by skill: 1980–2000". In: *American Economic Review* 106(3), pp. 479–524.

Dinkelman, T., G. Kumchulesi, and M. Mariotti (2021). *Labor Migration, Capital Accumulation, and the Structure of Rural Labor Markets*. GLM|LIC Working Paper 22. Institute of Labor Economics.

Dinkelman, T. and M. Mariotti (2016). "The Long-Run Effects of Labor Migration on Human Capital Formation in Communities of Origin". In: *American Economic Journal: applied Economics* 8(4), pp. 1–35.

Djajić, S., F. Docquier, and M. S. Michael (2019). "Optimal education policy and human capital accumulation in the context of brain drain". In: *Journal of Demographic Economics* 85(4), pp. 271–303.

Docquier, F., O. Lohest, and A. Marfouk (2007). "Brain drain in developing countries". In: *The World Bank Economic Review* 21(2), pp. 193–218.

Docquier, F. and J. Machado (2016). "Global Competition for Attracting Talents and the World Economy". In: *The World Economy* 39(4), pp. 530–542.

Docquier, F., J. Machado, and K. Sekkat (2015). "Efficiency gains from liberalizing labor mobility". In: *The Scandinavian journal of economics* 117(2), pp. 303–346.

Dreher, A., A. Fuchs, R. Hodler, B. C. Parks, P. A. Raschky, and M. J. Tierney (2019). "African leaders and the geography of China's foreign assistance". In: *Journal of Development Economics* 140, pp. 44–71.

Duranton, G. and D. Puga (2004). "Micro-foundations of urban agglomeration economies". In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2063–2117.

European-Commission (2015). "Governance and Procedure: EU Trust Fund for Africa for stability and addressing root causes of irregular migration and displaced persons". In: *European Union*.

Felbermayr, G. J., B. Jung, and F. Toubal (2010). “Ethnic networks, information, and international trade: Revisiting the evidence”. In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 41–70.

Fernández Sánchez, M. (2022). *Mass Emigration and Human Capital over a Century: Evidence from the Galician Diaspora*. Tech. rep. Luxembourg Institute of Socio-Economic Research (LISER).

Fields, G. S. (1990). “Labour market modelling and the urban informal sector: Theory and evidence”. In.

Fields, G. S. (2009). “Segmented labor market models in developing countries”. In.

Fields, G. S. (2011). “Labor market analysis for developing countries”. In: *Labour economics* 18, S16–S22.

Francken, N., B. Minten, and J. F. Swinnen (2012). “The political economy of relief aid allocation: evidence from Madagascar”. In: *World Development* 40(3), pp. 486–500.

Gamso, J. and F. Yuldashev (2018). “Does rural development aid reduce international migration?” In: *World Development* 110, pp. 268–282.

Gazeaud, J., E. Mvukiyehe, and O. Sterck (2023). “Cash transfers and migration: Theory and evidence from a randomized controlled trial”. In: *Review of Economics and Statistics* 105(1), pp. 143–157.

Gennaioli, N., R. La Porta, F. Lopez-de-Silanes, and A. Shleifer (2013). “Human capital and regional development”. In: *The Quarterly journal of economics* 128(1), pp. 105–164.

Gibson, J., D. McKenzie, and S. Stillman (2011). “The Impacts of International Migration on Remaining Household Members: Omnibus Results from a Migration Lottery Program”. In: *The Review of Economics and Statistics* 93(4), pp. 1297–1318.

Gollin, D., D. Lagakos, and M. E. Waugh (2014). “The agricultural productivity gap”. In: *Quarterly Journal of Economics* 129(2), pp. 939–993.

Grogger, J. and G. H. Hanson (2011). “Income maximization and the selection and sorting of international migrants”. In: *Journal of Development Economics* 95(1), pp. 42–57.

Hanushek, E. and L. Woesmann (2008). “The Role of Cognitive Skills in Economic Development”. In: *Journal of Economic Literature* 46(3), pp. 607–668.

Hanushek, E. and L. Woesmann (2021). “Education and Economic Growth”. In: *Oxford Research Encyclopedia of Economics and Finance* 31, Oxford University Press.

Hao, T., R. Sun, T. Tombe, and X. Zhu (2020). “The effect of migration policy on growth, structural change, and regional inequality in China”. In: *Journal of Monetary Economics* 113, pp. 112–134.

Haque, N. U. and S.-J. Kim (1995). “”Human capital flight”: Impact of migration on income and growth”. In: *Staff Papers* 42(3), pp. 577–607.

Hsieh, C.-T., E. Hurst, C. I. Jones, and P. J. Klenow (2019). “The allocation of talent and us economic growth”. In: *Econometrica* 87(5), pp. 1439–1474.

Hsieh, C.-T. and E. Moretti (2019). "Housing constraints and spatial misallocation". In: *American Economic Journal: Macroeconomics* 11(2), pp. 1–39.

Imbert, C., J. Monras, M. Seror, and Y. Zylberberg (2023). "Floating population: migration with (out) family and the spatial distribution of economic activity". In: Federal Reserve Bank of San Francisco.

Iranzo, S. and G. Peri (2009). "Migration and trade: Theory with an application to the Eastern–Western European integration". In: *Journal of International Economics* 79(1), pp. 1–19.

Javorcik, B. S., Ç. Özden, M. Spatareanu, and C. Neagu (2011). "Migrant networks and foreign direct investment". In: *Journal of development economics* 94(2), pp. 231–241.

Jones, B. F. (2014). "The human capital stock: a generalized approach". In: *American Economic Review* 104(11), pp. 3752–77.

Katz, E. and H. Rapoport (2005). "On human capital formation with exit options". In: *Journal of Population Economics* 18(2), pp. 267–274.

Kerr, S. P., W. Kerr, Ç. Özden, and C. Parsons (2016). "Global talent flows". In: *Journal of Economic Perspectives* 30(4), pp. 83–106.

Khanna, G. and N. Morales (2021). *The IT Boom and Other Unintended Consequences of Chasing the American Dream*. mimeo. University of Michigan.

Khanna, G., E. Murathanoglu, C. Theoharides, and D. Yang (2022). *Abundance from abroad: migrant income and long-run economic development*. Working Paper 29862. NBER.

King, R., R. Skeldon, and J. Vullnetari (2008). "Internal and international migration: Bridging the theoretical divide". In.

Klugman, J. (2009). "Human development report 2009. Overcoming barriers: Human mobility and development". In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

Kosack, E. (2021). "Guest Worker Programs and Human Capital Investment – The Bracero Program in Mexico, 1942–1964". In: *Journal of Human Resources* 56(2), pp. 570–592.

Kraay, A. (2012). "How large is the government spending multiplier? Evidence from World Bank lending". In: *The Quarterly Journal of Economics* 127(2), pp. 829–887.

Kraay, A. (2014). "Government spending multipliers in developing countries: evidence from lending by official creditors". In: *American Economic Journal: Macroeconomics* 6(4), pp. 170–208.

Kummu, M., M. Taka, and J. H. Guillaume (2018). "Gridded global datasets for gross domestic product and Human Development Index over 1990–2015". In: *Scientific data* 5(1), pp. 1–15.

Lagakos, D., M. Mobarak, and M. E. Waugh (2023). "The Welfare Effects of Encouraging Rural-Urban Migration". In: *Econometrical* forthcoming.

Lanati, M., M. Sanfilippo, and F. Santi (2023). "Aid and internal migration in Malawi". In: *World Development* 162, p. 106134.

Lanati, M. and R. Thiele (2018a). "Foreign assistance and migration choices: Disentangling the channels". In: *Economics letters* 172, pp. 148–151.

Lanati, M. and R. Thiele (2018b). "The impact of foreign aid on migration revisited". In: *World development* 111, pp. 59–74.

Lessault, D. and M.-L. Flahaux (2013). "Regards statistiques sur l'histoire de l'émigration internationale au Sénégal". In: *Revue européenne des migrations internationales* 29(4).

Lucas, R. E. (2014). "Migration and economic development: an introduction and synopsis". In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Marchal, L., C. Naiditch, B. Simsek, et al. (2022). *How Foreign Aid Affects Migration: Quantifying Transmission Channels*. Centre d'économie de la Sorbonne.

Marchiori, L., J.-F. Maystadt, and I. Schumacher (2012). "The impact of weather anomalies on migration in sub-Saharan Africa". In: *Journal of Environmental Economics and Management* 63(3), pp. 355–374.

Masaki, T. (2018). "The political economy of aid allocation in Africa: Evidence from Zambia". In: *African Studies Review* 61(1), pp. 55–82.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior". In: *Frontiers in econometrics*. Ed. by P. Zarembka. Academic Press: New York. Chap. 4, pp. 105–142.

McKenzie, D. (2017). "How effective are active labor market policies in developing countries? a critical review of recent evidence". In: *The World Bank Research Observer* 32(2), pp. 127–154.

McKenzie, D. and H. Rapoport (2011). "Can Migration Reduce Educational Attaintment? Evidence from Mexico". In: *Journal of Population Economics* 24(4), pp. 1331–1358.

Meghir, C., A. M. Mobarak, C. Mommaerts, and M. Morten (2022). "Migration and Informal Insurance: Evidence from a Randomized Controlled Trial and a Structural Model". In: *Review of Economic Studies* 89(1), pp. 452–480.

Menard, A. and A. Gary (2018). "Aid, trade and migration: How do bilateral flows interact?" In: *The World Economy* 41(2), pp. 431–456.

Mobarak, A., I. Sharif, and M. Shrestha (2023). "Returns to International Migration: Evidence from a Bangladesh-Malaysia Visa Lottery". In: *American Economic Journal: Applied Economics* forthcoming.

Mokyr, J. (2005). "The intellectual origins of modern economic growth". In: *Research and Technological Innovation*. Springer, pp. 17–80.

Mokyr, J. and H.-J. Voth (2009). "Understanding growth in early modern Europe". In: *Cambridge Economic History of Europe* 1, pp. 7–42.

Monte, F., S. J. Redding, and E. Rossi-Hansberg (2018). "Commuting, migration, and local employment elasticities". In: *American Economic Review* 108(12), pp. 3855–3890.

Mountford, A. (1997). "Can a brain drain be good for growth in the source economy?" In: *Journal of Development Economics* 53(2), pp. 287–303.

Mountford, A. and H. Rapoport (2011). “The brain drain and the world distribution of income”. In: *Journal of Development Economics* 95(1), pp. 4–17.

Mountford, A. and H. Rapoport (2016). “Migration policy, African population growth and global inequality”. In: *The World Economy* 39(4), pp. 543–556.

National-Security-Council (2021). “U.S. Strategy for Addressing the Root Causes of Migration in Central America”. In: *Washington, DC: White House.* Available at, p. 4.

Ortega, F. and G. Peri (2013). “The effect of income and immigration policies on international migration”. In: *Migration Studies* 1(1), pp. 47–74.

Otoiu, A., E. Titan, and R. Dumitrescu (2014). “Internal and international migration: Is a dichotomous approach justified?” In: *Procedia-Social and Behavioral Sciences* 109, pp. 1011–1015.

Ottaviano, G. I. and G. Peri (2012). “Rethinking the effect of immigration on wages”. In: *Journal of the European Economic Association* 10(1), pp. 152–197.

Page, B. (2020). “Remittances”. In: *International Encyclopedia of Human Geography* 2nd edn. Pp. 403–409.

Palma, A. de and K. Kilani (2007). “Invariance of conditional maximum utility”. In: *Journal of Economic Theory* 132(1), pp. 137–146.

Pan, Y. (2017). “The Impact of Removing Selective Migration Restrictions on Education: Evidence from China”. In: *Journal of Human Resources* 52(3), pp. 859–885.

Porcher, C., E. Morales, and T. Fujiwara (2024). *Measuring Information Frictions in Migration Decisions: A Revealed-Preference Approach*. Tech. rep. National Bureau of Economic Research.

Pratap, S. and E. Quintin (2006). “Are labor markets segmented in developing countries? A semiparametric approach”. In: *European Economic Review* 50(7), pp. 1817–1841.

Rapoport, H. and F. Docquier (2006). “The economics of migrants’ remittances”. In: *Handbook of the economics of giving, altruism and reciprocity* 2, pp. 1135–1198.

Robin, N. (1996). *Atlas des migrations ouest-africaines vers l’Europe, 1985-1993*. Montpellier: IRD Éditions.

Robin, N. (2000). *Facteurs d’attraction et de répulsion à l’origine des flux migratoires internationaux: rapport national Sénégal*. IRD et Eurostat.

Rosenthal, S. S. and W. C. Strange (2004). “Evidence on the nature and sources of agglomeration economies”. In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2119–2171.

Rosenzweig, M. R. (1988). “Labor markets in low-income countries”. In: *Handbook of development economics* 1, pp. 713–762.

Saiz, A. (2010). “The geographic determinants of housing supply”. In: *The Quarterly Journal of Economics* 125(3), pp. 1253–1296.

Shrestha, S. A. (2017). “No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants”. In: *The Economic Journal* 127(600), pp. 495–521.

Squicciarini, M. P. and N. Voigtländer (2015). "Human capital and industrialization: Evidence from the age of enlightenment". In: *The Quarterly Journal of Economics* 130(4), pp. 1825–1883.

Stark, O., C. Helmenstein, and A. Prskawetz (1997). "A brain gain with a brain drain". In: *Economics letters* 55(2), pp. 227–234.

Stark, O. and Y. Wang (2002). "Inducing human capital formation: migration as a substitute for subsidies". In: *Journal of Public Economics* 86(1), pp. 29–46.

Theoharides, C. (2018). "Manila to Malaysia, Quezon to Qatar International Migration and Its Effects on Origin-Country Human Capital". In: *Journal of Human Resources* 53(4), pp. 1022–1049.

Tombe, T. (2015). "The missing food problem: Trade, agriculture, and international productivity differences". In: *American Economic Journal: Macroeconomics* 7(3), pp. 226–258.

Tombe, T. and X. Zhu (2019). "Trade, migration, and productivity: A quantitative analysis of china". In: *American Economic Review* 109(5), pp. 1843–72.

UNDP (2009). "Human development report 2009. Overcoming barriers: Human mobility and development". In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

United Nations (2000). *Cross-national comparisons of internal migration: an update on global pattern and trends*. United Nations: Population Division, Technical Paper no. 2013/1.

Vidal, J.-P. (1998). "The effect of emigration on human capital formation". In: *Journal of Population Economics* 11(4), pp. 589–600.

Vollrath, D. (2009). "How important are dual economy effects for aggregate productivity?" In: *Journal of Development Economics* 88(2), pp. 325–334.

Yang, D. (2011). "Migrant remittances". In: *Journal of Economic perspectives* 25(3), pp. 129–152.

Appendix

Table A.1 lists the 45 *départments* 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 A.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

Continued on next page

Table A.1 – *Continued from previous page*

Code	*Département*	$Labor_i$	H_i	m_{ih}^{int}	m_{il}^{int}	m_{ih}^{OECD}	m_{il}^{OECD}
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
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

Chapter 3

Migration and Regional Development: *Evidence from Senegal*

Narcisse Cha'ngom, LISER

Abstract

I investigate the impact of heterogeneous migration patterns on the spatial distribution of economic activity and welfare across sub-national regions in Senegal. I use rich micro-data documenting internal and international in- and out-migration at a detailed geographic level. The data show significant regional variation in these migration patterns. To rationalize these patterns, I develop a Spatial General Equilibrium Model that endogenises education and migration decisions, local labour markets, and the feedback effects of migration. Counterfactual simulations reveal that: (i) migration decreases productivity countrywide but increases welfare, driven by remittances; (ii) it intensifies cross-regional productivity inequality while diminishing welfare inequality; (iii) reducing mobility frictions increases both productivity and welfare countrywide; (iv) at the expense of larger cross regional productivity disparities.

3.1 Introduction

Labour migration affects economic activity through complex mechanisms linked both to outflows and inflows, whether internal or international. On the one hand, emigration reduces the pool of workers available for local production, thereby reducing the direct and indirect productive capacity of origin locations (Bhagwati and Hamada, 1974). This is especially the case when emigration disproportionately involves high-skilled individuals, which deprives the origin location of critical skills needed for its development (Bhagwati and Hamada, 1974; Haque and Kim, 1995). This undermines the capacity of local economies to innovate, adopt new technologies, and consequently, to develop structurally and sustainably (Jones, 2014; Barro, 2001). On the other hand, emigrants send part of their earnings back home in the form of remittances (Rapoport and Docquier, 2006; Yang, 2011), proved to support local consumption and overcome vulnerabilities. Emigrants also facilitate foreign direct investments (Felbermayr et al., 2010; Iranzo and Peri, 2009), engage in entrepreneurship at home, and promote trade (Javorcik et al., 2011). Moreover, the emigration prospects for high-skilled increase the incentive to invest more in education (Shrestha, 2017; Beine et al., 2008; Cha'ngom et al., 2023). These positive feedback effects might partially or entirely offset the negative effects associated with the migrants' departure. In contrast, immigration, by increasing the reservoir of workers available for local production, creates agglomeration forces related not only to the direct contribution of new workers to local economic activity, but also to the positive externalities that emerge when a larger number of people interact with each other (Duranton and Puga, 2004; Rosenthal and Strange, 2004). On the other hand, immigration can also generate congestion effects that harm local production or quality of life (Desmet et al., 2018; Conte, 2022). This can operate through an increase in the living costs induced by higher demand (housing prices, goods and services prices), a decrease in amenities (pollution, traffic jams, congestion in public parks, schools, hospitals, etc.), and potentially lowers productivity.

However, none of the mechanisms described above is definitive as each offers only a partial view of how migration overall in terms of its type (internal vs. international), its size, its skill composition and its patterns with respect to destinations (internal, developed, and developing international destinations), interacts with economic activity. In practice, each location is jointly affected by both internal and international emigration and immigration. Each of these types have different direct and indirect consequences on local economic activity. Moreover, well established feedback effects such as remittances (Yang, 2011; Page, 2020), education incentives (Beine et al., 2008; Shrestha, 2017), and productivity externalities are also migration type specific.

Therefore, to fully understand the economic impact of migration, it is essential to consider internal and international emigration and immigration jointly, along with the specific feedback effects associated with each type of mobility.[59] Moreover, the mechanisms described above vary across sub-national units within countries. This variation is due to the local heterogeneous patterns of migration. For instance, some sub-national units are primarily connected to migration flows with other domestic units, while others are primarily connected internationally. Among the latter, some are primarily connected with developed countries while some others are connected to developing countries, resulting in a variety of migration patterns and associated feedback effects. This will likely lead to uneven economic effects across sub-national regions and likely play a crucial role in shaping the spatial distribution of economic activity. However, there is little evidence on the combined effects of different forms of migration and their impact on the spatial distribution of economic activity and welfare at sub-national level. This perspective suggests that assessing the impact of all migration forces taken simultaneously offers a more comprehensive and complete view. This paper aims to fill this important gap.

This paper uses detailed micro-data from Senegal to quantify the impact of varying migration patterns at the sub-national level on the spatial distribution of economic activity and welfare. The methodology employed in this paper accounts for the full structure of varying local migration patterns, modeled as a result of spatial mobility frictions, as well as the complexity of their associated feedback effects. Additionally, the paper quantifies the potential impacts of reducing spatial mobility frictions. The analysis proceeds in four steps.

In the first step, it combines rich census and survey data to highlight four stylised facts about the interaction between detailed migration patterns at dis-aggregated geographical level and economic activity within Senegal. (i) Total migration varies significantly across sub-national units within Senegal, and this correlates with spatial economic disparities. A one percentage point increase in the net emigration rate is associated to a 5% decrease in output per squared kilometer within 5 years.[60] (ii) Migrants within Senegal agglomerate in expensive locations. However, rising housing prices divert them to less costly, yet productive locations potentially spreading agglomeration forces across space. Although migrants concentrate in

[59] A large body of the literature has tackled the distributional effect of migration through the lens of spatial missallocation of labour resulting from the existence of spatial mobility frictions preventing workers to settle in the most productive locations (Hsieh et al., 2019; Albert and Monras, 2022). However, such an approach only takes into account the mechanisms operating via the spatial re-allocation of labour that migration can generate, leaving aside most of the feedback effects that migration has on locations of origin. Another body of the literature including Biavaschi et al. (2020); Docquier et al. (2015); Docquier et al. (2007) has accounted for those feedback effects, but has left aside the spatial dimension as well as internal migration.

[60] The net emigration rate is the difference between emigration and immigration numbers as a proportion of the native labour force at origin. A negative net emigration rate refers to a sub-national unit of net immigration while the reverse holds for positive net emigration rate.

expensive locations, a 10% increase in rental prices in a given sub-national unit is associated to a 5 to 7% decrease in migration flows toward that sub-national unit within 5 years. (iii) Productivity in Senegal is higher for high-skilled workers, those in the formal sector, and those in urban areas, and migrants cluster in the locations with larger premia. Earnings are about 43% higher in urban areas relative to rural areas, about 65% higher in the formal sector, and about 2.9 times higher for tertiary educated workers. (iv) Emigration directly benefits origin locations through remittances. A 10% increase in the proportion of emigrants in a sub-national region leads to 11% higher remittances. This effect increases to roughly 14% with the concentration of the emigration to the OECD.

In the second step, it develops a Spatial General Equilibrium Model that rationalises these stylised facts. In this model, workers choose the level education they want to invest acquire, where to live and work, how to allocate their earnings between consumption, housing, and conditional on having moved away from home, what portion of their earnings they remit back home. The heterogeneous patterns of total migration across space determines the size and skill composition of the local labour supply, which in turn influences the level of local economic activity and workers' productivity. The mechanisms differ based on the direction of total migration, and the strength of associated feedback effects. The model is connected to those used in Tombe and Zhu (2019); Bryan and Morten (2019); Albert and Monras (2022), and Cha'ngom et al. (2023), but extents them by simultaneously including internal and international dyadic migration, a dual labour market (formal/informal), and urban-rural migration.

In the third step, it estimates the main parameters of the model by employing an instrumental variables (IV) approach similar to that used in Tombe and Zhu (2019); Bryan and Morten (2019), leveraging plausibly exogenous sources of variation. The model depends on a few central parameters including the income elasticity of migration, the inverse housing supply elasticity, and the elasticity of remitting cost to migration size. It first estimates the inverse of the housing supply elasticity instrumenting local economic density with a Bartik-style expected income (Tombe and Zhu, 2019) and the average distance to the coast. It further estimates the income elasticity of migration using an IV strategy which consists of employing a leave one origin out approach introduced in Bryan and Morten (2019) in the Indonesian context. it then estimates the elasticity of remitting cost to migration size using a similar identification strategy. The inverse housing supply elasticity, and the elasticity of remitting cost to migration size are used to compute the price index. With the price index, and the Fréchet parameter, it infers skill specific bilateral migration costs and unobservables location characteristics needed in the analysis as residuals from the model structure.

In the fourth step, it uses the model to explore various counterfactual experiments. First, it shuts down all forms of migration and then compare the distribution of economic activity across Senegalese sub-national units obtained with the observed distribution. This exercise documents the local distributional effect of the overall migration, and more importantly showcases how these effects vary with the level and the direction of total migration. The results indicate that sub-national units of net immigration exhibit productivity gains, while those of net emigration experience productivity losses. productivity responses range from +10.3% in Guédiawaye to -18.0% in Oussouye. However, at country level, actual overall migration lowers productivity by 4.1%, driven by international migration. Despite this negative productivity effect, remittances still make migration welfare-enhancing in nearly all regions; The effect on welfare varies from -0.4 to 23% across areas and regions. Countrywide, labour migration raises welfare by 8.3% on average. Furthermore, actual migration increases productivity inequality across sub-national units by 8% while it decreases welfare inequality by 4%. Next, it shuts down internal, international, and OECD migration respectively and compare for each case the counterfactual distribution to the observed distribution. This exercise isolates the distributional effects of each of the three types of migration. It shows that internal migration increases productivity by 2.9% while international migration depletes productivity by roughly 1.7% on average. However, all forms of migration are welfare enhancing, which is consistent with the overall effect. When it comes to spatial inequality, all forms of migration enhance productivity inequality. However, while overall and international migrations reduce welfare inequality, internal migration widens welfare disparities across sub-national units.

Finally, it simulates migration policies aiming at (i) reducing migration costs, (ii) reducing dispersion in access to education across sub-national units, (iii) simultaneously aligning access to education to the standard observed in the capital region and reducing migration costs. Results predict that halving migration cost in Senegal increases productivity and welfare by 9.9 and 8.9% respectively. However, halving spatial dispersion in access to public education lowers productivity and welfare by 7.4% and 1.0% respectively. Finally, it shows that aligning access to education to the standards of the Dakar region and jointly halving migration costs increases productivity and welfare by 11.7 and 8.7% respectively. Results suggest modest overall gains but important heterogeneity across sub-national units. These results compare to those found by Bryan and Morten (2019) for Indonesia, and Tombe and Zhu (2019) for China. Furthermore, irrespective of the policy experiment considered, it leads to higher productivity inequality and lower welfare inequality across sub-national units.

Related literature. The paper relates to the literature on the distributional effects of migration. This literature can be organised into three main strands. A first strand focuses on the distributional effects of international migration, in particular its impact on countries of origin and cross country productivity disparities (Burzyński et al., 2020; Cha'ngom et al., 2023; Delogu et al., 2018; Docquier et al., 2015). However, this strand disregards variations in exposure to migration across sub-national regions within countries. I argue that migration flows are largely heterogeneous across space. To the extent that feedback effects are destination and skill composition specific, the local distributional impact of international migration likely varies significantly across sub-national regions. Secondly, this strand neglects internal migration, which is the dominant form of human mobility (Klugman, 2009). In Senegal, internal migration across administrative level 2 sub-national units (departments) is about 4.5 times larger than international migration, even when temporary internal migration is excluded.[61]

A second strand focuses on the distributional effects of internal migration (Bryan and Morten, 2019; Tombe and Zhu, 2019; Hao et al., 2020; Imbert et al., 2023), but it disregards the role international migration plays in influencing internal migration decisions and local economic activity. Internal migration often serves as a preliminary step toward international migration. Migrants from rural areas may first move to urban areas within their country to adapt, accumulate resources, and build contacts before moving abroad. Moreover, international migrants often originate from well-connected, productive cities (King et al., 2008; Bocquier et al., 2023). Relative to these two strands, I argue that it is important to jointly incorporate internal and international migration decisions to have a more comprehensive estimates of the distributional effects of migration and the potential effects of migration policies. This paper bridges the gap by jointly considering both internal and international migration decisions, leveraging the full structure of both types of migration across sub-national units. Beyond the integrated model that jointly considers both dimensions, I also simultaneously endogenise education decisions, migration decisions, and the well established feedback effects of migration.

A third strand has recently emerged that focuses on high spatial granularity, particularly at the pixel-level (Desmet et al., 2018; Burzyński et al., 2022; Conte, 2022). This approach has the advantage of considering internal and international mobility simultaneously. However, most sub-national mobility data (pixel level) are imputed. I add to this strand by using a unique micro-data covering the full population and mobility patterns (internal, international) at sub-national level, thus using real data.

[61] Internal migration discussed here includes both department-to-department migration and migration within departments, encompassing urban-to-urban, urban-to-rural, rural-to-rural, and rural-to-urban migrations. However, this discussion is limited to lifetime migration, excluding temporary migration.

The paper could be extended in several directions. First, it investigates the static impact of heterogeneous patterns of total migration on regional development, without considering how this impact evolves over time. There are potential sources of dynamic effects from total migration. For example, migration costs can change over time, which could, in turn, influence migration patterns, and associated feedback effects. Tombe and Zhu (2019) demonstrate that in China, migration costs decreased by about 18.1% between 2000 and 2005. However, exploring these dynamic impacts is beyond the scope of this paper and is left for future research. Second, when conducting counterfactual policy experiments, the paper focuses on the potential gains (losses) from reducing mobility frictions but does not address the costs associated with implementing such policies.

The remainder of the paper is structured as follows: Section 3.2 empirically establishes four key motivating facts that justify the approach taken in this paper. Section 3.3 develops a quantitative spatial general equilibrium model that rationalises these key motivating facts. Section 3.5 discusses the estimation and identification of the key parameters and model inversion, and further describes how the model is solved following an exogenous shock. Section 3.6 estimates the quantitative spatial general equilibrium model and simulates counterfactual experiments. Section 3.7 provides sensitivity analyses and tests the external validity of the model. Finally, Section 3.8 concludes the paper.

3.2 Motivating facts

In this paper, I focus on Senegal for two reasons. First, it is an interesting case because the census data provides enough details to jointly identify internal and international in- and out-migrants that I exploit to calculate the proportion of people born in department i of educational group s who migrate either internally to another Senegalese department or internationally to country j, which I denote m_{ijs}. Therefore, this study is conducted on life-time migrants, disregarding short term and return migration. Second, the Senegal 2013 census provides detailed information necessary to compute the size and skill structure of the local labour force denoted L_{is}. These data are complemented with department level skill-specific labour income data denoted w_{is}, department level housing prices, Q_i, from the 2018 Harmonized Survey on Household Living Conditions (EHCVM), geographic variables (land area, built area past department level population) from the Global Human Settlement Layer (GHSL), and bilateral remittances from the Migration and Remittances Household Survey (MRHSS). The motivating facts are presented at the departmental level.[62] However, for the estimation of the model, I further dis-aggregate the data to the department-area level

[62] See Appendix 3.A for detailed description of the data.

and economic sector level. Note that an area is either urban or rural, while a worker operates either in the formal or the informal economic sector.

3.2.1 Migration patterns and the distribution of economic activity are heterogeneous across sub-national units

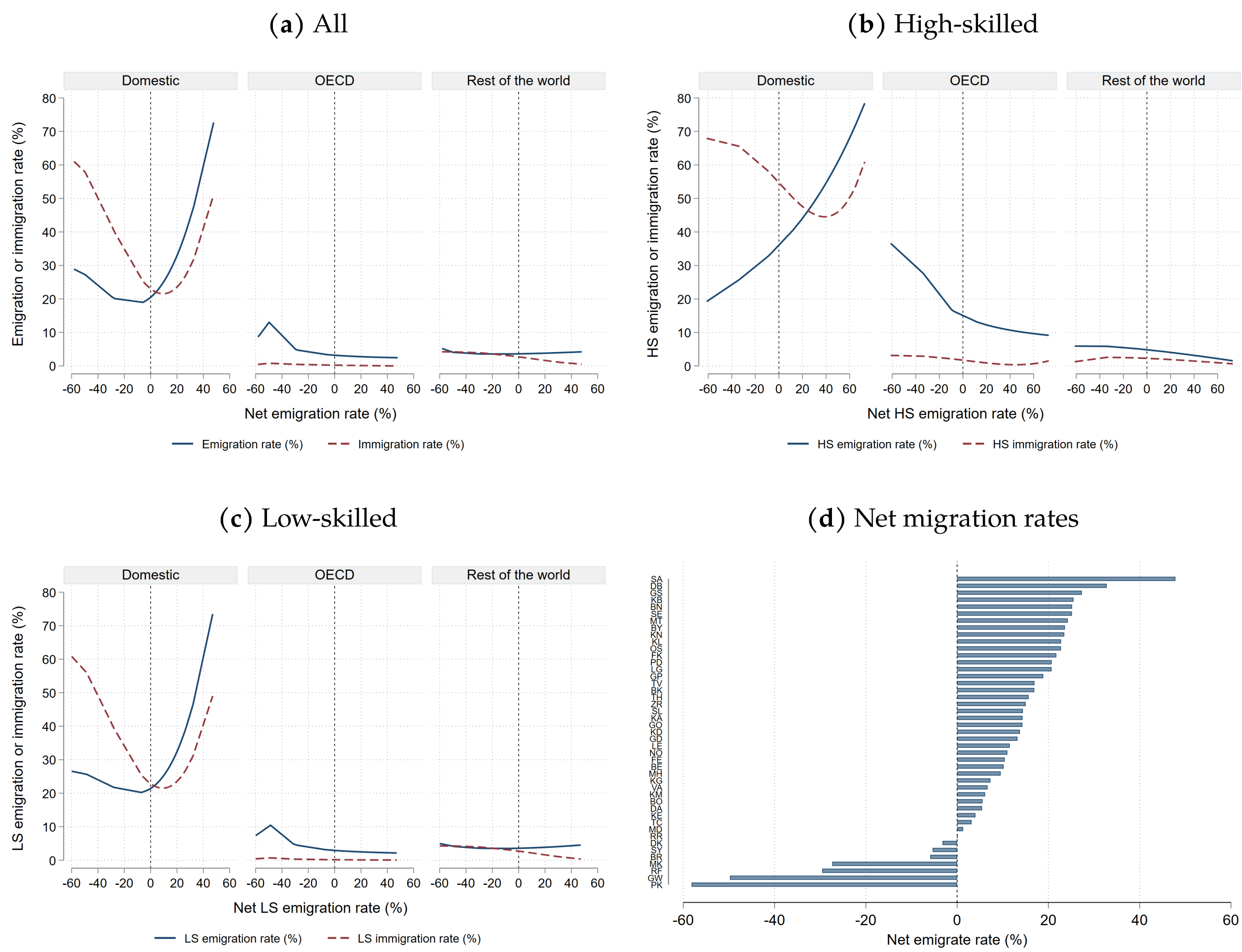
Migration patterns vary significantly across sub-national regions in Senegal.[63] The first three panels of Figure 3.2.1 display gross emigration and immigration rates (y-axis) across different destination and origin categories (internal, international, OECD) in relation to total net emigration rates (x-axis). The data shows that, regardless of education level, domestic immigration consistently exceeds domestic emigration in regions with total net immigration. The gap between the two graphs represents the extent of migration-driven labour supply shocks, indicating that domestic migration plays a significant role in reshaping the spatial allocation of labour within Senegal (panel 3.2.1a). This labour reallocation is particularly pronounced for high-skilled workers (panel 3.2.1b). Additionally, regions experiencing net immigration tend to see substantial emigration to OECD countries, with this effect being disproportionately large among high-skilled individuals. This suggests a brain drain, especially in regions of net immigration, and also pointing to potential education premia for both internal migration to rich domestic regions and international migration to OECD countries. Panel 3.2.1d illustrates the overall impact of migration on local labour supply. Some departments, as a results of migration, such as Salemata and Diourbel, have seen their labour force shrink by 48% and 33%, respectively. In contrast, some others, like Pikine stands out, having grown its workforce by nearly 60% through migration, highlighting its attractiveness as a destination. This polarized migration pattern reveals that around 84% of departments are net emigration locations, while only 16% are net immigration locations. These labour supply shifts raise important questions about their effects on local economies and the spatial distribution of economic activity across the country.

Figure 3.2.2 explores the relationship between local productivity fundamentals and various net emigration rates. Departments with higher exogenous productivity factors (e.g., closer proximity to the coast) tend to attract more migrants in net, they attract firms and generate higher opportunities for workers. This geographical advantage is reflected in

[63] These categories include internal destinations/origins, international OECD destinations/origins, and the rest of the world. The OECD destinations referred to here comprise a group of 11 countries: Belgium, Canada, Switzerland, Germany, Spain, France, Greece, Italy, Portugal, Turkey, and the United States. These destinations were selected based on the criterion that each must have attracted at least 500 Senegalese migrants over the past five years. Consequently, all other OECD countries not listed above, which attracted fewer than 500 Senegalese migrants in the five years prior to the 2013 census, are included in the residual category labeled "Rest of the World".

different migration patterns: coastal departments typically have lower net emigration rates (Panels 3.2.2a, 3.2.2b, and 3.2.2c) due to better local economic opportunities. However, net emigration to OECD countries is an exception, as coastal departments have higher positive net emigration rates compared to inland areas (Panel 3.2.2d). This suggests that while proximity to the coast boosts local economic activity and attracts workers, it also increases international migration to more developed economies.

Figure 3.2.1: Migration patterns across destinations

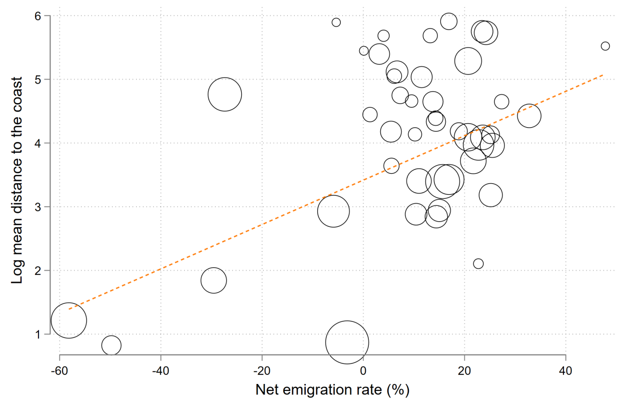


Notes: Panels 3.2.1a, 3.2.1b, and 3.2.1c plots the correlation between overall net emigration rates (X-axis) and emigration or immigration rates (Y-axis) across destination categories (Domestic, OECD, and Rest of the world). Panel 3.2.1d plots for each administrative's level 2 region (refers to as "departments") within Senegal the level of total net emigration. Negative net emigration rates refer to departments of net immigration (immigration > emigration) and indicate positive labour supply shock, while positive net emigration rates refer to departments of net emigration (emigration > immigration) and indicate negative labour supply shock.

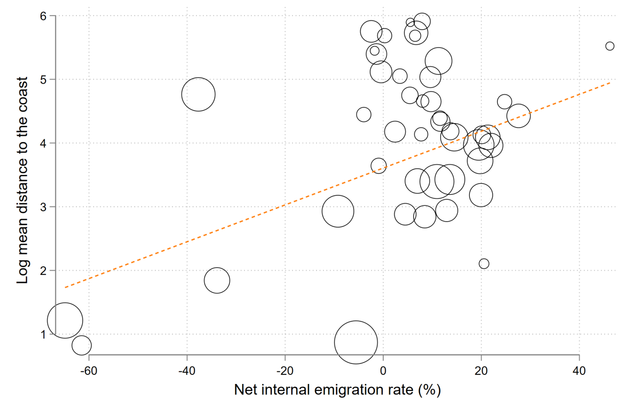
Figure 3.2.3 illustrates the distribution of productivity and net emigration rates across Senegalese departments. The analysis reveals significant productivity disparities between de-

Figure 3.2.2: Productivity fundamentals and the net migration across space

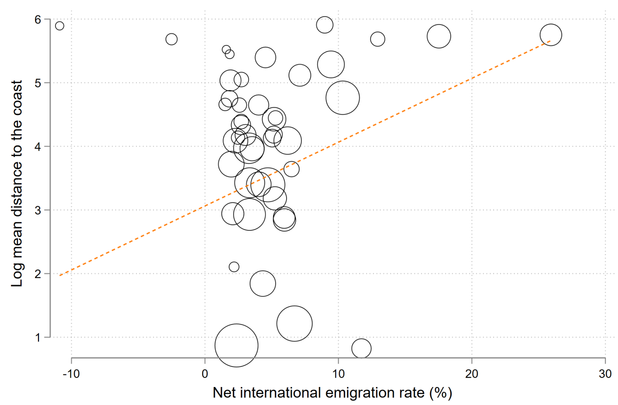
(**a**) All



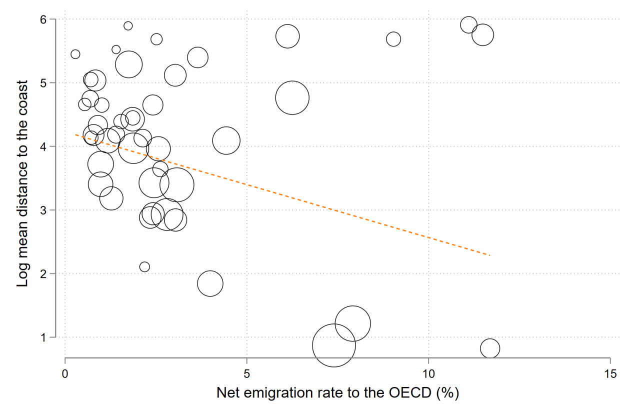
(**b**) Internal



(**c**) International



(**d**) OECD

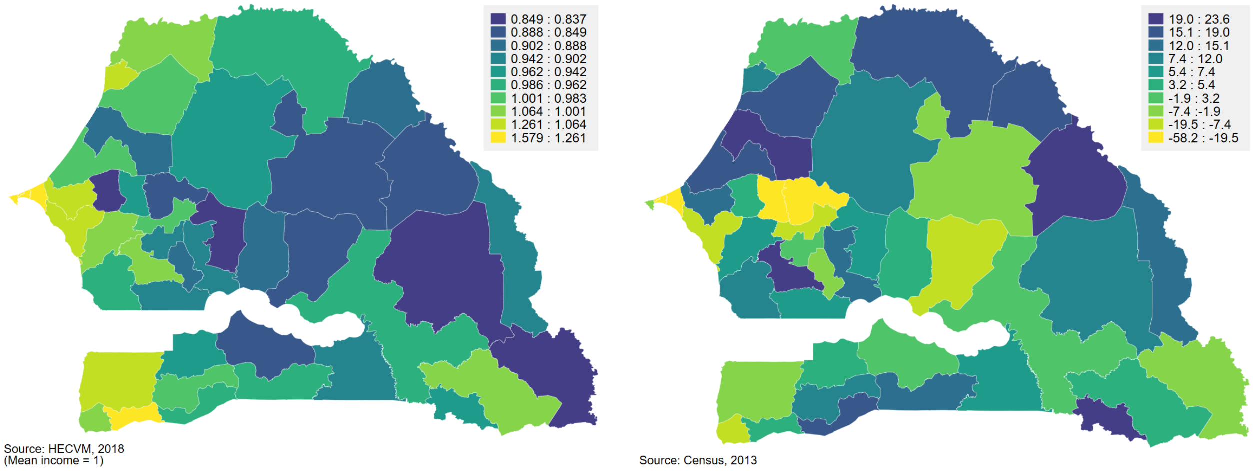


Notes: This figure illustrates the relationship between different types of net migration and local productivity fundamentals, which are represented here by the average distance from the centroid of each department to the coast. The data are aggregated at the department level, and the size of each circle reflects the size of the labour force in that department. Panel (3.2.2a) focuses on net migration relative to all destinations, panels 3.2.2b, 3.2.2c, and 3.2.2d examine net migration relative to internal, international and OECD destinations respectively.

partments, which correlates with varying net emigration rates. Generally, coastal departments in Senegal exhibit substantially higher productivity levels compared to those in other parts of the country. For instance, the ratio of the average income in the top five departments to that of the bottom five is approximately 2:1, indicating considerable spatial heterogeneity. These high-productivity departments also tend to be net immigration departments, characterized by negative net emigration rates. A notable exception is the department of Mbacké, which, despite experiencing significant net immigration, has a lower productivity. This suggests that Mbacke's attractiveness may be driven by non-economic factors. As highlighted in Bocquier et al. (2023), Mbacke is home to the city of Touba, which attracts many immigrants for reli-

Figure 3.2.3: Spatial distribution of productivity and net migration

(**a**) Income per worker (relative to the mean) (**b**) Net emigration share of total employment



Notes: Figure 3.2.3 displays choropleths of relative real income levels for each of Senegalese department and the net migration share of total employment. The lighter the color in panels 3.2.3a and 3.2.3b, the higher the relative productivity and the larger is net immigration.

gious reasons. To empirically test whether heterogeneous exposure to migration matters for the spatial distribution of economic activity within Senegal, I run the following reduced form

$$\Delta lny_i^{2009-2013} = \alpha_0 + \alpha_1 \left(erate_i - irate_i\right)^{2009-2013} + X_i^{2009'}\beta + \epsilon_i,$$

where $\Delta lny_i^{2009-2013}$ is the relative change in local output per squared kilometer between 2009 and 2013. $(erate_i - irate_i)^{2009-2013}$ is the net out-migration rate between 2009 and 2013 computed as the difference between exits and entries as a proportion of native population at the initial period. X_i^{2009} is the set of controls that capture the local initial conditions in 2009. The local output per squared kilometer response to net out-migration rate is obtained as $e^{-\alpha_1(erate_i - irate_i)^{2009-2013}}$.

Findings: The results suggest that a one percentage point increase in the net emigration rate at departmental level is associated to a 5% decline in output per square kilometer within five years. In other words, in departments experiencing positive net emigration rates, output per unit of land falls by 5% for every one percentage point increase in the emigration rate. This reduced-form estimate highlights the direct labour supply effect, with a positive labour supply shock in net immigration departments and a negative shock in net emigration departments. The results also suggest that the overall effect is primarily driven by internal migration (see Appendix A.1), which accounts for the bulk of the labour supply shock at the sub-national level. I further dis-aggregated the net emigration rate into its components -emigration and immigration rates- and estimated their individual effects, which I then compared with the local effect of the net emigration rate. The impact of net migration is a combination of both emigration and immigration effects. Therefore, neglecting either of these dimensions when analysing the distributional effects of migration would likely result in an incomplete or inaccurate understanding of the phenomenon.[64]

3.2.2 Migrants favor expensive departments, but this propensity decreases over time

Controlling for the size of the labour force, the proportion of workers in the formal sector, earnings, and amenity levels, the proportion of migrants locating in department i increases with housing prices. Controlling for initial conditions in Senegalese departments, migration flows to the most expensive departments decrease over time. In other words, the propensity of migrants to choose the most expensive departments diminishes over time, as migrants tend to opt for second-best alternatives.

To empirically document the propensity of migrants to concentrate in expensive departments, building on Albert and Monras (2022),[65] I run the following regression:

$$\ln\left(IM_j/\sum_j IM_j\right) = \pi + \vartheta \ln Q_j + X_j'\Gamma + \varepsilon_j, \tag{3.1}$$

Where IM_j is the number of in-migrants in department j, Q_j the mean yearly rental price in department j, and X_j the vector of additional controls including population size, proportion of workers in the formal sector, and the average income per worker. $\vartheta > 0$ implies that immigrants in Senegal are likely to concentrate more in expensive departments. I define immigrant concentration as the number of migrants residing in department j relative to the total number of migrants in Senegal.

To empirically test whether housing cost at destination affect the location choice of migrants over time, I run the following regression:

[64] Appendix A.1 provides detailed results at the departmental level.

[65] This approach differs from the immigration concentration measure used in Albert and Monras (2022). In their study, they divide my concentration measure by the number of natives in each geographical unit compared to the country-wide number of natives. Their measure serves a distinct purpose from mine, as they aim to analyze whether the concentration of immigrants in expensive locations differs from that of natives. In contrast, my focus is solely on determining whether immigrants concentrate in expensive locations.

$$\ln\left(\frac{M_{ij}^{2009-2013}}{M_{ij}^{2004-2008}}\right) = c + \nu \ln Q_j + X_{ij}^{'}\gamma + Z_{j,2008}^{'}\beta + \vartheta_{ir} + \varepsilon_{ij}, \tag{3.2}$$

where $M_{ij}^{2009-2013}/M_{ij}^{2004-2008}$ is the five years change in bilateral migration flows between Senegalese departments. Q_j is the rental price in the destination department j, X_{ij} is the set of dyadic controls including geographical distance, contiguity, $Z_{j,2008}$ is the set of initial destination controls including average distance to the coast, distance to cities, average travel time to the city center, and the average distance to the road. The specification also includes origin-region of destination pair fixed effects (ϑ_{ir}).[66] c is the constant.

Findings : There is a strong positive correlation between in-migrants concentration and housing prices, suggesting that in-migrants concentrate in high-cost housing departments, which appear to be, on average, the most populated (see Appendix A.2).[67] Appendix A.1 displays a range of regression results that account for potential endogeneity concerns of Q_j. The estimate in column 1 displays a similar picture as Appendix A.2 indicating a strong positive association between housing prices and in-migrants concentration. I estimate that the elasticity of in-migrants concentration with respect to housing prices is positive and statistically significant. A 10% increase in the housing prices in department i is leads to a 9% increase in immigrant concentration in that department. This effect stands at roughly 27% for High-skilled and 8% for the low-skilled.

I further estimate changes in migration flows over time with respect to housing prices at destination in Table 3.2.1. The first column reports the OLS estimate, the second column reports the PPML estimate while the last two columns report the IV estimate. In column 3, the housing prices are instrumented, as in Albert and Monras (2022) using the local share of unavailable land while column 4 uses local population density in 1990 as an instrument for the housing prices. The direction and the significance of the estimated elasticity is consistent across columns. Although migrants in Senegal concentrate in expensive departments, this concentration creates congestion that operates among other through higher housing prices which end up pushing migrants to consider alternative destinations. The point estimate shows that, a 10% increase in housing prices in a department reduces migration flows toward that department by 5 to 7% within five years.

[66] Note that the *region* is is larger than *j*. While there are 45 internal destinations, there are 14 admin-1 regions.
[67] Appendix A.2 plots the in-migrant concentration against the department housing prices, where circle sizes indicate the population size of the department.

Table 3.2.1: Rental prices and the dynamics of local immigration flows in Senegal

	Dep. var. : $\ln\left(M_{ij}^{2009-2013}/M_{ij}^{2004-2008}\right)$ or $M_{ij}^{2009-2013}/M_{ij}^{2004-2008}$			
	OLS	PPML	IV	
	(1)	(2)	(3)	(4)
Rental prices (log)	-0.240***	-0.428***	-0.514***	-0.775***
	(0.071)	(0.156)	(0.177)	(0.288)
Bilateral distance (log)	0.066***	0.137***	0.074***	0.082***
	(0.021)	(0.049)	(0.023)	(0.025)
Contiguity	0.183**	0.013	0.170*	0.158*
	(0.090)	(0.164)	(0.089)	(0.091)
Observations	1,927	1,969	1,927	1,927
R-squared	0.356		0.037	0.002
Origin FE	Y	Y	Y	Y
destination region FE	Y	Y	Y	Y
origin X region FE	Y	Y	Y	Y
Destination controls	Y	Y	Y	Y
Instrument	-	-	Share of unavailable land	Population density in 1990
K. Paap F-stat (First stage)	-		349.04	92.44

Notes: The dependent variable is the change in bilateral migration flows between 2009-2013 and 2004-2008. For the Ordinary Least Squares (OLS) and Instrumental Variables (IV) estimations, the logarithm of the dependent variable is taken, while for the Pseudo Poisson Maximum Likelihood (PPML) estimation, the dependent variable is not logged. The regressions use data from the 2013 Senegalese census, the 2018 Harmonized Survey on Household Living Conditions (EHCVM), and the Global Human Settlement Layer (GHSL) for the years 1990, 2000, and 2010. The term "unavailable land share" refers to the built-up non-water land area in each department, while "population density in 1990" refers to the number of people per square kilometer in each department in 1990. Standard errors in parentheses are clustered at the regional level (GADM level 1). OLS stands for Ordinary Least Squares, PPML for Pseudo Poisson Maximum Likelihood, and IV for Instrumental Variables. Destination controls include average distance to the coast, distance to cities, travel time to the city center, and average distance to the road. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.2.3 Productivity is higher in urban areas, within formal sectors, and among those with higher levels of education

Controlling for department fixed effect (δ_d), age and its square, gender and the prestige of occupation (X_ι), wages (w_ι) are higher in urban areas ($Urban_\iota$), in formal sector ($Formal_\iota$), and higher for high-skilled workers ($Education_\iota$).[68] This fact is established by running the following regression:

$$\ln\left(w_\iota\right) = \xi_0 + \xi_1 Urban_\iota + \xi_2 Formal_\iota + \xi_3 Education_\iota + X_\iota^{'}\Gamma + \delta_d + \Psi_\iota \qquad (3.3)$$

Findings: Estimates indicate that earnings in Senegal are 1.9 times higher in the formal sector compared to the informal sector, 1.3 times higher in urban areas than in rural areas, and roughly 3 times larger for highly educated compared to their less educated counterparts.

[68] ι denotes the individual worker.

Detailed results are provided Appendix A.2. I further assess the robustness of these premia by restricting the analysis to earnings from the primary job only (Appendix A.2) which indicate that results are consistent. This fact suggests that a Senegalese worker, as a utility maximiser, has a higher incentive to: (1) locate in urban areas, (2) work in the formal sector, (3) invest more in education, or all three at once, to the extent that they can afford the cost structure they face.

3.2.4 There are direct gains from emigration for origin locations

3.2.4.1 Monetary gains: remittances

Controlling for department size, the proportion of urban population and the mean distance to the coast, the share of remittances received by a department increases with the emigration concentration. In general, there is a positive correlation (0.8) between the share of remittances and the share of out-migrants from a sending department; as the concentration of out-migrants increases, so does the share of remittances received. This pattern holds regardless of destination category, although migrants to high-productivity countries tend to send more remittances per migrant. In particular, remittances per migrant from OECD countries $(\$1,991$/year) are about 2.5 times than those per migrant in other parts of the world ($\$799$/year) and more than 20 times larger than those per internal migrant ($\$90$/year). To go beyond a simple correlation, I run the following regression using OLS:

I run the following regression:

$$ln\left(R_i/\sum_i^N R_i\right) = \beta_0 + \beta_1 ln\left(EM_i/\sum_i^N EM_i\right) + X_i'\Gamma + \epsilon_i, \tag{3.4}$$

Where R_i and EM_i are respectively the amount of remittances received by department i and the number of emigrants from department i. X_i is the vector of controls including the size of the department, the average distance to the coast, and the proportion of the urban population in the department. However, emigrant concentration is potentially endogenous as the prospect of remittances can influence emigration decisions, preventing a causal interpretation of the estimated β_1. To address this, emigration concentration is instrumented using a gravity-based approach. This method predicts bilateral migration stocks using exogenous factors such as geographic distance, colonial history, and origin characteristics such as population density and proximity to the coast. In addition, interactions between geographical distance and type of destination (domestic, OECD or other international) as well as destination-specific effects are accounted for.

Findings: A 1% increase in emigration concentration leads to a 1.08% increase in the share of remittances received. By destination, the elasticity is 1.09% for internal destinations, 1.37% for OECD destinations and 0.78% for other destinations. Thus, regardless of destination, higher emigration concentration likely leads to higher remittances shares, with the effect increasing as the productivity level of the destination increases. Detailed results are presented in Appendix A.3.

3.2.4.2 Positive selection and education premium

In Senegal, high-skilled workers are 4.9 percentage points more likely to emigrate than the low-skilled. To empirically establish positive selection in the Senegalese migration, I run the following multinomial logit equation:

$$\ln \frac{Pr\left(M_{\iota}^{m}=1,2,3\right)}{Pr\left(M_{\iota}^{m}=0\right)} = \alpha + \gamma Education_{\iota} + X_{\iota}^{'}\beta + C_{\iota}^{'}\theta + D^{'}\eta + \epsilon_{\iota}, \tag{3.5}$$

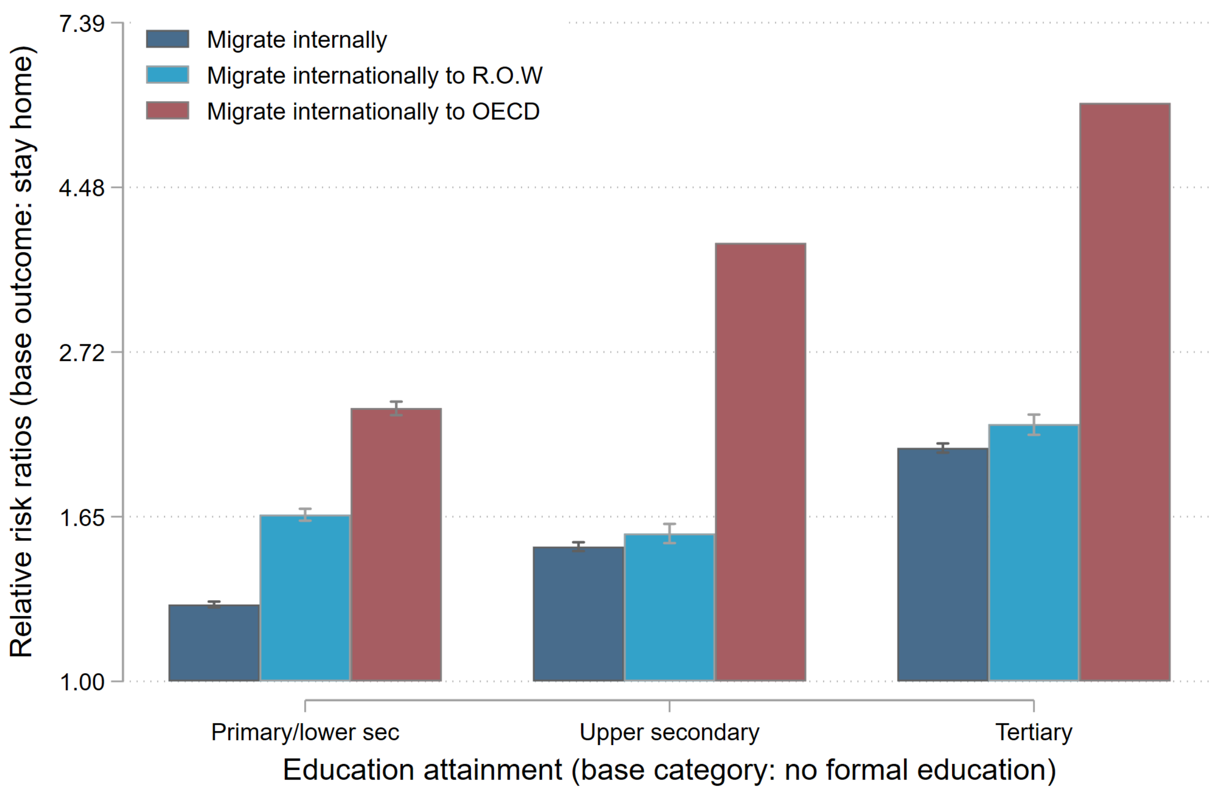
where M_{ι}^{m} is the destination choice variable such that m takes the value 0 if the individual ι decides not to migrate (the base outcome), 1 if the individual migrates to to another internal destination, 2 if she migrates internationally to non-OECD countries and 3 if she migrates to an OECD country. $Education_{\iota}$ is the education level of the individual that takes the value 0 if she has no formal education (reference group), 1 if she has primary or lower secondary education, 2 for upper secondary education, and 3 if tertiary education. X captures other individual characteristics that include the gender, age group, relation to the household head. C captures community level characteristics such as whether the respondent lives in a urban or rural area. Finally, D is the set of department dummies corresponding to the department of origin to control for origin level unobservable factors that influence migration such as weather shocks, local economic shocks.

Findings: Results reported in Figure 3.2.4 shows that Senegalese migration is overall positively selected along the education dimension.[69] The more the individuals are educated, the higher their chance of migrating relative to not migrating. This effect holds irrespective of the destination (internal, international rest of the world, OECD). Moreover, the developed the destination category is, the higher the level of positive selection as evidenced by maroon bars capturing the relative risk of migrating to an OECD country relative to not migrating. This trend suggests that the expected education premium in OECD destinations significantly

[69] The blue bar reports the likelihood of an individual with primary or lower secondary education relative to another one with no formal education who migrate relative to not migrating. The light blue bar reports the same information for individual with upper secondary education over another one with no formal education while the maroon bar reports that same information for an individual with tertiary education relative to another one without formal education.

motivates emigration among the highly educated, which has proven to encourage investment in human capital (Beine et al., 2008; Shrestha, 2017).

Figure 3.2.4: Senegalese migration is positively selected



Notes: Figure 3.2.4 displays the results from estimating Eq. 3.5 by multinomial logit. I plot the relative risk ratios. The base outcome is "*non-migrants*" and the base category of education variable, the main variable of interest, is "*no formal education*" so that estimates can be interpreted as relative to non-migrant for each destination category and relative to those with no formal education for each other education group. For instance, for Senegalese individuals with primary or lower secondary education relative to those with no formal education, the relative risk for migrating internally relative to no migrating is 1.28 times higher, holding other variables in the model constant. This relative risk is 1.54 times higher for those with upper secondary education and 2.12 times higher for those with tertiary education. The sample comprises 5,593,650 individuals aged 15+ across 45 departments in Senegal. Pseudo R^2 is 0.114. 95% confidence intervals from standard errors.

3.3 Quantitative model

Building on Monte et al. (2018), Tombe and Zhu (2019), Cha'ngom et al. (2023) and Bryan and Morten (2019), I develop an economic geography model in which locations are linked in factor markets by migration with two key additions. First, I assume non-homothetic preferences by allowing agricultural consumption to be subject to subsistence food requirements within a Stone-Geary utility function.[70] Second, I simultaneously introduce internal and international skill specific migration frictions to account for the full heterogeneous exposure to net migration across space. In this literature, locations are also linked in the goods market by trade, a dimension I abstract from due to data limitations. I assume free trade across locations and normalize the prices of consumption goods to one.

Environment. The economy consists of a set of N internal locations representing Senegalese departments indexed $i \in N$ interacting with $N-1$ other Senegalese departments indexed $j \in N$ and D foreign countries indexed $j \in D$.[71] Each internal location i or j consists of either an urban (U) or a rural (R) area, or both, indexed $\zeta \in (U, R)$. Each area consists of two economic sectors: the formal (F) and the informal (I), indexed $f \in (F, I)$. The formal sector is on average more productive than the informal sector. The economy produces two final tradable goods: agricultural (a) in rural areas and non-agricultural (na) in urban areas, using workers who are heterogeneous in skills accumulated through education. These workers are either high-skilled or low-skilled, indexed $s \in (h, l)$. In the rural informal sector, I assume that only less-educated workers produce subsistence agriculture. Workers live where they work and devote their income to consumption of agricultural and non-agricultural goods C, as well as on housing services H. Conditional on emigrating, workers also sent part of their income back home in the form of remittances. The model abstracts from savings. To allow labour income to be the only source of income, I further assume, as in Hsieh and Moretti (2019), that the housing stock is consumed by workers but owned by absentee landlords. The local economy is initially populated by $\bar{L}^0_{i\zeta}$ workers,[72] who supply one unit of labour.

Workers preferences. Workers are geographically mobile and have heterogeneous preferences over destinations (home, internal, and international). Each worker born in location $i\zeta$ chooses her location of residence and work such as to maximize her utility taking as given the location of firms and other workers. The utility of type s worker born in location $i\zeta$ who chooses to migrate to destination department-area or country J is defined over final good consumption (C^s_J),[73] remittances send back by migrants $(R^s_{i\zeta J})$, housing (H^s_J), amenities in J (B_J), idiosyncratic preferences for a specific destination $(\epsilon^s_{i\zeta J})$, average bilateral migration costs $(\tau^s_{i\zeta J} < 1)$. To model the nexus between migration and education decisions, I follow Cha'ngom et al. (2023) and introduce a second source of heterogeneity in the cost of acquiring

[70] Non-homothetic preferences play an important role. Higher subsistence food requirement, higher agricultural prices and lower total productivity increase the share of food in total expenditure (Tombe, 2015). The latter depends on the demand for agricultural goods, which is also a critical dimension of the model.

[71] Throughout this paper, I do not differentiate between urban and rural areas in foreign destinations, as the census data does not provide information on the specific locations of individuals who have migrated abroad.

[72] $\sum_s L^{0s}_{i\zeta} \equiv \bar{L}^0_{i\zeta}$

[73] Note that $J \equiv j\zeta$ if $j \in N$ or $J = j$ if $j \in D$

higher education ($e^{h\iota} \in [0,1]$)[74]. I allow individual specific effort to acquire higher education to decrease with the access to education and to vary with other region specific characteristics affecting access to both basic (primary and secondary) and higher education all embodied in the scale variable $G_{i\zeta}$. This highlights the complementarity between the access to education and the individual effort needed to get educated. Consequently, workers need a varying level of effort, and heterogeneous preferences over destination locations for some to be incentivised to invest more in higher education. The utility of individual ι born in $i\zeta$ who migrate to J is given by:

$$U^{\iota s}_{i\zeta J} = \epsilon^{\iota s}_{i\zeta J}(1 - \tau^{s}_{i\zeta J}) \left(1 - \frac{e_s}{G_{i\zeta}}\right) \left(\frac{C^s_J}{\beta}\right)^{\beta} \left(\frac{H^s_J}{1-\beta}\right)^{1-\beta} \tag{3.6}$$

where $J = j\zeta$ if $J \in N$ or $J = j$ if $J \in D$. C^s_J and H^s_J are respectively the utility derived from consuming agricultural, non agricultural, housing services in J, and sending remittances back home for type-s worker. Workers in J decide how much to consume of agricultural and non agricultural goods ($C^{a,s}_J, C^{na,s}_J$) and how much to devote to housing services (H^s_J). Conditional on being a migrant, they also decide what proportion of their income to send back home in the form of remittances. Additionally, their consumption of agricultural good is subject to a minimum food requirement, $\bar{a}$. The consumption aggregate is modeled as:

$$C^s_J = \left((C^{a,s}_J - \bar{a})^{\xi} (C^{na}_J)^{1-\xi}\right)^{\alpha} \left[1 + R^s_{Ji\zeta}\mathbb{1}\{J \neq i\zeta\}\right]^{1-\alpha}$$

Workers seek to maximize Eq. (3.6) subject to the following budget constraint: $P^a_J C^{a,s}_J + P^{na}_j C^{na,s}_J + P_{J,i\zeta} R^s_{Ji\zeta} + Q_j H^s_J \leq w^s_J$. α, ξ and β denote the preference weights ($\alpha < 1, \xi < 1, \beta < 1$). I add remittances in the form $1 + R_{jis}$ to ensure that the utility remains positive for non migrants, i.e., when $i = j$.[75] Workers have idiosyncratic preference shock $\epsilon^{s\iota}_{i\zeta J}$ for a specific location is assumed to be $i.i.d.$ and drawn from an extreme value distribution (Fréchet type):

$$F\left(\epsilon^{s\iota}_{i\zeta J}\right) = e^{-B_J\left(\epsilon^{s\iota}_{i\zeta J}\right)^{-\mu}}, \tag{3.7}$$

where the shape parameter $\mu > 1$ regulates the heterogeneity of workers' tastes across locations. The larger μ, the lower the dispersion or heterogeneity among workers, and the higher the μ, the more likely it is that workers choose to migrate to a destination with better economic fundamentals (such as real income) rather than purely idiosyncratic preferences. However, the lower the μ, the greater the heterogeneity among workers, who now derive higher utility

[74] This cost is 0 i.e. $e^{l\iota} = 0$ if the individual does not to invest is higher education.

[75] When $i\zeta = J$, $R^s_{Ji\zeta} = 0$ and $\alpha = 1$ i.e., non movers don't remit, instead their expenditure capacity is augmented by the remittances received from movers and this will be later on characterized in the indirect utility.

from idiosyncratic preferences than from economic fundamentals of the destination.[76] The scale parameter B_J measure the amenity of location J and captures how attractive a location is conditional on real income. that I assume to decrease with population density (L_J/T_J). In the economic geography literature, amenities could include natural beauty, availability of services, and housing prices among others (Bryan and Morten, 2019; Diamond, 2016). The amenities I refer to, are net of housing services as this component is explicitly accounted for in the model. $\tau^s_{i\zeta J}$, the average migration cost, captures the utility cost of moving away from the origin location. I assume that staying in the home location implies no costs.

As in Desmet et al. (2018), amenities take the following functional form: $B_J = \bar{B}_J\left(L_J/T_J\right)^{-\lambda}$ where $\bar{B}_J > 0$, $\lambda > 0$. λ determines the extend to which population density deters the quality of life in J. I further assume that provision of public education, $G_{i\zeta}$, partly depends on location fundamentals, $\bar{G}_{i\zeta}$, and population density, $L_{i\zeta}/T_i$, such that $G_{i\zeta} = \bar{G}_{i\zeta}\left(L_{i\zeta}/T_i\right)^b$ where b determines the extent to which population density affects the level of educational infrastructures provided by the government. $\bar{G}_{i\zeta}$ includes exogenous reasons that explain why some locations are more endowed in educational infrastructures than others. This includes the initial settlements of missionaries and colonizers, namely Saint-Louis and Dakar, which today are the areas with the most extensive educational infrastructures (Bouche, 1974).

Regarding the individual effort/cost required to acquire higher education, no effort is needed if an individual opts to remain low-skilled ($e^{l\iota} = 0$). However, choosing higher education requires a positive effort ($e^{h\iota} \geq 0$). Following Cha'ngom et al. (2023), I assume that $e^{h\iota}$ is distributed over the interval [0,1] according to the following cumulative distribution function:

$$F_2(e^h) = \left(e^h\right)^{1+z}, \tag{3.8}$$

where the parameter $z \in \mathbb{R}^+$ governs the slope of the density function, $f_2(e^h) = (1+z)\left(e^h\right)^z$ which increases in e^h. The higher the z, the higher the level of effort required to acquire higher education, and consequently, the lower the proportion of individuals willing to invest in the acquisition of human capital. $1+z$ ensures that $\int_0^1 f_2(e^h) = 1$. $z = 0$ reflects a location in which the entire work-force faces the same effort cost required to get educated. However, $z > 0$ implies of a density of $f_2(e^h)$ which is strictly increasing in e^h reflecting the fact more individuals face large individual effort. The higher the z, the higher the required effort.

Utility maximization under the budget constraints implies that the equilibrium consumption bundle for a representative type-s worker in department-area J is given by:

[76] A higher μ makes dispersion forces smaller while a lower μ makes dispersion forces higher. In other words, when $\mu \to 1$ workers are totally immobile while they are perfectly mobile when $\mu \to \infty$.

$P^a_J C^{a,s}_J = P^a_J \bar{a} + \alpha\beta\xi\,(w^s_J - P^a_J \bar{a})$, $P^{na}_J C^{na,s}_J = \alpha\beta(1-\xi)\,(w^s_J - P^a_J \bar{a})$, $P_{i\zeta,J} R^s_{J,i\zeta} = (1-\alpha)\,\beta\,(w^s_J - P^a_J \bar{a})$, $Q_J H^s_J = (1-\beta)\,(w^s_J - P^a_J \bar{a})$.

Given that I do not observe $\bar{a}$, I follow Tombe (2015) and use data on household food expenditure shares to define final demand. The income share of type-s worker in department J ($s^{a,s}_J$) is given as:

$$s^{a,s}_J = P^a_J C^{a,s}_J / w^s_J,. \tag{3.9}$$

The implied local individual demand in each destination location J as well as the remittances supplied can be expressed as:

$$P^a_J C^{a,s}_J = s^s_J w^s_J,$$

$$P^{na}_J C^{na,s}_J = \frac{\alpha\beta(1-\xi)}{1-\alpha\beta\xi}\left(1 - s^{a,s}_J\right) w^s_J,$$

$$P_{i\zeta,J} R^s_{J,i\zeta} = \frac{(1-\alpha)\beta}{1-\alpha\beta\xi}\left(1 - s^{a,s}_J\right) w^s_J,$$

$$Q_J H^s_J = \frac{(1-\beta)}{1-\alpha\beta\xi}\left(1 - s^{a,s}_J\right) w^s_J.$$

I assume free trade across locations and normalize the prices of the consumption goods to one (agricultural and non agricultural goods). Plugging optimal demands into the direct utility function (Eq. 3.6) yields the following indirect utility of living in each location :

$$V^{\iota,s}_{i\zeta,J} = \Omega \epsilon^{\iota,s}_{i\zeta,J} \left(1 - \frac{e^{\iota,s}}{G_{i\zeta}}\right)\left(1 - \tau^s_{i\zeta,J}\right)\left(\frac{w^s_J}{\left(P_{J,i\zeta}\right)^{(1-\alpha)\beta}\left(Q_J\right)^{1-\beta}}\right)\frac{1 - s^{a,s}_J}{1-\alpha\beta\xi} \tag{3.10}$$

where $\Omega \equiv \left(\alpha^\alpha (1-\alpha)^{1-\alpha}\right)^\beta$ is a constant and the price index faced by a type-s migrant in J is given as:

$$\mathbb{P}_{J,i\zeta} = \left(P_{J,i\zeta}\right)^{(1-\alpha)\beta}\left(Q_J\right)^{1-\beta} \tag{3.11}$$

Note that $\mathbb{P}_{J,i\zeta}$ varies across dyads due to differences in bilateral remittances. $\mathbb{1}\{x\}$ is an indicator variable that takes the value of one if condition x is satisfied and zero otherwise. If $i\zeta = J$, r^s_J represents additional income enjoyed by a non-migrant, derived from the income earned by migrants in their respective destinations and sent back home as remittances. In a scenario without remittances, this price index simplifies to $Q^{1-\beta}_J$. I define dyadic remitting costs, $P_{J,i\zeta}$, as a function of the skill-specific bilateral component $\bar{\Phi}^s_{i\zeta J}$ (a constant) that accounts for corridor-specific fundamentals differing by skill level, and a component that depends on the density of usage of the given corridor, $M^s_{i\zeta J}$. Thus:

$$P_{i\zeta J} = \bar{\Phi}^s_{i\zeta J} \times \left(M^s_{i\zeta J}\right)^{-\psi}, \qquad \psi \geq 0 \tag{3.12}$$

Eq. (3.12) indicates that the remitting cost decreases with bilateral migration size and the intensity of the decrease is governed by the elasticity of remitting cost to migration size, ψ. In this setting, any outflow of remittances entails a cost on the representative sender, which increases her average price index by $\bar{\xi}_J$ that I capture here as the weighted average of the sending cost over all dyads for any given sending location J. For the sake of simplicity, the average price index is obtained as:

$$\mathbb{P}_J = \left(1 + \bar{\xi}_J\right)^{(1-\alpha)\beta} Q_J^{1-\beta} \quad \text{where} \quad \bar{\xi}_J = \sum_i \upsilon_{i\zeta J} P_{i\zeta J} \tag{3.13}$$

where $\upsilon_{i\zeta J}$ is the share of remittances sent from J to $i\zeta$.

Education decisions. Individuals acquire higher education if the expected utility gains from being highly educated exceed the effort cost needed to become highly educated ($\mathbb{E}\left(V^h_{i\zeta}\right) \geq \mathbb{E}\left(V^l_{i\zeta}\right)$). Under the Fréchet distribution, the total expected utility gain from choosing to be a type-s worker is given by: $\mathbb{E}\left(V^s_{i\zeta}\right) = \Omega^\mu \left(1 - \frac{e^{s\iota}}{G_{i\zeta}}\right)^\mu \sum_k \left(\widetilde{U}^s_k (1 - \tau^s_{i\zeta k})\right)^\mu$ where $\widetilde{U}^s_k = w^s_k \mathbb{P}^{-1}_k$.

Investing in higher education is optimal if

$$\left(1 - \frac{e^{h\iota}}{G_{i\zeta}}\right)^\mu \sum_K \left(\widetilde{U}^h_K (1 - \tau^h_{i\zeta K})\right)^\mu \geq \sum_K \left(\widetilde{U}^l_K (1 - \tau^l_{i\zeta K})\right)^\mu, \tag{3.14}$$

Dividing both sides of Eq. (3.14) by the right hand side of the same equation yields $e^h \leq G_{i\zeta}\left[1 - 1/\Lambda^{1/\mu}_{i\zeta}\right]$ where $G_{i\zeta}\left(1 - 1/\Lambda^{1/\mu}_i\right)$ is the critical level of education or skill acquisition cost below which investing is higher education is optimal. This critical level increases with the available educational infrastructures ($G_{i\zeta}$), and the expected education premium ($\Lambda_{i\zeta}$) which accounts for skill specific migration prospects.

$\Lambda_{i\zeta} \equiv \sum_k \left(\widetilde{U}^h_K\right)^\mu (1 - \tau^h_{i\zeta K})^\mu / \sum_k \left(\widetilde{U}^l_K\right)^\mu (1 - \tau^l_{i\zeta K})^\mu$.

The expected education premium consists of three components and can be explicitly rewritten as:

$$\Lambda_{i\zeta} = \frac{\left(\widetilde{U}_i^h\right)^\mu + \sum_{J\in N}\left(\widetilde{U}_J^h\right)^\mu (1-\tau_{i\zeta J}^h)^\mu + \sum_{J'\in D}\left(\widetilde{U}_{J'}^h\right)^\mu (1-\tau_{i\zeta J'}^h)^\mu}{\left(\widetilde{U}_i^l\right)^\mu + \sum_{J\in N}\left(\widetilde{U}_J^l\right)^\mu (1-\tau_{i\zeta J}^l)^\mu + \sum_{J'\in D}\left(\widetilde{U}_{J'}^l\right)^\mu (1-\tau_{i\zeta J'}^l)^\mu} \tag{3.15}$$

The first component captures the local education premium, the second and third components capture the part of $\Lambda_{i\zeta}$ driven by internal migration prospects (second) and international migration prospects (third). This suggests that migration prospects affect the expected return to higher education. Given the distributional assumptions on $e^{h\iota}$ defined in Eq. (3.8), the endogenous fraction of natives in location $i\zeta$ who decide to invest in higher education is obtained as :

$$H_{i\zeta} = \left[G_{i\zeta}\left(1 - 1/\Lambda_{i\zeta}^{1/\mu}\right)\right]^{1+z} \tag{3.16}$$

Eq. (3.16) shows that the share of highly educated native workers in each department-area of origin increases with the local access to education, $G_{i\zeta}$, as well as with the expected education premium, $\Lambda_{i\zeta}$. To the extent that the education premium is on average higher in all potential destinations other than the home location, the migration prospect stimulates human capital accumulation among natives. This is in line with Beine et al. (2008); Cha'ngom et al. (2023); Bocquier et al. (2023). However, it should be noted that post-migration human capital is more important than pre-migration human capital for local production. Consequently, the ex-post human capital is given by the share of highly educated natives who did not migrate, adjusted by the share of highly educated immigrants. This is given by :

$$h_{i\zeta} = \frac{(1-\sum_J m_{i\zeta J}^h)H_{i\zeta}L_{i\zeta}^0 + \sum_J m_{Ji\zeta}^h L_J^{h0}}{\left[(1-\sum_J m_{i\zeta J}^h)H_{i\zeta} + (1-\sum_J m_{i\zeta J}^l)(1-H_{i\zeta})\right]L_{i\zeta}^0 + \sum_s\sum_J m_{Ji\zeta}^s L_J^{s0}} \tag{3.17}$$

Eq. (3.17) shows that the stock of resident human capital in any location exposed to migration responds ambiguously to migration prospects. Indeed, the share of highly educated residents increases with the fraction of highly educated non-migrants, $(1-\sum_j m_{i\zeta J}^h)H_{i\zeta}L_{i\zeta}^0$, and immigrants $\sum_J m_{Ji\zeta}^h L_J^{h0}$, but decreases with the fraction of lower educated non-migrants, $(1-\sum_J m_{i\zeta J}^l)(1-H_{i\zeta})L_{i\zeta}^0$, and immigrants $\sum_J m_{Ji\zeta}^l L_J^{l0}$.

Migration decisions. Once education decision is taken, workers choose where to live and work by selecting the destination that maximizes their indirect utility given the realization of the idiosyncratic shock. Eq. (3.10) shows that indirect utility is a monotonic function of the idiosyncratic preferences over potential destinations ($\epsilon_{i\zeta J}^s$), which are extreme value

Fréchet-type distributed. Therefore, the indirect utility of a worker born in i who migrated to j is also Fréchet-type distributed: $\mathcal{O}^s_{i\zeta J} = e^{B_J\left[\Omega \widetilde{U}^s_J\left(1-\tau^s_{i\zeta J}\right)\left(1-e^{s\iota}/G_{i\zeta}\right)\right]^{\mu} V^{-\mu}}$. Each worker chooses the destination that maximizes her utility net of migration cost. Let $m^s_{i\zeta J}$ be the share of workers who migrated from $i\zeta$ to J. Given real wages $w^s_J \mathbb{P}^{-1}_J$, amenity level B_J, and individual effort cost required to acquire higher education $e^{s\iota}$ in all locations, workers from $i\zeta$ choose J, the destination that maximizes their utility level. The law of large numbers implies that

$$m^s_{i\zeta,J} = \frac{B_J\left(\widetilde{U}^s_J(1-s^{a,s}_J)\right)^{\mu}\left(1-\tau^s_{i\zeta,J}\right)^{\mu}}{\sum_K B_K\left(\widetilde{U}^s_K(1-s^{a,s}_K)\right)^{\mu}\left(1-\tau^s_{i\zeta,K}\right)^{\mu}}, \tag{3.18}$$

where $K = k\zeta$ if $K \in N$ or $K = k$ if $K \in D$.

Spatial allocation of labour. I assume that each worker inelastically supplies one unit of labour such that $m^s_{i\zeta J}$ can be replaced by $M^s_{i\zeta J}/L^{s0}_{i\zeta}$, which is the proportion of type-s worker supply in location J by workers born in $i\zeta$. Using Eq. (3.18) and summing across origins and destinations, the total number of type-s workers who choose to live and work in J is given as:

$$L^s_J = B_J\left(\widetilde{U}^s_J\right)^{\mu}\sum_{i\zeta}\left[\frac{\left(1-\tau^s_{i\zeta J}\right)^{\mu}}{\sum_K B_K\left(\widetilde{U}^s_K\right)^{\mu}\left(1-\tau^s_{i\zeta K}\right)^{\mu}}\right]L^{s0}_{i\zeta}, \tag{3.19}$$

Eq. (3.19) shows that the skill-specific labour supply in location J increases in amenities and wages but decreases in prices[77]. Note that the average price index, for non-migrants, accounts for the price of consumption goods and housing services while this index is augmented by the remitting costs for migrants. In the presence of migration, the local labour supply of type s in location $i\zeta$ consists of two components: the initial labour supply of $i\zeta'$ made of non-migrants ($L^s_{i\zeta i\zeta}$), and workers, born elsewhere, who immigrated to $i\zeta$. Consequently, Eq. (3.19) can be rewritten from the location $i\zeta$ perspective as follows:

$$L^s_{i\zeta} = \underbrace{\left[\left(1-\sum_{J\in N} m^s_{i\zeta J}\right)L^{s0}_{i\zeta} + \sum_{J\in N} m^s_{Ji\zeta}L^{s0}_J\right]}_{\text{Internal net migration}} + \underbrace{\left[-\sum_{J'\in D} m^s_{i\zeta J'}L^{s0}_{i\zeta} + \sum_{J'\in D} m^s_{J'i\zeta}L^{s0}_{J'}\right]}_{\text{International net migration}} \tag{3.20}$$

where J and J' identifies internal and international destinations respectively.

[77] Knowing that $\widetilde{U}_{js} = w^s_J/\mathbb{P}_J$.

3.3.1 Housing price determination

Following Diamond (2016), Albert and Monras (2022), the supply of housing services in department i is provided by combining a fixed factor i.e., land (T), and a quantity of aggregate output as input according to the following technology:

$$HS_{i\zeta} = \epsilon_{i\zeta}^{-\epsilon_{i\zeta}} Y_{i\zeta}^{\epsilon_{i\zeta}} T_{i\zeta}^{1-\epsilon_{i\zeta}}, \tag{3.21}$$

where $1 - \epsilon_{i\zeta}$ is the relative importance of land in the production of housing and $Y_{i\zeta}$ is the total output in the department $i\zeta$. Following Diamond (2016), Hsieh and Moretti (2019), Albert and Monras (2022), I assume land is owned by an absentee landlord residing in a different country. Therefore, profit maximization and zero profits in the construction sector $(max_{Y_{i\zeta}}\ Q_{i\zeta}\epsilon_{i\zeta}^{-\epsilon_{i\zeta}} Y_{i\zeta i\zeta}^{\epsilon} T_{i\zeta}^{1-\epsilon_{i\zeta}} - Y_{i\zeta} - r_{i\zeta}T_{i\zeta})$ implies that $Y_{i\zeta} = \epsilon_{i\zeta} Q_{i\zeta}^{\epsilon_{i\zeta}/(1-\epsilon_{i\zeta})} T_{i\zeta}$. Plugging the expression of Y_i into Eq. (3.21) allows me to obtain the following housing supply equation:

$$HS_{i\zeta} = Q_{i\zeta}^{\eta_{i\zeta}} T_{i\zeta}, \qquad \textit{where } \eta_{i\zeta} = \frac{\epsilon_{i\zeta}}{1-\epsilon_{i\zeta}}; \tag{3.22}$$

η_i is the housing supply elasticity in department i. As Eq. (3.22) shows, the higher the relative importance of land in the production of housing $(1 - \epsilon_i)$, the lower the elasticity of housing supply.

The local demand for housing is given by the sum of local demands across skill groups as :

$$HD_{i\zeta} = (1-\beta) \sum_s \left((1 - s_{i\zeta}^{a,s}) w_{i\zeta}^s + r_{i\zeta}^s \right) L_{i\zeta}^s \quad \equiv \quad (1-\beta) \left((1 - s_{i\zeta}^a) w_{i\zeta} + r_{i\zeta} \right) L_{i\zeta}.$$

Housing market clears at the intersection between $HS_{i\zeta}$ and $HD_{i\zeta}$ which defines the local/department level housing price as:

$$Q_{i\zeta} = \bar{Q}_{i\zeta} \left[\left((1 - s_{i\zeta}^a) w_{i\zeta} + r_{i\zeta} \right) D_{i\zeta} \right]^{\frac{1}{\eta_{i\zeta}}}, \tag{3.23}$$

where $D_{i\zeta} \equiv L_{i\zeta}/T_{i\zeta}$ is the local employment density, $r_{i\zeta}$ is the average amount of remittances received by the resident from relatives who have migrated elsewhere, and $w_{i\zeta}$ is the average labour income per worker. $\bar{Q}_{i\zeta} \equiv (1-\beta)^{1/\eta_{i\zeta}}$ can be referred to as the exogenous component of the housing price, which reflects the location fundamentals. Eq. (3.23) shows that the housing price increases with local average wage and the density of employment.

3.3.2 Determination of remittances

The average amount of remittances send back home by type-s worker born in $i\zeta$ who migrated to destination J is given by the individual supply function derived in Section 3.3 given as: $R^s_{i\zeta J} = \beta(1-\alpha)(1-s^{a,s}_J)w^s_J P^{-1}_{i\zeta J}$ where the remitting cost $P_{i\zeta J}$ is a decreasing function of the migrant stock as shown in Eq. (3.12). Plugging Eq. (3.12) into the individual supply function for remittances and multiplying it by the number of type-s migrants and aggregating the values obtained across skill groups gives:

$$\mathcal{R}_{i\zeta J} = \frac{(1-\alpha)\beta}{P_{i\zeta J}} \sum_s (1-s^{a,s}_J) w^s_J \bar{\Phi}^s_{i\zeta J} \left(M^s_{i\zeta J}\right)^{1-\psi} \quad \text{and} \quad \mathbf{r}_{i\zeta} = \sum_J \mathcal{R}_{i\zeta J}/L_{i\zeta}, \tag{3.24}$$

where $\mathbf{r}_{i\zeta}$ is the average amount of remittances received by a resident worker in location $i\zeta$.

3.3.3 Output, agglomeration, and sectoral composition of labour

Production. For simplicity, I assume that the formal (F) and informal (I) sectors produce the same final goods: agricultural goods, a, in rural areas and non-agricultural goods, na, in urban areas. In urban areas, both the formal and informal sectors use a combination of high- and low-skilled workers in their production process. In rural areas, however, only the formal sector uses both skill groups. Conversely, the informal sector treats high-skilled and low-skilled workers as interchangeable because it is assumed to operate in subsistence agriculture. The imperfect substitutability between high- and low-skilled workers is governed by an elasticity of substitution σ. High-skilled workers earn higher wages than their low-skilled counterparts. In addition, the formal sector is more productive than the informal sector, and this is reflected in a positive average wage gap between workers in the formal sector and those in the informal sector. I further assume that formal and informal firms are heterogeneous in the sense that formal firms face additional costs that are not faced by those in the informal sector. This structural framework is consistent with the literature on labour market segmentation in the context of developing economies (Rosenzweig, 1988; Fields, 2011; Fields, 1990; Fields, 2009; Pratap and Quintin, 2006).

Let $Y^{na}_{i\zeta}$ and $Y^a_{i\zeta}$ denote the local output in the urban and rural areas. They are assumed to be respectively obtained according to the following production technologies:

$$Y_{i\zeta}^{na} = \sum_{f \in \{I,F\}} A_{i\zeta}^{na,f} \left(\sum_{s \in \{h,l\}} \theta_{i\zeta}^{s,na,f} \left(L_{i\zeta}^{s,na,f} \right)^{\rho} \right)^{1/\rho} \tag{3.25}$$

$$Y_{i\zeta}^{a} = A_{i\zeta}^{a,I} L_{i\zeta}^{a,I} + A_{i\zeta}^{a,F} \left(\sum_{s \in \{h,l\}} \theta_{i\zeta}^{s,a,F} \left(L_{i\zeta}^{s,a,F} \right)^{\rho} \right)^{1/\rho} \tag{3.26}$$

Where $A_{i\zeta}^{a,f}$ and $A_{i\zeta}^{na,f}$ denote the department-sector specific total factor productivity in rural and urban areas respectively. $\sigma \equiv 1/(1-\rho)$ is the elasticity of substitution between high- (h) and low- (l) skilled workers. $\theta_{i\zeta}^{sf}$ is the preference weight for type s workers in ζf. A departure from the benchmark model, beyond the points already indicated, is that in the rural informal sector total factor productivity is fixed and thus not affected by neither spatial productivity spillovers nor the skill structure of employment in the sector.

Agglomeration forces. In line with Ahlfeldt et al. (2015) and Cha'ngom et al. (2023), I allow total factor productivity to depend on production fundamentals, $(\bar{A}_{i\zeta})$, production externalities derived from the employment density in neighboring regions, $(\Upsilon_{i\zeta})$, and the skill structure of employment, $L_{i\zeta}^{h}/L_{i\zeta}^{l}$. Production fundamentals capture features of physical geography that make a region more or less productive irrespective of the local density of economic activity (e.g., proximity with the coast). Production externalities impose a structure on how the productivity in a given Senegalese region is affected by the characteristics of other regions, and the skill structure of the region's workforce. I model these externalities, on the one hand, as depending on the skill composition of the $i\zeta$ workforce, and on the other hand, as depending on the distance-weighted sum between the department $i\zeta's$ and other department' employment densities:

$$A_{i\zeta}^{f} = \begin{cases} \bar{A}_{i\zeta}^{f} \Upsilon_{i\zeta}^{\upsilon} \left(L_{i\zeta}^{h}/L_{i\zeta}^{l} \right)^{\kappa}, & \text{if Urban or Rural formal} \\ \bar{A}_{i\zeta}^{I}, & \text{if Rural informal,} \end{cases} \tag{3.27}$$

where $\Upsilon_{i\zeta} \equiv \sum_{J \neq i\zeta} e^{-\phi d_{i\zeta J}} \left(L_J/T_J \right)$. L_J/T_J is the department's employment density. Production externalities decline with distance $(d_{i\zeta J})$ through the iceberg factor $e^{-\phi d_{i\zeta J}} \in (0,1]$ and increase with the proportion of high-skilled workers in the workforce $\left(L_{i\zeta}^{h}/L_{i\zeta}^{l} \right)$; ϕ determines the rate of spatial decay, υ $(\upsilon \geq 0)$ controls for the relative importance in determining the overall productivity, and κ $(\kappa \geq 0)$ controls for the relative importance of the density of high-skilled employment in determining the overall productivity.

Sectoral composition of employment. Firms are competitive and workers are paid their marginal product. The profit function depends on whether the firm operates in the formal or informal sector. Firms in the formal sector additionally face a skill specific hiring cost which is set for simplicity as a linear function of the number of type-s workers. This cost can be referred to as the cost of formality and could include indirect formal employment costs. The profit function of each of the representative firms is given as:

$$\Pi_{i\zeta}^{f} = \begin{cases} A_{i\zeta}^{F} \sum_{s\in\{h,l\}} \left(\theta_{is\zeta}^{F} \left(L_{is\zeta}^{F}\right)^{\rho}\right)^{1/\rho} - \sum_{s} \left(w_{is\zeta}^{F} + \gamma_{i\zeta}^{s}\right) L_{is\zeta}^{F} \\ A_{i\zeta}^{I} \sum_{s\in\{h,l\}} \left(\theta_{is\zeta}^{I} \left(L_{is\zeta}^{I}\right)^{\rho}\right)^{1/\rho} - \sum_{s\in\{h,l\}} w_{is\zeta}^{I} L_{is\zeta}^{I}, & \text{if} \quad \text{Urban-informal} \\ A_{i\zeta}^{I} L_{i\zeta}^{I} - w_{i\zeta}^{I} L_{i\zeta}^{I}, & \text{if} \quad \text{Rural-Informal,} \end{cases} \tag{3.28}$$

where $\gamma_{i\zeta}^{s}$ is the area and skill specific additional cost that a firm in the formal sector has to support to be able to hire an additional type s worker. First-order conditions for profit maximization and the zero profit condition imply that the wage equation for type-s worker across areas, and sectors is given as:

$$w_{i\zeta}^{sf} = \begin{cases} A_{i\zeta}^{F} \theta_{i\zeta}^{sF} \left(\frac{\Gamma\left(\theta_{i\zeta}^{sF}, L_{i\zeta}^{sF}\right)}{L_{i\zeta}^{sF}}\right)^{1/\sigma} - \gamma_{i\zeta}^{s} & \text{if} \;\; \text{Formal} \\ A_{i\zeta}^{I} \theta_{i\zeta}^{sI} \left(\frac{\Gamma\left(\theta_{i\zeta}^{sI}, L_{i\zeta}^{sI}\right)}{L_{i\zeta}^{sI}}\right)^{1/\sigma} & \text{if} \;\; \text{Urban - Informal} \\ A_{i\zeta}^{I} & \text{if} \;\; \text{Rural - Informal} \end{cases} \tag{3.29}$$

and,

$$\theta_{i\zeta}^{sf} = \begin{cases} \frac{\Xi_{i\zeta}^{f}}{1+\Xi_{i\zeta}^{f}} & \text{if} \quad s = h \\ \frac{1}{1+\Xi_{i\zeta}^{f}} & \text{if} \quad s = l \end{cases} \tag{3.30}$$

where $\Xi_{i\zeta}^{f} = \left(w_{i\zeta}^{hf}/w_{i\zeta}^{lf}\right)\left(L_{i\zeta}^{hf}/L_{i\zeta}^{lf}\right)^{1/\sigma}$.

Labour market clears when skill specific wages are equalized across sectors and this identifies the critical level of $\gamma_{i\zeta}^{s}$ that guarantees the co-existence of the formal and informal sectors. To simplify the notations, I further define $\bar{\gamma}_{i\zeta}^{s}$ as a proportion of $w_{i\zeta}^{sF}$.[78] Wage equalization across sectors given in Eq. 3.29 ($w_{i\zeta}^{sI} = w_{i\zeta}^{sF}\left(1-\gamma_{i\zeta}^{s}\right)$) defines the optimal number of workers

[78] $\bar{\gamma}_{is\zeta} \equiv \gamma_{is\zeta}/w_{i\zeta}^{sF}$

that firms operating in the formal sector can hire as:

$$L_{i\zeta}^{sF} = \begin{cases} \underbrace{\left[1 + \left(\frac{\theta_{i\zeta}^{sI} A_{i\zeta}^{I}}{\theta_{i\zeta}^{sF} A_{i\zeta}^{F}(1-\bar{\gamma}_{i\zeta}^{s})}\right)^{\sigma} \frac{\Gamma\left(\theta_{i\zeta}^{sI}, L_{i\zeta}^{sI}\right)}{\Gamma\left(\theta_{i\zeta}^{sF}, L_{i\zeta}^{sF}\right)}\right]^{-1}}_{\mho_{i\zeta}^{s}} L_{i\zeta}^{s}, & \text{if} \quad \zeta = Urban \\ \left(\frac{A_{i\zeta}^{I}}{\theta_{i\zeta}^{sF} A_{i\zeta}^{F}(1-\bar{\gamma}_{i\zeta}^{s})}\right)^{-\sigma} \Gamma\left(\theta_{i\zeta}^{sF}, L_{i\zeta}^{sF}\right), & \text{if} \quad \zeta = Rural \end{cases} \tag{3.31}$$

In Eq. 3.31, $\mho_{iU}^{s}$ denotes the equilibrium share of type-s workers that can be absorbed by the formal sector in urban areas. By Eq. 3.31, the informal sector mainly operates as a residual sector taking the workers who can not be absorbed by the formal sector.

3.3.4 Spatial general equilibrium

The spatial equilibrium of the model is defined as follows: (i) Workers decide whether to invest or not in education. (ii) Once education decision is taken, they decide where to live and work. (iii) Firms in each sector and area decide how many workers to hire such as to maximize their profit. (iv) Goods, housing and labour markets clear.

Given the geography and the model's parameters $\{\alpha, \beta, \mu, \lambda, \sigma, \psi, \kappa, \phi, \eta, \xi, \upsilon\}$, the exogenous dyadic characteristics $\{\bar{\boldsymbol{\Phi}}, \boldsymbol{\tau}\}$, and the vector of exogenous location characteristics $\{\boldsymbol{G_\zeta}, \bar{\boldsymbol{A}}_{\boldsymbol{\zeta}}, \bar{\boldsymbol{B}}_{\boldsymbol{\zeta}}, \boldsymbol{T}, \bar{\boldsymbol{L}}_{\boldsymbol{\zeta}}^{\boldsymbol{0}}, \boldsymbol{\mho_\zeta}\}$, the general equilibrium of the model is referenced by the eight vectors $\{\boldsymbol{H_\zeta}, \boldsymbol{m_\zeta}, \boldsymbol{L_\zeta}, \boldsymbol{P_\zeta}, \boldsymbol{A_\zeta}, \boldsymbol{w_\zeta}, \boldsymbol{\theta_\zeta}, \boldsymbol{L_\zeta^f}\}$. The eight components of the equilibrium vector are determined by the following equations: Human capital formation ($H_{i\zeta J}^{s}$ in Eq. 3.16), workers mobility ($m_{i\zeta J}^{s}$ in Eq. 3.18), spatial allocation of labour ($L_{i\zeta}^{s}$ in Eq. 3.20), price index ($\mathbb{P}$ in Eq. 3.11), total factor productivity ($A_{i\zeta}^{f}$ in Eq. 3.27), wages ($w_{i\zeta}^{sf}$ in Eq. 3.29), relative preference for type-s workers ($\theta_{i\zeta}^{sf}$ in Eq. 3.30) and sectoral allocation of labour ($L_{i\zeta}^{sf}$ in Eq. 3.31).

3.4 Cross regional productivity and welfare inequality

I further measure productivity (T_{inc}), and welfare (T_{welf}) inequality across sub-national units using the Theil index as follow:

$$T_{inc} = \sum_{i\zeta} \sum_{s} \frac{w_{i\zeta}^{s} \mathbb{P}_{i\zeta}^{-1} L_{i\zeta}^{s}}{\bar{w} \bar{\mathbb{P}}^{-1} L} \ln\left(\frac{w_{i\zeta}^{s} \mathbb{P}_{i\zeta}^{-1}}{\bar{w} \bar{\mathbb{P}}^{-1}}\right) \tag{3.32}$$

$$T_{welf} = \sum_{i\zeta} \sum_{s} \frac{\widetilde{W}_{i\zeta} L^s_{i\zeta}}{\widetilde{W} L} \ln \left(\frac{\widetilde{W}_{i\zeta}}{\widetilde{W}} \right) \tag{3.33}$$

Where $\widetilde{W}^s_{i\zeta} = (1 - s^{a\,s}_{i\zeta})(w^s_{i\zeta} + r^s_{i\zeta})\mathbb{P}^{-1}_{i\zeta}$, $L \equiv \sum_i \sum_\zeta \sum_s L^s_{i\zeta}$, $\widetilde{W} = \left(\sum_{i\zeta} \sum_s \widetilde{W}^s_{i\zeta}\right)/L$ and $\bar{w} \equiv \left(\sum_{i\zeta} \sum_s w^s_{i\zeta} L^s_{i\zeta}\right)/L$ denote the total employment in Senegal and the countrywide average income, respectively. The ratio $w^s_{i\zeta} L^s_{i\zeta}/\bar{w}L$ is the proportion of country income that is earned by type s workers living in department $i\zeta$.

3.5 Parameter estimation, model inversion, and solution

I briefly present the estimation of the elasticities λ, $1/\eta$, ψ, and μ, υ, κ. The remaining parameters $\{\alpha, \beta, \sigma, \psi, \xi\}$ are either taken from the literature or retrieve from data. Once these elasticities are available, I invert the model and extract location fundamentals.

3.5.1 Estimation of model parameters

In this section, I discuss how I identify and estimate the key exogenous parameters of the model $\{\mu, 1/\eta, \psi\}$.

Fréchet Parameter, $\{\mu\}$**–** From the migration probability in Eq. (3.18), one of the key predictions of the model is the log-gravity equation for migration shares from $i\zeta$ to J. Taking the logs of Eq. (3.18), I have:

$$\ln(m_{i\zeta J}) = \underbrace{\ln B_J + \mu \ln\left(w_J \mathbb{P}_J^{-1}\right)(1 - s^a_J)}_{\text{Destination FE } (\delta_J)} + \mu \underbrace{\ln(1 - \tau_{i\zeta J})}_{\text{dyadic factors } (\omega_{i\zeta J})} \underbrace{- \ln\left(\sum_K \left[B_K w_K P_K^{-1}(1 - s^a_K)(1 - \tau_{i\zeta K})\right]^\mu\right)}_{\text{Origin FE } (\delta_{i\zeta})}$$

This logarithmic transformation yields the following reduced-form gravity equation, generated directly from the model, to which I add a stochastic error $e_{i\zeta J}$:

$$\ln m_{i\zeta J} = \delta_{i\zeta} + \delta_J + \mu \ln \omega_{i\zeta J} + e_{i\zeta J}. \tag{3.34}$$

To account for the heterogeneity of destination locations (internal versus foreign destinations), I add to Eq. (3.34) an additional fixed effect that controls for origin-destination group specificities where destination groups include domestic destinations, OECD destinations, and the rest of the world. Eq. (3.34) becomes :

$$\ln m_{i\zeta J} = \mu \ln \omega_{i\zeta J} + \delta_{i\zeta g} + \delta_J + e_{i\zeta J}.$$

Since I do not observe $\omega_{i\zeta J}$, I use a two-step procedure to indirectly capture μ. Based on the intuition that the probability of bilateral migration includes origin, destination and dyadic characteristics, I first regress migration probabilities on origin and destination fixed effects and extract the residuals, which serve as my measure of $\omega_{i\zeta J}$. However, the predicted residuals include a wide range of bilateral characteristics such as geographical distance, productivity differentials, networks, contiguity, cultural and linguistic proximity, among others. It is worth noting that while some dyadic characteristics are exogenous (e.g. geographical distance, contiguity), others are likely to have bidirectional causality as they both affect migration and are affected by migration (e.g. productivity differentials, networks). They are therefore susceptible to reverse causality. I address this endogeneity concern by using an instrumental variable approach. I want to isolate the variation in $\omega_{i\zeta J}$ that is driven by the relative attractiveness of J and characteristics in other locations $\neg J$. The dyadic characteristics of other origins $\neg i\zeta$ with destination J are affected by these factors, but not by the random term $e_{i\zeta J}$. The set of bilateral characteristics $\{\omega_{J \neg i\zeta}\}$ are therefore valid instruments for $\omega_{i\zeta J}$, (see Bryan and Morten (2019) for a similar approach).

The estimate of μ using different techniques is reported in Table A.5. My preferred specification includes origin-destination groups fixed effects and results are reported in columns (2), (4), (6) and (8). I opt for the average value across estimates as benchmark value and set $\mu = 2.3$. In Appendix A.9, I provide robustness checks for values of $\mu \in [1, 3]$. These estimates are in line with those reported in the literature including Hsieh et al. (2019) with an estimate of 2.0 for the USA; Tombe and Zhu (2019) with an estimate of 1.5 for China; Bryan and Morten (2019) with an estimate of 3.2 for Indonesia.

Elasticity of housing price to economic density, $\{1/\eta\}$**–** Housing price formation in Eq. (3.23), identifies the inverse of the housing supply elasticity $(1/\eta)$. Taking Eq. (3.23) in logs yields:

$$\ln Q_{i\zeta} = \underbrace{\frac{1}{\eta_{i\zeta}} \ln(1-\beta)}_{\bar{Q}_{i\zeta}} + \frac{1}{\eta_{i\zeta}} \underbrace{\ln((w_{i\zeta} + r_{i\zeta}) D_{i\zeta})}_{\text{Economic density}} + \varepsilon_{i\zeta} \tag{3.35}$$

The first term of the right-hand side of the Eq. (3.35), $\bar{Q}_{i\zeta}$, denotes the part of the local housing price that does not vary with economic density. The second block on the right-hand side refers to the part of the housing price that depends on the density of economic activity included in the income level (both labour income and remittances) and the employment level per square kilometre of land. Ideally, $1/\eta$ should vary across departments, as there is substantial evidence that the elasticity of housing supply varies across space (Hsieh and Moretti, 2019; Saiz, 2010; Albert and Monras, 2022; Diamond, 2016). However, given the limited number of observations I have (45 ADMIN 2 level regions) in a cross-sectional setting, I assume that the elasticity of housing supply is identical across Senegalese departments. The empirical specification also includes higher level region fixed effects (ADMIN 1 regions) and thus Eq. (3.35) becomes :

$$\ln Q_{i\zeta} = a_0 + 1/\eta \ln \left((w_{i\zeta} + r_{i\zeta}) D_{i\zeta} \right) + \delta_r + \varepsilon_{i\zeta}$$

However, there is a threat to identification of $1/\eta$. As shown in Saiz (2010), changes in housing stock are endogenous to changes in prices through the changes in demand (labour and economic density). Both productivity and employment are endogenous which lead to endogenous economic density. Indeed, while economic density is likely to affect housing prices, housing prices may also affect economic density by influencing workers' location decisions. This suggests the possibility of reverse causality. To deal with this endogeneity concern, I use three sets of instruments, the first being my benchmark and the second and third being used as additional robustness checks. First, a Bartik-style expected income instrument based on national average income (wages and remittances) multiplied by each department's share of national employment. That is, $\tilde{w}_i^{2013} = \bar{w}_{SEN}^{1990} l_i^{1990}$ instrument for the income of department i using only its employment share two decades earlier (l_j^{1990}) and the national average income ($\bar{w}_{SEN}^{2013}$) where $l_i^{year} = L_i^{year} / \sum_i L_i^{year}$ all years $\in \{1990, 2013\}$. Second, I employ a similar strategy but using average national GDP per capita in 1990 as $\tilde{w}_i^{2013} = \bar{w}_{SEN}^{2013} l_i^{2013}$. Third, I instrument the economic density of each department with the average distance to the coast. The intuition here is that departments close to the coast are likely to be more economically dense than departments far from the coast. To implement this, I combine data from the 2013 Senegalese census on population and employment size per administrative level 2 unit with gridded GDP and population data from Kummu et al. (2018); bilateral remittance flows from the 2009 Migration and Remittances Household Survey; local wage data from the 2018 Harmonised Survey on Households Living Standards; additional controls are from AidData. The results are reported in Table A.7. The first column reports the OLS estimates, while columns (2) to (4) report the IV estimates corresponding to the use of each of the three alternative instruments. The results show that a 100% increase in economic density leads to a 24% to 30% increase in housing prices. These estimates compare with those found in Hsieh et al. (2019).

Elasticity of remitting cost to migration size, $\{\psi\}$– Eq. (3.12) implies that the cost of sending remittances from J to $i\zeta$ is a function of corridor specific fundamentals ($\bar{\Phi}_{i\zeta J}$) and the diaspora size ($M_{i\zeta J}$).[79] Taking the logarithm of Eq. (3.12), and incorporating both the random component and the heterogeneity across destination groups, results in the following equation:[80]

$$\ln \mathbb{P}_{i\zeta J} = \delta_{i\zeta g} + \delta_J + \psi \ln M_{i\zeta J} + e_{i\zeta J} \tag{3.36}$$

I document a negative relationship between remittance costs and the number of migrants at the corridor level. I estimate the elasticity of remittance costs with respect to migration size to be -0.25. This suggests that a 10% increase in the number of migrants in a corridor leads to a 2.5% decrease in remittance costs. Detailed results are provided in the appendix A.6.

Other exogenous parameters: $\{\alpha, \beta, \sigma, \delta, z\}$**–** For β, I use the household expenditure data from the EHCVM. The fraction of housing spending in household budget is around 0.2, and implies $\beta = 0.8$. For α, From MRHSS, the non-housing budget share of remittances is 0.11, which implies a non remitted share of non-housing budget of $\alpha = 0.89$. I take the spatial decay δ and agglomeration parameter υ from Ahlfeldt et al. (2015) set them at 0.32 and 0.07 respectively. I borrow κ from Burzyński et al. (2020), and z from Cha'ngom et al. (2023) and set at 0.1 and 3.8 respectively. Elasticity of substitution between high- and low-skilled is taken from Ottaviano and Peri (2012) and set at $\sigma = 2$.

Table 3.5.1: Model parameters

Parameter	Value	Description	Source
z	3.8	Scarcity of high-skilled workers	Cha'ngom et al. (2023)
σ	2.0	Elasticity of substitution b/w HS and LS	Ottaviano and Peri (2012)
κ	0.1	Skill-biased directed technical change	Burzyński et al. (2020)
μ	2.3	Income elasticity of migration	Estimated
ψ	0.25	Elasticity of remitting cost	Estimated
λ	0.17	Elasticity of amenities to density	Estimated
$1/\eta$	0.25	Inverse of housing supply elasticity	Estimated
b	0.15	Elasticity of provision of public education to population size	Estimated
β	0.80	Non housing share of expenditures	Data
α	0.89	Non remitted share of Non-housing expenditures	Data

3.5.2 Recovering locations and dyadic unobservable characteristics

Location characteristics $\{\bar{A}_{i\zeta}, \bar{B}_{i\zeta}, G_{i\zeta}\}$**–** In this section, I show that there is a unique mapping from observed to unobserved location characteristics. These unobserved characteristics

[79] Corridor-specific fundamentals are broken down into destination fixed effects (δ_J) and origin-destination group fixed effects ($\delta_{i\zeta g}$).

[80] destination groups include domestic destinations, OECD destinations, and the rest of the world.

include local access to education, and the fundamental component of local amenities. I Start with Eqs. 3.25, and 3.26, to recover $A^f_{i\zeta}$ as a residual component of the area-specific outputs that are not explained by labour composite. As discussed in Section 3.3.3, there are agglomeration forces in the local economy such that the observed level of productivity $A_{i\zeta}$ results from the combination of the local production fundamentals $\bar{A}_{i\zeta}$ and production externalities. Production fundamentals are recovered as a residual using Eq. (3.27). Finally, the exogenous component of the local amenity level ($\bar{B}_{i\zeta}$) is recovered as a residual of the amenity equation. I now turn my attention to the local access to education. Given that $H_{i\zeta}$, $\Lambda_{i\zeta}$, μ, and z, I recover $G_{i\zeta}$ as the residual that allows Eq. (3.16) to hold.

Exogenous dyadic characteristics $\{\Phi^s_{i\zeta J}\}$– Corridor fundamentals with respect to remitting cost, $\Phi^s_{i\zeta J}$, are exogenous factors that make some corridors more or less expensive when it comes to sending part of the income back home. They comprise every factors other than the migration size that affect remitting costs and are extracted as residual of Eq. (3.12).

Inferring skill specific migration costs $\{\tau^s_{i\zeta J}\}$– The probability that a worker chooses not to move away from their location of origin is a special case of Eq. (3.18) where $J = i\zeta$ and given as: $m^s_{i\zeta i\zeta} = B_{i\zeta}\left(\widetilde{U}^s_{i\zeta}\right)^\mu / \left[\sum_K B_K \left(\widetilde{U}^s_K\right)^\mu \left(1-\tau^s_{i\zeta K}\right)^\mu\right]$. The ratio between the probability to migrate and the probability to stay identifies the skill specific migration costs.

$$\tau^s_{i\zeta J} = 1 - \left(\frac{\widetilde{U}^s_{i\zeta}}{\widetilde{U}^s_J}\right)\left[\frac{m^s_{i\zeta J}}{m^s_{i\zeta i\zeta}}\frac{B_{i\zeta}}{B_J}\right]^{1/\mu}. \qquad \forall\ J \neq i\zeta \tag{3.37}$$

Migration costs (τ_{ij}) vary significantly across destinations. On average, as shown in Appendix A.11, Senegalese workers face significant differences in compensation for relocation. For example, moving to the Dakar region requires a 69% higher income, while moving to a neighboring country or to another internal region outside Dakar requires a 91% and 95% higher income respectively. Moreover, the farther a Senegalese migrant moves away from their home location, the larger the compensation required - 98% higher income for non-neighbouring non-OECD destinations and 99% higher income for OECD destinations. However, these mobility costs vary by skill level and are consistently lower for the highly educated. For example, a high-skilled Senegalese migrant requires 33% higher income to migrate to the capital region of Dakar, 91% and 94% higher income for a neighboring country or another non-Dakar internal location, and 97% and 98% higher income for non neighboring - non OECD, and OECD countries respectively. Conversely, these costs are much higher for low-skilled migrants, for instance this cost is about 2.2 times larger for Senegalese migrants relocating to the capital region of Dakar. As expected, the costs of international migration exceed those of domestic migration, reflecting higher mobility frictions. The categorisation of international destinations into groups (neighbouring countries, OECD, rest of the world), suggests that the further migrants go, the higher the migration costs incurred. The lower costs associated with highly educated workers are due to their greater adaptability to opportunities and integration potential at destination, as well as their likelihood of having transferable skills and possibly skill-specific policies at destination. While migration costs may appear very substantial, they are strongly correlated with factors commonly used as proxies for such costs. In Appendix A.8, I show a significant correlation between log skill-specific migration costs and log distance as well as contiguity with an estimated distance elasticity of 0.08 and common border elasticity of -0.02. This implies that doubling the distance between two locations leads to a 8% increase in migration costs while sharing common border with a destination location reduces migration cost by roughly 2%.

3.5.3 Solving the model

I proceed here by solving the counterfactual changes. Let $\hat{x} = x'/x$ be the counterfactual relative change in variable x in response to an exogenous change in the model. In this paper, I simulate changes in migration costs, and changes in migration costs complemented by changes in local access to education. I focus here only on key changes and provide further detailed results in the appendix.

Proposition 5 *Migration costs affect migration shares. Given changes in migration shares, the change in the size and structure of local employment is:*

$$\widehat{L}^s_{i\zeta} = \lambda^s_{i\zeta i\zeta}\left(1 - \sum_{i\zeta} \widehat{m}^s_{i\zeta J}\right) + \lambda^s_{im\zeta} \sum_J \widehat{m}^s_{Ji\zeta}$$

(3.38)

where $\left(1 - \sum_{i\zeta} \widehat{m}^s_{i\zeta J}\right)$ *denotes the change in the share of stayers (non-migrants) and* $\sum_J \widehat{m}^s_{Ji\zeta}$ *denotes the change in the share of immigrants.* $\lambda^s_{i\zeta i\zeta}$ *and* $\lambda^s_{im\zeta}$ *are respectively the initial share of stayers and immigrants in the local employment. Changes in the size and structure of employment leads to changes in productivity, housing cost and wages. Given those changes, the change in local real income per worker is:*

$$\widehat{y}_{ri\zeta} = \frac{\widehat{A}_{i\zeta}\left(\sum_s \widehat{\theta}^s_{i\zeta}\left(\widehat{L}^s_{i\zeta}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}}{\widehat{Q}^{1-\beta}_{i\zeta}\sum_s \lambda^s_{i\zeta}\widehat{L}^s_{i\zeta}} \tag{3.39}$$

where $\lambda^s_{i\zeta}$ is the share of type s workers in department-area $i\zeta$. Similarly, department-area change in welfare level is:

$$\widehat{\widetilde{W}}_{i\zeta} = \left(\frac{\lambda_{wi\zeta}\widehat{w}_{i\zeta} + \lambda_{ri\zeta}\widehat{r}_{i\zeta}}{\widehat{Q}^{1-\beta}_{i\zeta}}\right)\frac{1-s^{a'}_{i\zeta}}{1-s^{a}_{i\zeta}}, \tag{3.40}$$

where $\widehat{w}_{i\zeta}$, $\widehat{r}_{i\zeta}$ are local changes in nominal income and remittances per worker. $\lambda_{wi\zeta}$ and $\lambda_{ri\zeta}$ are the weights of income and remittances in per worker welfare level in department-area $i\zeta$. Finally, the change in the cross-departmental productivity and welfare inequality is obtained as:

$$\begin{cases} \widehat{T}_{inc} = \sum\limits_{i\zeta}\lambda_{i\zeta}\sum\limits_{s}\lambda_s \dfrac{\widehat{w}^s_{i\zeta}\widehat{Q}^{\beta-1}_{i\zeta}\widehat{L}^s_{i\zeta}}{\widehat{\overline{w}}\widehat{\overline{Q}^{\beta-1}}\widehat{L}}\ln\left(\dfrac{\widehat{w}^s_{i\zeta}\widehat{Q}^{\beta-1}_{i\zeta}}{\widehat{\overline{w}}\widehat{\overline{Q}^{\beta-1}}}\right) \\ \widehat{T}_{welf} = \sum\limits_{i\zeta}\lambda_{i\zeta}\sum\limits_{s}\lambda_s \dfrac{\widehat{\widetilde{W}}^s_{i\zeta}\widehat{L}^s_{i\zeta}}{\widehat{\widetilde{W}}\widehat{L}}\ln\left(\dfrac{\widehat{\widetilde{W}}^s_{i\zeta}}{\widehat{\widetilde{W}}}\right) \end{cases}. \tag{3.41}$$

3.6 Quantitative analysis

In this section, I quantify the economic and welfare consequences of internal and international migration shocks in Senegal, both for each sub-national unit and for the country as a whole. I further evaluate their implications for cross-regional productivity and welfare disparities. The analysis proceeds in two steps. First, I evaluates the impacts of actual migration shocks, including overall, internal, international, and OECD migration shocks. Second, I evaluate the potential distributional effects of various migration policies. These policies include: (i) lowering migration costs, (ii) reducing spatial disparities in access to education while keeping the country-level access unchanged, (iii) equalising access to education across the country to match the standards of the capital region, and (iv) simultaneously aligning education access to capital region's standards and lowering migration costs.

3.6.1 Distributional impact of the actual migration shock

This section considers four distinct migration shocks: (i) the overall migration shock, where the size of the shock mimics the difference between skill specific labour supply without any migration ($\tau^s_{i\zeta,J} = 1$) and the observed labour supply; (ii) the internal migration shock, where the size of the shock reflects the change in labour supply by shutting-down internal migration ($\tau^s_{i\zeta,J} = 1, \forall J \in N$); (iii) the international migration shock, which compares the labour supply without international migration ($\tau^s_{i\zeta,J} = 1, \forall J \in D$) to the observed supply; and (iv) the OECD migration shock, where the labour supply without migration from and to OECD countries is compared to the observed supply.

Note that the economic and welfare adjustments to any migration shock occurs through changes in living costs, total factor productivity, levels of human capital, relative productivity of skilled workers, wages, remittances, and the share of food expenditures. According to the 2013 Senegalese census, the internal migration rate in Senegal was 31.2%. Foreign-born workers made up 2.6% of the labour force, while 8% of Senegalese natives had emigrated abroad, with 47% of these emigrants (or 3.7 percentage points) going to OECD countries. Shutting-down migration would result in the spatial reallocation of about 37.5% of the labour force across Senegal. Similarly, shutting-down internal migration would reallocate 31.2% of the workers, while shutting-down international migration would increase the number of workers by 5.4% (taking into account both emigration and immigration). Finally, shutting-down OECD migration would increase the available workers by 3.7%.

3.6.1.1 Effect on per capita income

Country level effect. As shown in column (1) of the "*Income effect*" of Table 3.6.1, the overall migration as well as any form of international migration depletes real per capita income countrywide with the effect varying between -4.1% and -1.9%. Such income losses are mainly explained by the drop in the size of the labor force, human capital and total factor productivity.[81] However, internal migration increases real per capita income by nearly 3% and this operates through the concentration of resident human capital in the most productive departments complemented by larger productivity gains operating through agglomeration forces. I further analyse this effect by separating the capital region, the country's wealthiest area,[82] from the rest of the country (columns 2 and 3). The results show that the decline in real per capita income due to migration is mainly driven by the rest of the country, while the capital region ends up better off. In particular, while migration reduces real per capita income by 6% in the rest of the country, it increases it by 4.5% in the capital region. However, when the departments are further broken down based on whether they experience net emigration or net immigration (columns 4 and 5), migration always leads to a decline in real per capita income. This indicates that the overall effect of migration is not only determined by the direction of

[81] See Table 3.6.3 for details on the mechanisms.

[82] Senegal's capital region comprises four departments: Dakar, Pikine, Rufisque and Guediawaye, out of a total of 45 departments in the country.

the labour supply shock (negative or positive), but also by the strength of the feedback effects. For example, while the capital region, a group of net immigration departments, experiences a 4.5% increase in real per capita income, the group of net immigration departments as a whole, which includes the capital region, experiences a small loss of 0.5%. Furthermore, internal migration alone increases real per capita income by 12.8% in the capital region, compared with just 0.9% in the rest of the country. Meanwhile, international migration has a stronger negative impact on both the capital region and the departments of net inward migration than on the rest of the country and the departments of net emigration. This stronger negative effect, especially for migration to OECD countries, is explained by the fact that these locations are the most exposed to international migration. These locations face net international emigration with high positive selection, which affects their productivity more relative to other regions.

Sub-national level effect. The income effect of migration presented so far masks significant heterogeneity across sub-national units. To get a sense of how heterogeneous this effect is, I further dis-aggregate the income effect of overall migration by department that I further break down by area (urban/rural). As illustrated in Figure A.12, the strength of real per capita income responses at the sub-national level is closely correlated with total migration (both inflows and outflows, internal and international). However, Panel A.12a shows that rural areas, regardless of their net migration status (whether net immigration or net emigration), tend to fare worse. In contrast, urban areas with net immigration experience real per capita income gains, while those with net emigration see losses. Specifically, rural areas with net immigration suffer significant drops in real per capita income, with losses exceeding 10% in the rural regions of Louga and Diourbel. Meanwhile, although urban areas in departments with net emigration also experience considerable per capita income losses —with six departments reporting losses over 10%— large urban centers like Guediawaye, Pikine, Dakar, Rufisque, and Louga still exhibit per capita income gains. This suggests that large inflows of workers into rural areas deplete local economic conditions, leading to greater poverty. Conversely, urban areas with net immigration benefit from positive feedback effects that outweigh the negative externalities. These dynamics contribute to the widening rural-urban income gap. At the department level, the employment channel is key through its size and skill composition is key. For example, migration has boosted employment by 58.2% in Pikine, 29.6% in Rufisque, 49.8% in Guediawaye, and 3.2% in Dakar. On the other hand, departments like Salemata, Diourbel, Gossas, and Bignona have suffered significant labour force losses due to total migration, with reductions of 47.8%, 32.8%, 27.3%, and 25.2%, respectively.

Income inequality effect. I now measure the impact of migration on income disparities across sub-national units using the Theil index. Column 1 of Table 3.6.2 reports how spatial income disparities respond to the various types of observed migration. Irrespective of the type of migration, it always amplifies income inequality across sub-national units with the effect varying from 0.7% to 8.1%. More specifically overall migration widens spatial income disparities by 8.1% while internal migration has a stronger effect as it widens cross departmental income inequality by 30%. This effect is driven by the spatial concentration of workers in the most productive locations, which initially appear to be the wealthiest. As shown in Table 3.6.1, locations in the capital region experience increases in real per capita income of 4.5% and 12.8% respectively as a result of total and internal migration, while the rest of the country experiences decreases of 6% and increases of 0.9%, contributing to increased income disparities between locations and thus the level of the Theil index. In addition, international migration, although being inequality amplifying induces limited spatial income disparities, 2.2% for the whole international migration and 0.7% for OECD migration.

Table 3.6.1: Effect of various migration types on per capita income and welfare

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Countrywide	Dakar	Non-Dakar	Net emig.	Net immig.	Urban	Rural
Income effect							
Overall migration	0.959	1.045	0.940	0.938	0.995	0.961	0.957
Internal migration	1.030	1.128	1.009	1.007	1.070	1.043	1.016
International migration	0.979	0.953	0.988	0.986	0.970	0.997	0.987
OECD migration	0.981	0.949	0.992	0.991	0.969	0.976	0.992
Welfare effect							
Overall migration	1.065	1.088	1.060	1.058	1.078	1.077	1.057
Internal migration	1.009	1.050	1.000	0.996	1.030	1.030	0.994
International migration	1.055	1.058	1.054	1.047	1.066	1.053	1.061
OECD migration	1.044	1.050	1.042	1.034	1.057	1.045	1.047

Notes: I compute the relative changes (Baseline = 1) on real per capita income and welfare of experiencing each of these shocks. Welfare effect differs from the real income effect as it add gains from remittances and changes in food expenditure shares. Dakar refers to the capital region of Senegal which comprises four departments (Dakar, Pikine, Rufisque, and Guediawaye). Non-Dakar refers to the remaining 41 Senegalese departments. "*Net emig.*" and "*Net immig.*" refer respectively to locations where outflows exceed inflows (negative labour supply shock) and vice versa (positive labour supply shock).

3.6.1.2 Effect on Welfare

Country level effect. As shown on the "*Welfare effect*" of Table 3.6.1, migration is always welfare enhancing, independent of the type of migration. The only exception arises from net emigration department with respect to domestic migration. The overall migration improves welfare by 6.5% countrywide. This welfare enhancing effect of migration appears to be stronger in the capital region and in locations of net immigration (8.8% and 7.8% respectively) than in the rest of the country and locations of net emigration (6% and 5.8% respectively). This effect is particularly driven by remittances which are larger in the capital regions and locations of net immigration.[83] This is the case because these locations are the main origin of people emigrating to the OECD who appear to send back more remittances than those migrating either internally or internationally to non OECD destinations. As shown in Appendix A.3, an average Senegalese migrant to the OECD remits $ 2,000 USD per year, compared to $ 800 for a migrant to the rest of the world and $ 90 for an internal migrant.

Sub-national level effect. The welfare effect of migration presented so far masks significant heterogeneity across sub-national units. Panel A.12b reports the welfare effect of total migration at the sub-national unit level broken down by areas (urban/rural). With few exceptions in rural areas of net immigration, nearly all locations in Senegal exhibit welfare gains due to total migration, primarily driven by remittances.[84] Interestingly, the higher the net emigration, the stronger the welfare gains, especially in rural areas, although this trend also extends to urban areas. Unlike rural areas of net immigration, their urban counterparts experience positive welfare gains largely due to remittance inflows from migration to wealthier destinations (OECD countries). However, in locations of net immigration, some of these gains are absorbed by congestion forces, such as increased housing prices (appendix A.17d). These welfare gains exceed 10% in the rural areas of Mbacke, Kebemer, Louga, Ranerou Ferlo, and Goudiry, as well as in the urban areas of Guediawaye, Dakar, Podor, Saint Louis, Matam, and Malem Hodar.

Welfare inequality effect. Column 2 of Table 3.6.2 reports how spatial welfare disparities respond to the various observed migration shocks. Total migration reduces spatial disparities by approximately 3.9%. Breaking this effect down by migration type, internal migration appears to increase welfare inequality in Senegal by about 27.4%. In contrast, all forms of international migration reduce spatial welfare inequality, with migration to OECD countries having the strongest equalizing effect. Specifically, while total migration lowers welfare inequality by 3.9%, international migration has a more significant impact (-5.2%), driven almost entirely by OECD migration (-5.6%). This inequality-reducing effect is primarily due to remittances, a channel that is more potent in the context of international migration, especially migration to OECD countries. As for internal migration, the feedback effects —such as education incentives and remittances— have proven to be smaller, particularly in locations experiencing net internal emigration. As productive resources tend to concentrate in the wealthiest sub-national units, this exacerbates the economic gap between them and the rest of the country. The resulting feedback effects are not strong enough to offset the welfare burden created by this growing disparity.

[83] See table 3.6.3 for details on the mechanisms.
[84] Appendix A.17 for further details

Table 3.6.2: Effect of various migration types on spatial disparities

	(1)	(2)
	Productivity inequality	Welfare inequality
Overall migration	1.081	0.961
Internal migration	1.301	1.274
International migration	1.022	0.948
OECD migration	1.007	0.944

Notes: I compute the relative changes (Baseline = 1) in Theil index of income and welfare inequality. These changes reflect the shift from the level of inequality observed when each type of migration considered here is eliminated to the actual, observed levels of income and welfare inequality. In this context, welfare refers to real income per capita, adjusted for remittances received and the share of expenditure devoted to food.

3.6.2 Policy experiments

After evaluating the distributional impact of different types of observed net migration levels (overall, internal, international, and OECD), I now turn my attention to policy interventions.

3.6.2.1 Potential effects on productivity and welfare

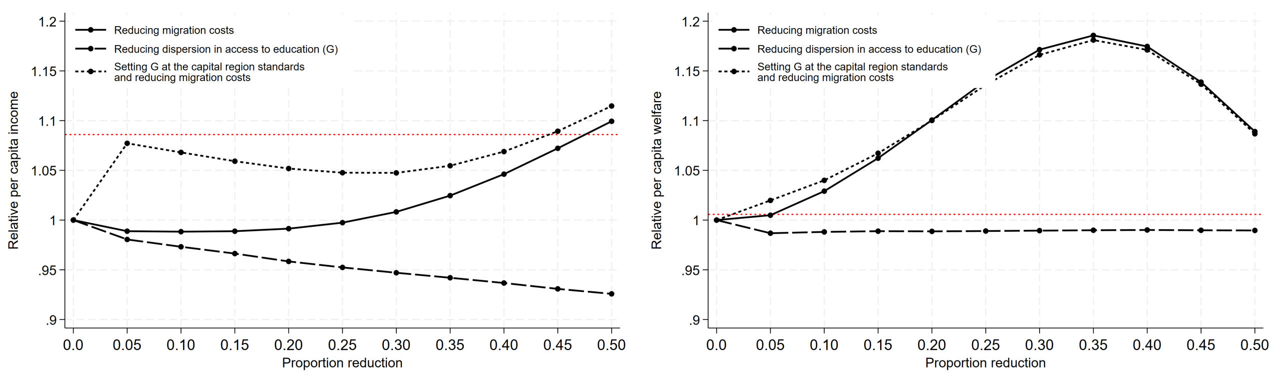
Reducing migration costs. The first policy I consider here is a reduction in migration costs which can be achieved through interventions such as migration subsidies, language training, information support and travel cost assistance (Bryan et al., 2014b; Porcher et al., 20240; Bergman et al., 20240; Baseler, 20230; Bah et al., 20230). I compare the current state of the Senegalese economy to several counterfactual scenarios in which migration costs change gradually, everything else remaining unchanged. To estimate potential impacts, I scale the skill specific migration costs by a factor $\varkappa$ yielding $\tau^{'}_{ijs} = 1 - (1 - \tau_{ijs})^{1-\varkappa}$ where $\varkappa \in [0, 1]$. If $\varkappa = 0$, $\tau^{'}_{ijs} \equiv \tau_{ijs}$, which corresponds to baseline migration costs. $\varkappa = 1$ corresponds to fully removing migration costs and $\tau^{'}_{ijs} \equiv 0$. In this experiment, I simulate for different reduction factor up to 0.5. I limit the reduction in migration barriers to $\varkappa = 0.5$, meaning half of the existing migration barriers are removed. This goal seems more realistic and feasible than completely eliminating migration barriers. As depicted by solid black curves on panels 3.6.1a and 3.6.1b of Figure 3.6.1, this reduction is predicted to result in a 9.9% increase in productivity and an 8.9% increase in welfare. However, the relationship between reducing migration costs and its impact on productivity and welfare is non-linear. As migration barriers decrease, there can be instances where both productivity and welfare decline. This phenomenon, as highlighted in Bryan and Morten (2019), occurs when reduced migration costs shift workers from more productive departments with lower amenities to less productive departments with higher amenities. My estimates suggest that, on the productivity side, this negative effect, though modest (less than 1%), appears when the reduction factor is low ($\varkappa < 0.25$). On the welfare side, gains from reducing migration barriers start decreasing when the reduction factor exceeds 0.35. These average effects, however, hide significant heterogeneity across different departments-areas. While the average increase in productivity and welfare from halving migration barriers in Senegal are 9.9 and 8.9%, respectively, the effects vary widely—from a -10.1% to 28.3% for productivity, and from -13.4% to 65.0% for welfare.

Reducing spatial dispersion in access to education. The second experiment I consider is to reduce the spatial dispersion in access to education. This may be the result of policies aimed at building schools in remote, yet populated areas, improving teaching materials and recruiting and training more teachers (Benavente and Panchaud, 2008). As for migration costs, I re-scale provision of public education by a reduction factor $\varkappa$ yielding: $\bar{G}'_{i\zeta} = \tilde{\bar{G}} \left(\bar{G}_{i\zeta}/\tilde{\bar{G}}\right)^{1-\varkappa}$ where $\tilde{\bar{G}}$ is the average provision of public education country-wide, and $\varkappa \in [0, 1]$. $\varkappa = 0$ corresponds to the benchmark $G_{i\zeta}$ while $\varkappa = 1$ corresponds to perfect equalization of the provision of public education across all departments-areas in Senegal. In this experiment, I progressively reduce the spatial dispersion in access to education up to $\varkappa = 0.5$, meaning that disparities are reduced by half. This approach is more realistic since factors like geography and climate make it impossible to fully equalize access to education across locations. As depicted by long-dashed back curves on panels 3.6.1a and 3.6.1b, halving spatial disparities in access to education in Senegal lead to a decline in both productivity and welfare, by 7.4% and 1.0%, respectively. Similar to the case with migration costs, there is substantial heterogeneity across space. The response of productivity ranges from a -26.6% to 0.6%, while the welfare response ranges from a -12.2% to 72.1%. The negative impact on productivity and welfare from reducing disparities in access to education is primarily due to negative selection. Highly productive areas, which are usually densely populated, tend to offer better access to education, leading to higher levels of human capital, which in turn sustains high local productivity. A policy that seeks to equalize access to education across space reallocates resources from these productive, densely populated areas to less productive, sparsely populated areas. This reallocation reduces human capital in high-productivity locations and increases it in low-productivity locations. Given that local productivity also depends on factors like proximity to the coast and physical geography, the overall effect is a decline in productivity, leading to lower productivity and welfare.

Aligning access to education to the standards observed in the capital region combined with reduced migration costs. Finally, I consider an experiment involving two simultaneous interventions: aligning access to education across the country with the standard in the Dakar region and reducing migration costs. The resulting changes in productivity and welfare are illustrated in panels 3.6.1a and 3.6.1b of Figure 3.6.1. First, I examine the scenario where only access to education (denoted as G) is raised to the level of the Dakar region. This adjustment leads to an 8.6% increase in productivity and a 0.6% increase in welfare. Next, I combine this improvement in education access with a reduction in migration costs. Halving migration costs while aligning G at the Dakar region's level, I predict an 11.5% increase in productivity and an 8.7% increase in welfare. Although the productivity effect of reducing migration costs while setting G at the Dakar region's level is slightly smaller than the sum of the effects of each separate policy, the combined effect is still greater than each individual effect, indicating a complementarity between these two policies. However, when considering welfare, the joint effect shows a greater degree of substitutability between the policies, with an overall welfare increase of 8.7%, compared to 8.9% and 0.6% when each policy is implemented independently. Moreover, this combined policy approach not only reduces spatial inequality but also results in fewer locations experiencing negative outcomes. The productivity response varies from a -1.3% to 38.2%, while the welfare response ranges from -9.4% to 20.3%.

Figure 3.6.1: Productivity and welfare gains from policy interventions

(**a**) Productivity (**b**) Welfare



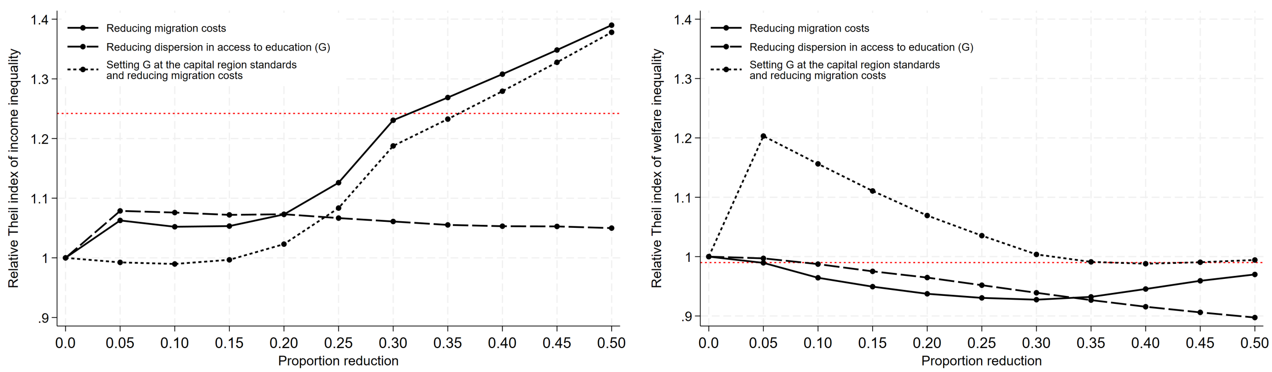
Notes: productivity and welfare response to various counterfactual experiments in Senegal. The dashed black curve shows, for each reduction factor, $\varkappa$, the corresponding income and welfare effects of reducing spatial dispersion in access to education while keeping unchanged the country level access to public education. The solid black curve shows for any $\varkappa$ the effect of reducing migration costs. The long dashed curve reports the effects of reducing migration costs combined with aligning access to education countrywide to the standards observed in the capital region. The red dashed line in the two panels indicates the productivity and welfare effect of independently aligning access to education in the whole country with the standards observed in the capital region of Senegal. Panels 3.6.1a, and 3.6.1b report the productivity and welfare effects respectively.

3.6.2.2 Potential implications of spatial inequalities

As illustrated in Figure 3.6.2, regardless of the specific policy implemented —whether it involves halving migration costs, halving spatial disparities in access to education, or both halving migration costs and aligning access to education countrywide with the level observed in the capital region of the country— each policy significantly reduces welfare inequality but increases income inequality across Senegalese sub-national units. Specifically, reducing migration costs by half increases income inequality by about 39% but decreases welfare inequality by 0.6%. Halving spatial disparities in access to education results in a 5% increase in income inequality and a 10.3% decrease in welfare inequality respectively. Finally, combining a migration costs reduction and aligning access to education countrywide to the standards of the capital region increases income inequality by about 37% but decreases welfare inequality by 3.1%.

Figure 3.6.2: Productivity and welfare inequality changes from policy experiments

(**a**) productivity | (**b**) Welfare



Notes: productivity and welfare disparities response to various counterfactual experiments in Senegal. The dashed black curve shows, for each reduction factor, $\varkappa$, the corresponding income and welfare inequality effects of reducing spatial dispersion in access to education while keeping unchanged the country level access to education. The solid black curve shows for any $\varkappa$ the inequality effect of reducing migration costs. The long dashed curve reports the inequality effects of reducing migration costs combined with aligning access to education countrywide to the standards observed in the capital region. The red dashed line in the two panels indicates the income per capita and welfare effect of independently aligning access to education in the whole country with the standards observed in the capital region of Senegal. Panels 3.6.2a, and 3.6.2b report the income and welfare effects respectively.

3.6.2.3 Heterogeneous effects

Appendix A.16 illustrates the potential distributional effects of three counterfactual experiments described in Section 3.6.2.1. First, halving migration costs increases productivity by 8 to 11%, with a stronger effect in rural areas, and in the rest of the country as compared to the capital region of Dakar. Reducing migration costs also improves welfare, with a 2% and a 30% increase in urban and rural areas respectively. The stronger effect in rural areas is due to lower congestion and higher remittance inflows. However, in the highly congested Dakar region, halving migration costs reduces welfare by 1.6%, while increasing it by 15% in the rest of the country. Second, halving spatial disparity in access to education in Senegal decreases productivity across all areas and regions, with potential productivity losses ranging from 6 to 8%. This policy reduces welfare by about 6% in urban areas against a 5% increase in rural areas. In the capital region, this policy has no impact on welfare, but decreases it by about 2.1% in the rest of the country. In summary, reducing the spatial disparity in access to education in Senegal improves welfare in rural areas while decreasing it in urban areas and in all regions other than the Dakar region, where welfare remains unaffected. Third, bringing access to education up to the standards of the Dakar region while cutting migration costs by half would have a greater impact than reducing migration costs alone. Implementing such a policy could increase productivity by 9 to 14.7%. In addition, it would likely increase welfare in almost all cases, except in the capital region of Dakar, which could suffer a modest welfare loss of about 1.7%.

3.6.3 Key mechanisms underlying these results

In sections 3.6.1 and 3.6.2, I show that although the overall migration in Senegal reduces productivity countrywide and amplifies spatial productivity inequality, it nevertheless enhances welfare and reduces welfare inequality across space. In this section, I explore the key mechanisms underlying these results.

Table 3.6.3: Effect of migration on productivity and welfare: mechanisms

	(1)	(2)	(3)	(4)	(5)
	Countrywide	Capital region	Rest of the country	Net emigration	Net immigration
Productivity effect					
Employment	0.946	1.282	0.869	0.836	1.129
Human capital	0.948	1.190	0.893	0.873	1.073
Housing prices	0.986	1.114	0.957	0.949	1.047
Total factor productivity	0.958	1.038	0.940	0.939	0.991
Relative productivity HS	0.975	1.008	0.967	0.969	0.985
Welfare effect					
Nominal income per capita	0.981	1.148	0.943	0.942	1.047
Housing prices	0.986	1.114	0.957	0.949	1.047
Remittances	1.047	1.039	1.049	1.045	1.050
Food expenditure shares	1.008	0.960	1.018	1.019	0.989

Notes: I compute the relative changes (Baseline = 1) on the pivotal endogenous variables of going from the equilibrium without migration to the observed equilibrium where the number of migrants (internal and international immigrants and emigrants) moves from zero to the observed level.

productivity effect– As reported in column (1) on the *"productivity effect"* panel of Table 3.6.3, countrywide, actual migration depletes the pool of workers available for the production process by about 5.4% explained by international emigration that exceeds international immigration.[85] Given positive selection in the Senegalese migration along the skill dimension,

[85] While internal migration re-allocates workers spatially within the boundaries of the country, international migration will lead to a decline in available workers as far as out-migrants cannot be fully replaced in size and in skill composition by immigrants from foreign countries.

dominated by emigration to the OECD, migration overall has contributed to deplete the stock of human capital in Senegal and emigration-driven education incentives are able to fully compensate for the loss. Indeed, human capital countrywide declines by 5.2% accompanied by a decline in TFP by 4.2%. Although housing prices decrease due to net emigration which increases the purchasing power, the change is minor relative to the decline in other key variables. The decline in relative preference of high-skilled combined to the drop in the human capital and the labour force contribute to lower productivity countrywide and finally productivity. I further split the country between sub-national units that belong to the capital region of the country, and the rest of the country. Results are reported in columns (2) and (3) and show that, although migration increases the living costs in the capital region, it also increases its productivity (higher human capital, higher productivity, higher employment) while the reverse holds in the rest of the country. Given that the capital region is the richest of the country, experiencing large productivity gains while the poorest experience productivity losses, migration widens spatial productivity disparities in Senegal. Channels operate the same way for all units of net immigration versus those of net emigration as evidenced in columns (4) and (5).

Welfare effect– The *"welfare effect"* panel of Table 3.6.3 shows that remittances are the primary channel through which migration boosts welfare countrywide. However, the productivity effect is more pronounced in the capital region and areas with net immigration. The significant impact of remittances, coupled with the contradictory effects of housing prices, explains the reduction in welfare disparities at the national level. Specifically, regions with net immigration, despite their higher productivity, face steep increases in living costs, which diminish productivity gains. Conversely, regions of net emigration benefit from larger remittance inflows and reduced living costs, collectively leading to improved living standards.

3.7 Sensitivity analysis and robustness checks

This section presents two robustness exercises. The first examines the sensitivity of the results to variations in parameter values, considering both individual changes and simultaneous adjustments across all parameters. The second evaluates the model's ability to accurately predict the size and spatial distribution of economic activity across Senegalese departments in the past (One and two decades earlier).

3.7.1 Sensitivity to parameters values

In this section, I explore the sensitivity of the results to the parameter values by using the upper and lower bound values, both individually and collectively. For the income elasticity of migration (μ) and the elasticity of substitution between high- and low-skilled workers (σ), I use bounds established in the labour market literature. Specifically, I consider a lower bound value of 1.5, which is close to the estimates used by Tombe and Zhu (2019) and Cha'ngom et al. (2023) for μ, and an upper bound value of 3.0, similar to the value used in Bryan and Morten (2019). A comparable range is applied to σ, consistent with the findings of Ottaviano and Peri (2012) and Caiumi and Peri (2024). For the remaining parameters, I systematically reduce and increase each by 25% to evaluate how these variations influence the estimated effects based on the benchmark parameter values. Additionally, I simultaneously adjust all parameters jointly to their respective lower and upper bounds to investigate whether the estimated effects are not merely artifacts of the specific parameter values chosen. The results, detailed in Appendix A.9 show that these alternative parameters do not alter results fundamentally. The benchmark parameter values suggest a 4% decline in productivity and an 8% increase in welfare as a consequence of net migration country-wide. The sensitivity analysis reveals a range of outcomes, with productivityning between a 2.4% to 6.9%, and welfare increasing between 6.3% and 9.0%.

3.7.2 Model validation: predicting the past

In this section, I use the department fundamentals, along with the historical spatial distribution of skill-specific labour force across departments, to backcast the model's implied economic activity across Senegalese departments. Starting with the calibration detailed in Section 3.5.2 around the year 2010, I run the simulation backward to estimate the distribution of gross domestic product (GDP) across Senegalese departments for the years 1990 and 2000. I then compare the model's estimated distribution to the data from Kummu et al. (2018). Due to the administrative reforms that took place in 1984, 2002, and 2008, the number of departments changed across census rounds—from 27 in the 1988 census to 36 in the 2002 round and 45 in the 2013 round. To ensure consistency and comparability of geographic units over time, I conduct my backcasting exercise using the 27 departments present in the 1988 census. To further enhance the comparability of my model predictions with various datasets, I aggregate my model predictions up to the Administrative Unit 1 (Regions) level and compare these predictions with regional GDP data from Gennaioli et al. (2013). Gennaioli et al. (2013) document sub-national GDP for 1,569 regions across 110 countries around the world, including Senegal, and provide GDP data for 10 Senegalese regions in the year 2000, corresponding to the first-order sub-national regions resulting from the 1984 administrative reform. In Appendices A.14 and A.15, I show that the model performs well, with the correlation between model's prediction and the data at department level reaching 62% and 70% for the years 1990 and 2000 respectively. At the administrative unit level 1, the correlation is even stronger standing at 91% when compared to Kummu et al. (2018) data and 94% when compared to

Gennaioli et al. (2013) data for the year 2000.

3.8 Conclusion

Large spatial disparities in migration patterns across sub-national units within countries point to a number of issues. First, there could be significant implications for the spatial distribution of economic activity and for regional development inequalities in developing countries. Second, spatial disparities in migration patterns indicate that there could be mobility frictions, and if this is the case, reducing these frictions could have distributional implications at both local and country levels.

This paper evaluates these implications by estimating the distributional effects of actual heterogeneous migration patterns in Senegal, and predicting the effects of reducing barriers to mobility. My approach is to use the full structure of migration - including inflows, outflows, internal and international flows, as well as location-specific characteristics - to identify mobility barriers. This allows me to isolate the distributional impact of the actual level of total migration and to examine how reducing mobility frictions would affect the distribution of economic activity, taking into account general equilibrium effects. I implement my approach using unique data from Senegal, which includes information on the sub-national unit of birth, sub-national unit of residence, and details about household members who have migrated abroad, including the destination country they migrated to. This dataset is further enriched with data on earnings and expenditure composition. By combining this data with the model, I can identify the key parameters of my model.

This paper represents an innovative approach by integrating internal and international migration decisions at a sub-national level. It demonstrates that the economic consequences of labour migration are not uniform but vary significantly depending on the specific characteristics of the regions involved. Moreover, the spatial general equilibrium model developed in this paper provides a robust and generalized framework for analyzing the distributional impacts of migration. The model captures the effect of heterogeneous migration patterns on local labour markets, productivity, and housing prices, as well as the additional feedback effects such as remittances and emigration-driven education incentives.

I find that actual migration in Senegal reduces productivity by 4%, but increases welfare by 8%. At the sub-national level, the spatial distribution of productivity and welfare reflects the level of local total migration. On average, locations of net immigration show productivity gains, while the opposite is true for locations of net emigration. Nevertheless, almost all locations exhibit welfare gains , primarily derived from remittances. Overall, heterogeneous migration patterns increase productivity inequality across sub-national units but reduce welfare inequality. In addition, I simulate the effects of several policies aiming at reducing mobility frictions and they all predict larger productivity disparities and lower welfare disparities across space. These likely conflicting effects of overall migration on productivity and welfare may puzzle over whether it should be seen as a curse or a boon. Nevertheless, a policy that halves migration frictions in Senegal would increase productivity and welfare by about 10% and 9%, respectively. More interestingly, complementing this reduced migration costs with an alignment of access to education in the rest of the country to the standards observed in the capital region would raise productivity by almost 12% and welfare by almost 9%. This strongly indicates that unequal migration patterns reduce the spatial mis-allocation of labour at the cost of larger spatial productivity inequalities. Nevertheless, although some locations will be economically deprived, the feedback effects, especially those unrelated to the production process (e.g. remittances), improve the welfare of most workers.

Bibliography

Abarcar, P. and C. Theoharides (2021). "Medical Worker Migration and Origin-Country Human Capital: Evidence from U.S. Visa Policy". In: *Review of Economics and Statistics* forthcoming, pp. 1–46.

Aggarwal, S. (2018). "Do Rural Roads Create Pathways Out of Poverty? Evidence from India". In: *Journal of Development Economics* 133, pp. 375–395.

Ahlfeldt, G. M., S. J. Redding, D. M. Sturm, and N. Wolf (2015). "The economics of density: Evidence from the Berlin Wall". In: *Econometrica* 83(6), pp. 2127–2189.

Albert, C. and J. Monras (2022). "Immigration and spatial equilibrium: the role of expenditures in the country of origin". In: *American Economic Review* 112(11), pp. 3763–3802.

Angrist, J. D. and J.-S. Pischke (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

Antman, F. M. (2011). "The intergenerational effects of paternal migration on schooling and work: What can we learn from children's time allocations?" In: *Journal of Development Economics* 96(2), pp. 200–208.

Arslan, C., J.-C. Dumont, Z. Kone, Y. Moullan, C. Ozden, C. Parsons, and T. Xenogiani (2015). "A new profile of migrants in the aftermath of the recent economic crisis". In: *OECD Social Employment and Migration Working Papers* 160.

Ba, C., J. Bourgoin, and D. Diop (2017). "The fluidity of internal migration as an answer to local constraints". In: *In: Mercandalli, S. and Losch, B. (eds.). Rural Africa in motion: Dynamics and drivers of migration South of the Sahara*, pp. 32–33.

Bah, T. L., C. Batista, F. Gubert, and D. McKenzie (2023). "Can information and alternatives to irregular migration reduce "backway" migration from The Gambia?" In: *Journal of Development Economics* 165, p. 103153.

Barro, R. J. (2001). "Human capital and growth". In: *American economic review* 91(2), pp. 12–17.

Baseler, T. (2023). "Hidden income and the perceived returns to migration". In: *American Economic Journal: Applied Economics* 15(4), pp. 321–352.

Batista, C., A. Lacuesta, and P. C. Vicente (2012). "Testing the 'brain gain' hypothesis: Micro evidence from Cape Verde". In: *Journal of Development Economics* 97(1), pp. 32–45.

Beauchemin, C., M.-L. Flahaux, and B. Schoumaker (2020). "Three sub-Saharan migration systems in times of policy restriction". In: *Comparative Migration Studies* 8(19).

Beine, M., F. Docquier, and H. Rapoport (2008). "Brain drain and human capital formation in developing countries: winners and losers". In: *The Economic Journal* 118(528), pp. 631–652.

Beine, M., F. Docquier, and Ç. Özden (2011). "Diasporas". In: *Journal of Development Economics* 95(1), pp. 30–41.

Beine, M., F. Docquier, and H. Rapoport (2001). "Brain drain and economic growth: theory and evidence". In: *Journal of Development Economics* 64(1), pp. 275–289.

Beine, M., F. Docquier, and H. Rapoport (2010). "On the robustness of brain gain estimates". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 143–165.

Beine, M. and C. Parsons (2015). "Climatic factors as determinants of international migration". In: *The Scandinavian Journal of Economics* 117(2), pp. 723–767.

Bell, M., E. Charles-Edwards, A. Bernard, and P. Ueffing (2018). "Global trends in internal migration". In: *Internal migration in the developed world: are we becoming less mobile?* Ed. by T. C. T. Champion and I. Shuttleworth. Routledge: United Kingdom.

Belot, M. V. and T. J. Hatton (2012). "Immigrant Selection in the OECD". In: *The Scandinavian Journal of Economics* 114(4), pp. 1105–1128.

Benavente, A. and C. Panchaud (2008). "Lutte contre la pauvreté et éducation pour l'inclusion: transformer l'école en Afrique subsaharienne". In.

Bergman, P., R. Chetty, S. DeLuca, N. Hendren, L. F. Katz, and C. Palmer (2024). "Creating moves to opportunity: Experimental evidence on barriers to neighborhood choice". In: *American Economic Review* 114(5), pp. 1281–1337.

Berthélemy, J.-C., M. Beuran, and M. Maurel (2009). "Aid and migration: Substitutes or complements?" In: *World Development* 37(10), pp. 1589–1599.

Bertoli, S. and J. F.-H. Moraga (2013). "Multilateral resistance to migration". In: *Journal of development economics* 102, pp. 79–100.

Bhagwati, J. and K. Hamada (1974). "The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis". In: *Journal of Development Economics* 1(1), pp. 19–42.

Biavaschi, C., M. Burzyński, B. Elsner, and J. Machado (2020). "Taking the skill bias out of global migration". In: *Journal of Development Economics* 142, p. 102317.

Bocquier, P., N. Cha'ngom, F. Docquier, and J. Machado (2023). "The within-country distribution of brain drain and brain gain effects: A case study on Senegal". In: *Journal of Demographic Economics*, pp. 1–28.

Bouche, D. (1974). "The French school and Muslims in Senegal from 1850 to 1920". In: *Revue d'histoire* 61, pp. 218–235.

Brauw, A. de and J. Giles (2017). “Migrant Opportunity and the Educational Attainment of Youth in Rural China”. In: *Journal of Human Resources* 52(1), pp. 272–311.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014a). “Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh”. In: *Econometrica* 82, pp. 1671–1748.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014b). “Underinvestment in a profitable technology: The case of seasonal migration in Bangladesh”. In: *Econometrica* 82(5), pp. 1671–1748.

Bryan, G. and M. Morten (2019). “The aggregate productivity effects of internal migration: Evidence from Indonesia”. In: *Journal of Political Economy* 127(5), pp. 2229–2268.

Burzyński, M., C. Deuster, and F. Docquier (2020). “Geography of skills and global inequality”. In: *Journal of Development Economics* 142, p. 102333.

Burzyński, M., C. Deuster, F. Docquier, and J. De Melo (2022). “Climate change, inequality, and human migration”. In: *Journal of the European Economic Association* 20(3), pp. 1145–1197.

Caballero, M. E., B. Cadena, and B. K. Kovak (2021). *The International Transmission of Local Economic Shocks Through Migrant Networks*. NBER Working Papers 28696. National Bureau of Economic Research, Inc.

Caiumi, A. and G. Peri (2024). *Immigration’s Effect on US Wages and Employment Redux*. Tech. rep. National Bureau of Economic Research.

Castelló-Climent, A. and A. Mukhopadhyay (2013). “Mass education or a minority well educated elite in the process of growth: The case of India”. In: *Journal of Development Economics* 105, pp. 303–320.

Cha’ngom, N., C. Deuster, F. Docquier, and J. Machado (2023). “Selective Migration and Economic Development: A Generalized Approach”. In.

Chand, S. and M. A. Clemens (2019). *Human Capital Investment under Exit Options: Evidence from a Natural Quasi-Experiment*. IZA Discussion Papers 12173. Institute of Labor Economics (IZA).

Clemens, M. and E. R. Tiongson (2017). “Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work”. In: *Review of Economics and Statistics* 99(3), pp. 531–543.

Clemens, M. A. (2014). “Does development reduce migration?” In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Clemens, M. A. and H. M. Postel (2018). “Deterring emigration with foreign aid: An overview of evidence from low-income countries”. In: *Population and Development Review* 44(4), p. 667.

Clemens, M. A., S. Radelet, R. R. Bhavnani, and S. Bazzi (2012). "Counting chickens when they hatch: Timing and the effects of aid on growth". In: *The Economic Journal* 122(561), pp. 590–617.

Conte, B. (2022). "Climate change and migration: the case of africa". In.

Cucu, F. (2019). "Roads, Internal Migration and the Spatial Sorting of US High-Skilled Workers". In: *Manuscript, Université Libre de Bruxelles (ECARES)*.

De Mesquita, B. B. and A. Smith (2009). "A political economy of aid". In: *International Organization* 63(2), pp. 309–340.

Delogu, M., F. Docquier, and J. Machado (2018). "Globalizing labor and the world economy: the role of human capital". In: *Journal of Economic Growth* 23(2), pp. 223–258.

Desmet, K., D. K. Nagy, and E. Rossi-Hansberg (2018). "The geography of development". In: *Journal of Political Economy* 126(3), pp. 903–983.

Diamond, R. (2016). "The determinants and welfare implications of US workers' diverging location choices by skill: 1980–2000". In: *American Economic Review* 106(3), pp. 479–524.

Dinkelman, T., G. Kumchulesi, and M. Mariotti (2021). *Labor Migration, Capital Accumulation, and the Structure of Rural Labor Markets*. GLM|LIC Working Paper 22. Institute of Labor Economics.

Dinkelman, T. and M. Mariotti (2016). "The Long-Run Effects of Labor Migration on Human Capital Formation in Communities of Origin". In: *American Economic Journal: applied Economics* 8(4), pp. 1–35.

Djajić, S., F. Docquier, and M. S. Michael (2019). "Optimal education policy and human capital accumulation in the context of brain drain". In: *Journal of Demographic Economics* 85(4), pp. 271–303.

Docquier, F., O. Lohest, and A. Marfouk (2007). "Brain drain in developing countries". In: *The World Bank Economic Review* 21(2), pp. 193–218.

Docquier, F. and J. Machado (2016). "Global Competition for Attracting Talents and the World Economy". In: *The World Economy* 39(4), pp. 530–542.

Docquier, F., J. Machado, and K. Sekkat (2015). "Efficiency gains from liberalizing labor mobility". In: *The Scandinavian journal of economics* 117(2), pp. 303–346.

Dreher, A., A. Fuchs, R. Hodler, B. C. Parks, P. A. Raschky, and M. J. Tierney (2019). "African leaders and the geography of China's foreign assistance". In: *Journal of Development Economics* 140, pp. 44–71.

Duranton, G. and D. Puga (2004). "Micro-foundations of urban agglomeration economies". In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2063–2117.

European-Commission (2015). "Governance and Procedure: EU Trust Fund for Africa for stability and addressing root causes of irregular migration and displaced persons". In: *European Union*.

Felbermayr, G. J., B. Jung, and F. Toubal (2010). "Ethnic networks, information, and international trade: Revisiting the evidence". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 41–70.

Fernández Sánchez, M. (2022). *Mass Emigration and Human Capital over a Century: Evidence from the Galician Diaspora*. Tech. rep. Luxembourg Institute of Socio-Economic Research (LISER).

Fields, G. S. (1990). "Labour market modelling and the urban informal sector: Theory and evidence". In.

Fields, G. S. (2009). "Segmented labor market models in developing countries". In.

Fields, G. S. (2011). "Labor market analysis for developing countries". In: *Labour economics* 18, S16–S22.

Francken, N., B. Minten, and J. F. Swinnen (2012). "The political economy of relief aid allocation: evidence from Madagascar". In: *World Development* 40(3), pp. 486–500.

Gamso, J. and F. Yuldashev (2018). "Does rural development aid reduce international migration?" In: *World Development* 110, pp. 268–282.

Gazeaud, J., E. Mvukiyehe, and O. Sterck (2023). "Cash transfers and migration: Theory and evidence from a randomized controlled trial". In: *Review of Economics and Statistics* 105(1), pp. 143–157.

Gennaioli, N., R. La Porta, F. Lopez-de-Silanes, and A. Shleifer (2013). "Human capital and regional development". In: *The Quarterly journal of economics* 128(1), pp. 105–164.

Gibson, J., D. McKenzie, and S. Stillman (2011). "The Impacts of International Migration on Remaining Household Members: Omnibus Results from a Migration Lottery Program". In: *The Review of Economics and Statistics* 93(4), pp. 1297–1318.

Gollin, D., D. Lagakos, and M. E. Waugh (2014). "The agricultural productivity gap". In: *Quarterly Journal of Economics* 129(2), pp. 939–993.

Grogger, J. and G. H. Hanson (2011). "Income maximization and the selection and sorting of international migrants". In: *Journal of Development Economics* 95(1), pp. 42–57.

Hanushek, E. and L. Woesmann (2008). "The Role of Cognitive Skills in Economic Development". In: *Journal of Economic Literature* 46(3), pp. 607–668.

Hanushek, E. and L. Woesmann (2021). "Education and Economic Growth". In: *Oxford Research Encyclopedia of Economics and Finance* 31, Oxford University Press.

Hao, T., R. Sun, T. Tombe, and X. Zhu (2020). "The effect of migration policy on growth, structural change, and regional inequality in China". In: *Journal of Monetary Economics* 113, pp. 112–134.

Haque, N. U. and S.-J. Kim (1995). ""Human capital flight": Impact of migration on income and growth". In: *Staff Papers* 42(3), pp. 577–607.

Hsieh, C.-T., E. Hurst, C. I. Jones, and P. J. Klenow (2019). "The allocation of talent and us economic growth". In: *Econometrica* 87(5), pp. 1439–1474.

Hsieh, C.-T. and E. Moretti (2019). "Housing constraints and spatial misallocation". In: *American Economic Journal: Macroeconomics* 11(2), pp. 1–39.

Imbert, C., J. Monras, M. Seror, and Y. Zylberberg (2023). "Floating population: migration with (out) family and the spatial distribution of economic activity". In: Federal Reserve Bank of San Francisco.

Iranzo, S. and G. Peri (2009). "Migration and trade: Theory with an application to the Eastern–Western European integration". In: *Journal of International Economics* 79(1), pp. 1–19.

Javorcik, B. S., Ç. Özden, M. Spatareanu, and C. Neagu (2011). "Migrant networks and foreign direct investment". In: *Journal of development economics* 94(2), pp. 231–241.

Jones, B. F. (2014). "The human capital stock: a generalized approach". In: *American Economic Review* 104(11), pp. 3752–77.

Katz, E. and H. Rapoport (2005). "On human capital formation with exit options". In: *Journal of Population Economics* 18(2), pp. 267–274.

Kerr, S. P., W. Kerr, Ç. Özden, and C. Parsons (2016). "Global talent flows". In: *Journal of Economic Perspectives* 30(4), pp. 83–106.

Khanna, G. and N. Morales (2021). *The IT Boom and Other Unintended Consequences of Chasing the American Dream*. mimeo. University of Michigan.

Khanna, G., E. Murathanoglu, C. Theoharides, and D. Yang (2022). *Abundance from abroad: migrant income and long-run economic development*. Working Paper 29862. NBER.

King, R., R. Skeldon, and J. Vullnetari (2008). "Internal and international migration: Bridging the theoretical divide". In.

Klugman, J. (2009). "Human development report 2009. Overcoming barriers: Human mobility and development". In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

Kosack, E. (2021). "Guest Worker Programs and Human Capital Investment – The Bracero Program in Mexico, 1942–1964". In: *Journal of Human Resources* 56(2), pp. 570–592.

Kraay, A. (2012). "How large is the government spending multiplier? Evidence from World Bank lending". In: *The Quarterly Journal of Economics* 127(2), pp. 829–887.

Kraay, A. (2014). "Government spending multipliers in developing countries: evidence from lending by official creditors". In: *American Economic Journal: Macroeconomics* 6(4), pp. 170–208.

Kummu, M., M. Taka, and J. H. Guillaume (2018). "Gridded global datasets for gross domestic product and Human Development Index over 1990–2015". In: *Scientific data* 5(1), pp. 1–15.

Lagakos, D., M. Mobarak, and M. E. Waugh (2023). "The Welfare Effects of Encouraging Rural-Urban Migration". In: *Econometrical* forthcoming.

Lanati, M., M. Sanfilippo, and F. Santi (2023). "Aid and internal migration in Malawi". In: *World Development* 162, p. 106134.

Lanati, M. and R. Thiele (2018a). "Foreign assistance and migration choices: Disentangling the channels". In: *Economics letters* 172, pp. 148–151.

Lanati, M. and R. Thiele (2018b). "The impact of foreign aid on migration revisited". In: *World development* 111, pp. 59–74.

Lessault, D. and M.-L. Flahaux (2013). "Regards statistiques sur l'histoire de l'émigration internationale au Sénégal". In: *Revue européenne des migrations internationales* 29(4).

Lucas, R. E. (2014). "Migration and economic development: an introduction and synopsis". In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Marchal, L., C. Naiditch, B. Simsek, et al. (2022). *How Foreign Aid Affects Migration: Quantifying Transmission Channels*. Centre d'économie de la Sorbonne.

Marchiori, L., J.-F. Maystadt, and I. Schumacher (2012). "The impact of weather anomalies on migration in sub-Saharan Africa". In: *Journal of Environmental Economics and Management* 63(3), pp. 355–374.

Masaki, T. (2018). "The political economy of aid allocation in Africa: Evidence from Zambia". In: *African Studies Review* 61(1), pp. 55–82.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior". In: *Frontiers in econometrics*. Ed. by P. Zarembka. Academic Press: New York. Chap. 4, pp. 105–142.

McKenzie, D. (2017). "How effective are active labor market policies in developing countries? a critical review of recent evidence". In: *The World Bank Research Observer* 32(2), pp. 127–154.

McKenzie, D. and H. Rapoport (2011). "Can Migration Reduce Educational Attaintment? Evidence from Mexico". In: *Journal of Population Economics* 24(4), pp. 1331–1358.

Meghir, C., A. M. Mobarak, C. Mommaerts, and M. Morten (2022). "Migration and Informal Insurance: Evidence from a Randomized Controlled Trial and a Structural Model". In: *Review of Economic Studies* 89(1), pp. 452–480.

Menard, A. and A. Gary (2018). "Aid, trade and migration: How do bilateral flows interact?" In: *The World Economy* 41(2), pp. 431–456.

Mobarak, A., I. Sharif, and M. Shrestha (2023). "Returns to International Migration: Evidence from a Bangladesh-Malaysia Visa Lottery". In: *American Economic Journal: Applied Economics* forthcoming.

Mokyr, J. (2005). "The intellectual origins of modern economic growth". In: *Research and Technological Innovation*. Springer, pp. 17–80.

Mokyr, J. and H.-J. Voth (2009). "Understanding growth in early modern Europe". In: *Cambridge Economic History of Europe* 1, pp. 7–42.

Monte, F., S. J. Redding, and E. Rossi-Hansberg (2018). "Commuting, migration, and local employment elasticities". In: *American Economic Review* 108(12), pp. 3855–3890.

Mountford, A. (1997). "Can a brain drain be good for growth in the source economy?" In: *Journal of Development Economics* 53(2), pp. 287–303.

Mountford, A. and H. Rapoport (2011). "The brain drain and the world distribution of income". In: *Journal of Development Economics* 95(1), pp. 4–17.

Mountford, A. and H. Rapoport (2016). "Migration policy, African population growth and global inequality". In: *The World Economy* 39(4), pp. 543–556.

National-Security-Council (2021). "U.S. Strategy for Addressing the Root Causes of Migration in Central America". In: *Washington, DC: White House.* Available at, p. 4.

Ortega, F. and G. Peri (2013). "The effect of income and immigration policies on international migration". In: *Migration Studies* 1(1), pp. 47–74.

Otoiu, A., E. Titan, and R. Dumitrescu (2014). "Internal and international migration: Is a dichotomous approach justified?" In: *Procedia-Social and Behavioral Sciences* 109, pp. 1011–1015.

Ottaviano, G. I. and G. Peri (2012). "Rethinking the effect of immigration on wages". In: *Journal of the European Economic Association* 10(1), pp. 152–197.

Page, B. (2020). "Remittances". In: *International Encyclopedia of Human Geography* 2nd edn. Pp. 403–409.

Palma, A. de and K. Kilani (2007). "Invariance of conditional maximum utility". In: *Journal of Economic Theory* 132(1), pp. 137–146.

Pan, Y. (2017). "The Impact of Removing Selective Migration Restrictions on Education: Evidence from China". In: *Journal of Human Resources* 52(3), pp. 859–885.

Porcher, C., E. Morales, and T. Fujiwara (2024). *Measuring Information Frictions in Migration Decisions: A Revealed-Preference Approach*. Tech. rep. National Bureau of Economic Research.

Pratap, S. and E. Quintin (2006). "Are labor markets segmented in developing countries? A semiparametric approach". In: *European Economic Review* 50(7), pp. 1817–1841.

Rapoport, H. and F. Docquier (2006). "The economics of migrants' remittances". In: *Handbook of the economics of giving, altruism and reciprocity* 2, pp. 1135–1198.

Robin, N. (1996). *Atlas des migrations ouest-africaines vers l'Europe, 1985-1993*. Montpellier: IRD Éditions.

Robin, N. (2000). *Facteurs d'attraction et de répulsion à l'origine des flux migratoires internationaux: rapport national Sénégal*. IRD et Eurostat.

Rosenthal, S. S. and W. C. Strange (2004). "Evidence on the nature and sources of agglomeration economies". In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2119–2171.

Rosenzweig, M. R. (1988). "Labor markets in low-income countries". In: *Handbook of development economics* 1, pp. 713–762.

Saiz, A. (2010). "The geographic determinants of housing supply". In: *The Quarterly Journal of Economics* 125(3), pp. 1253–1296.

Shrestha, S. A. (2017). "No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants". In: *The Economic Journal* 127(600), pp. 495–521.

Squicciarini, M. P. and N. Voigtländer (2015). "Human capital and industrialization: Evidence from the age of enlightenment". In: *The Quarterly Journal of Economics* 130(4), pp. 1825–1883.

Stark, O., C. Helmenstein, and A. Prskawetz (1997). "A brain gain with a brain drain". In: *Economics letters* 55(2), pp. 227–234.

Stark, O. and Y. Wang (2002). "Inducing human capital formation: migration as a substitute for subsidies". In: *Journal of Public Economics* 86(1), pp. 29–46.

Theoharides, C. (2018). "Manila to Malaysia, Quezon to Qatar International Migration and Its Effects on Origin-Country Human Capital". In: *Journal of Human Resources* 53(4), pp. 1022–1049.

Tombe, T. (2015). "The missing food problem: Trade, agriculture, and international productivity differences". In: *American Economic Journal: Macroeconomics* 7(3), pp. 226–258.

Tombe, T. and X. Zhu (2019). "Trade, migration, and productivity: A quantitative analysis of china". In: *American Economic Review* 109(5), pp. 1843–72.

UNDP (2009). "Human development report 2009. Overcoming barriers: Human mobility and development". In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

United Nations (2000). *Cross-national comparisons of internal migration: an update on global pattern and trends*. United Nations: Population Division, Technical Paper no. 2013/1.

Vidal, J.-P. (1998). "The effect of emigration on human capital formation". In: *Journal of Population Economics* 11(4), pp. 589–600.

Vollrath, D. (2009). "How important are dual economy effects for aggregate productivity?" In: *Journal of Development Economics* 88(2), pp. 325–334.

Yang, D. (2011). "Migrant remittances". In: *Journal of Economic perspectives* 25(3), pp. 129–152.

Appendix

3.A Data

To quantify heterogeneous exposure to migration across geographical units within Senegal, I need detailed information on both internal and international migration in two dimensions. For internal migration, I need data that record the geographic region of birth, region of current residence, and work for each individual. For international migration, I need, for each sub-national region of Senegal, data that report the country of birth of foreign born and the country of destination for international out-migrants. This allows to map internal and international in- and out-migration flows at the sub-national level for each location. Such data, especially in the context of developing countries, are rare. Senegal census meets these requirements with locations recorded up to administrative level 4 (GADM 4). The migration data are complemented with wage and housing expenditure data from the Harmonized Survey on Households Living Conditions (HECVM), remittance data from the Migration and Remittances Household Survey-Senegal (MRHSS), and the Global Human Settlement Layer (GHSL).

3.A.1 Migration and Employment Data

I use data from the 2013 Senegalese census to compute migration flows. First, I choose administrative level 2 regions as my unit of observation. Although data are available up to administrative level 4, a significant administrative reform in 2008 substantially changed the boundaries of existing units and created new ones, increasing the risk of measurement errors in migration flows. The census records for the entire population include the location of birth (which can be an internal location or a different country), current residence, and work locations. For each household, it records the number of members who migrated abroad and, if applicable, their country of destination. The census also provides detailed information on employment status, educational attainment, and whether the person is in a rural or urban location. However, there are two limitations: it only documents international migration in the last five years, and it fails to capture entire households that have migrated abroad. To address these limitations, I use the total number of working-age Senegalese abroad from the World Bank bilateral migration matrix and apply the distribution of the five-year flows recorded by the census. Notably, the five-year working-age international migration flows documented by the census are roughly one-third of the overall international migration stock from the World Bank bilateral migration matrix around 2010.

3.A.2 Wage Data

Data on wages come from the Harmonized Survey on Household Living Conditions (EHCVM). I construct the yearly average wage for each location by multiplying the hourly wage by the full-time equivalent hours worked per year. I then recompute these wages for urban and rural areas and for the formal and informal sectors. A formal worker is defined here as one with health insurance coverage, a definition consistent for both self-employed and informal workers employed by formal firms. This method is chosen because total yearly wages provided by the EHCVM may be biased due to respondents reporting either too many hours worked (full-time workers) or too few (part-time workers). Outliers, defined as workers reporting a salary wage larger than XOF 10,000,000 (approximately $16,920 per year), are excluded. These dropped observations account for less than 4% of the sample and should not bias the results. Senegalese wages are complemented with country-level, skill-specific wages from ILOSTAT.

3.A.3 Expenditure Shares

Expenditure shares refers to household budget share allocated to food expenditures, non-food consumption expenditures, and housing expenditures. These data within Senegal are taken from EHCVM. Housing price across geographic unit are proxied by the rental price. Outside Senegal, expenditure shares are extracted from the International Price Comparison (ICP).

3.A.4 Remittances Data

Data on remittances are extracted from the 2009/2010 Migration and Remittances Household Survey (MRHSS). These data provide the yearly amount of remittances received from internal and international migrants for each Senegalese department. The data indicate the country of origin of remittances for money received from abroad. This allows building a bilateral remittances matrix between each Senegalese department and each country of origin of remittances. For internal money transfers, the survey only indicates whether the funds come from urban or rural Senegal. For each department, I use the dyadic distribution of urban and rural internal migrants to split the internal transfers across internal dyads.

3.A.5 Past Population Data and Land Areas

The census data provide the spatial distribution of the population in 2013. For my approach, I need past spatial distribution of the Senegalese population and the share of built and non-built land areas. I extract these data from the Global Human Settlement Layer (GHSL), which provides population scans by pixel and the built-up versus available land area for each location from 1990 to 2020. I further extract the skill structure of the labour force around the years 1990 and 2000 from the International Integrated Public Use Microdata Series (IPUMS-international) that provides a 10% Senegalese census rounds 1988 and 2002.

3.B Production technology

Firms produce tradable final good under perfect competition and constant return to scale. For the sake of simplicity, I assume a Cobb Douglas form to production technology so that output in the Senegalese department-area $i\zeta$ is obtained as:

$$Y_{i\zeta} = A_{i\zeta} K_{i\zeta}^{\chi} L_{i\zeta}^{1-\chi} \tag{3.42}$$

where

$$L_{i\zeta} = \sum_{s\in(h,l)} \left[\left(1 - \sum_{j\in N} m_{i\zeta Js} - \sum_{J'\in D} m_{i\zeta J's} \right) L_{i\zeta s}^{0} + \sum_{J\in N} m_{Ji\zeta s} L_{Js}^{0} + \sum_{J'\in D} m_{J'i\zeta s} L_{J's}^{0} \right]$$

$A_{i\zeta}$ the total factor productivity, $K_{i\zeta}$ the physical capital. χ and $1-\chi$ denotes the capital and labor share in regional output respectively. It is well established that physical capital is complementary to labor, and that it adjusts in the long run to keep the capital-labor ratio constant at its efficient level (Caiumi and Peri, 2024; Ottaviano and Peri, 2012) which is proportional to total factor productivity. Consequently, the capital term K from the production technology can be rewritten to make total output a linear function of the labor and the modified total factor productivity. Such that, the aggregate productivity growth and the accumulation of physical capital explain the average wage growth in the long run. In other words, the marginal productivity of capital $\chi A_{i\zeta}(K_{i\zeta}/L_{i\zeta})^{\chi-1}$ tends asymptotically toward the discount rate, ρ, in the long run. The implied efficient level of capital-labor ratio is proportional to total factor productivity:

$$K_{i\zeta}/L_{i\zeta} = (1/A_{i\zeta})^{1/(\chi-1)}(\rho/\chi)^{1/(\chi-1)}$$

from which one can easily derive $K_{i\zeta}$ as $K_{i\zeta} = (L_{i\zeta}^{\chi-1}/A_{i\zeta})^{1/(\chi-1)}(\rho/\chi)^{1/(\chi-1)}$. Replacing K in the production technology by its long run expression yields

$$Y_{i\zeta} = A_{i\zeta}^{-1/(\chi-1)}(\rho/\chi)^{1/(\chi-1)} L_{i\zeta} \equiv \widetilde{A}_{i\zeta} L_{i\zeta}$$

where $\widetilde{A}_{i\zeta} = A_{i\zeta}^{-1/(\chi-1)}(\rho/\chi)^{1/(\chi-1)}$ This allows to writes down the production technology as the linear combination between the modified TFP and the labor input.

$$Y_{i\zeta} = \widetilde{A}_{i\zeta} L_{i\zeta}$$

In what follows, the notation $A_{i\zeta}$ will be preferred over $\widetilde{A}_{i\zeta}$ but will be implicitly referring to the modified TFP induced by a context in which the marginal productivity of capital is constant. I further assumes that workers are heterogeneous in skills and imperfectly substitutable. In each department $i\zeta \in N$, production takes place by combining two imperfectly substitutable groups of workers, either high-skilled or low-skilled, working as complements. The productivity of firms varies at the department level, so that the total output produced in each department is obtained as a constant elasticity of substitution (C.E.S.) form and expressed as :

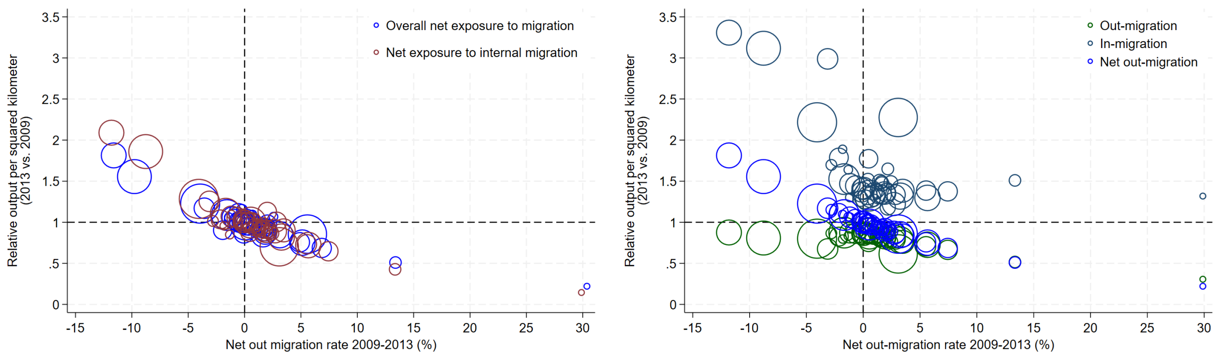
$$Y_{i\zeta} = A_{i\zeta} \left(\sum_{s \in (h,l)} \theta_{i\zeta s} L_{i\zeta s}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{3.43}$$

where $L_{i\zeta s}$ denote the number of type-s workers. $A_{i\zeta}$ refers to the total factor productivity (TFP), σ is the elasticity of substitution between skill groups, and $\theta_{i\zeta s}$ denotes the relative productivity and the firm's preference for type-s workers such that $\sum_s \theta_{i\zeta s} = 1$.

3.C Figures

Figure A.1: Over time changes in output per unit of land strongly correlate with overall migration

(**a**) overall effect (**b**) By migration type



Notes: This figure shows the response of output per squared kilometer to net exposure to migration by department. The relative output per unit area is obtained from a reduced-form estimation of the following equation: $\ln\left(y_i^{2013}/y_i^{2009}\right) = \alpha_0 + \alpha_1 mig_i^{2009-2013} + X_i^{\prime 2009}\beta + \epsilon_i$ where mig denotes the exposure type, which includes in-migration exposure, out-migration exposure, and net exposure defined as the net out-migration rate. $mig \equiv \{erate, irate, nor\}$ where $erate$, $irate$, and nor denote emigration, immigration, and net emigration rates, respectively. The relative change in output per unit area predicted by the reduced form equation is obtained as $y_i^{2013}/y_i^{2009} = e^{\widehat{\alpha}_1 \times mig_i^{2009-2013}}$. The size of the circle indicates the initial population size. On panel A.1a, blue circles denote the local output response to aggregate net exposure to migration (internal+international), while maroon circles indicate the local effect of net exposure to internal migration. On panel A.1b, blue circles denote the local effect of net exposure to aggregate migration, dark green circles denote the local effect of emigration, and navy circles denote the local effect of immigration.

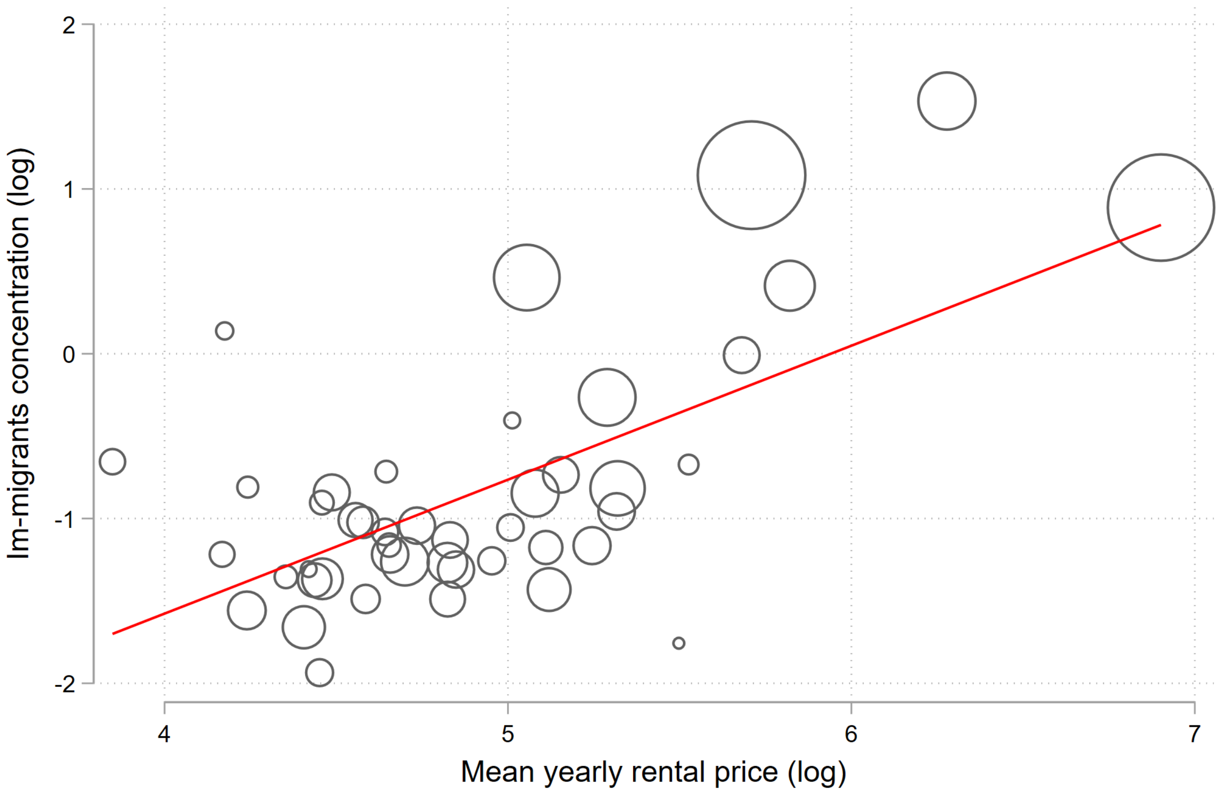
3.C.1 Direct gains from emigration for origin locations

3.C.1.1 Emigration concentration and remittances

On average, the share of remittances and the share of out-migrants from an origin department co-move. The higher the emigration concentration, the higher the share of remittances received. This momentum holds irrespective of the destination category although high productivity destinations send, on average more remittances per migrant (see appendix A.4 for detailed results).[86] The described relationship being a simple correlation, appendix A.3 displays a range of regression results. The first four columns display the OLS results while the last four display the IV results. Columns 1 to 4 display similar picture as appendices A.4 and A.3. However, emigration concentration is potentially endogenous as remittances prospect potentially affect emigration decisions and thus emigration concentration. This prevents

[86] Appendix A.3 shows that remittances from OECD are larger mainly because migrants hosted there remit on average roughly three times more than an average worker who migrated to the rest of the world and 10 times more than an average internal migrant.

Figure A.2: In-migrants concentration in Senegal and housing price



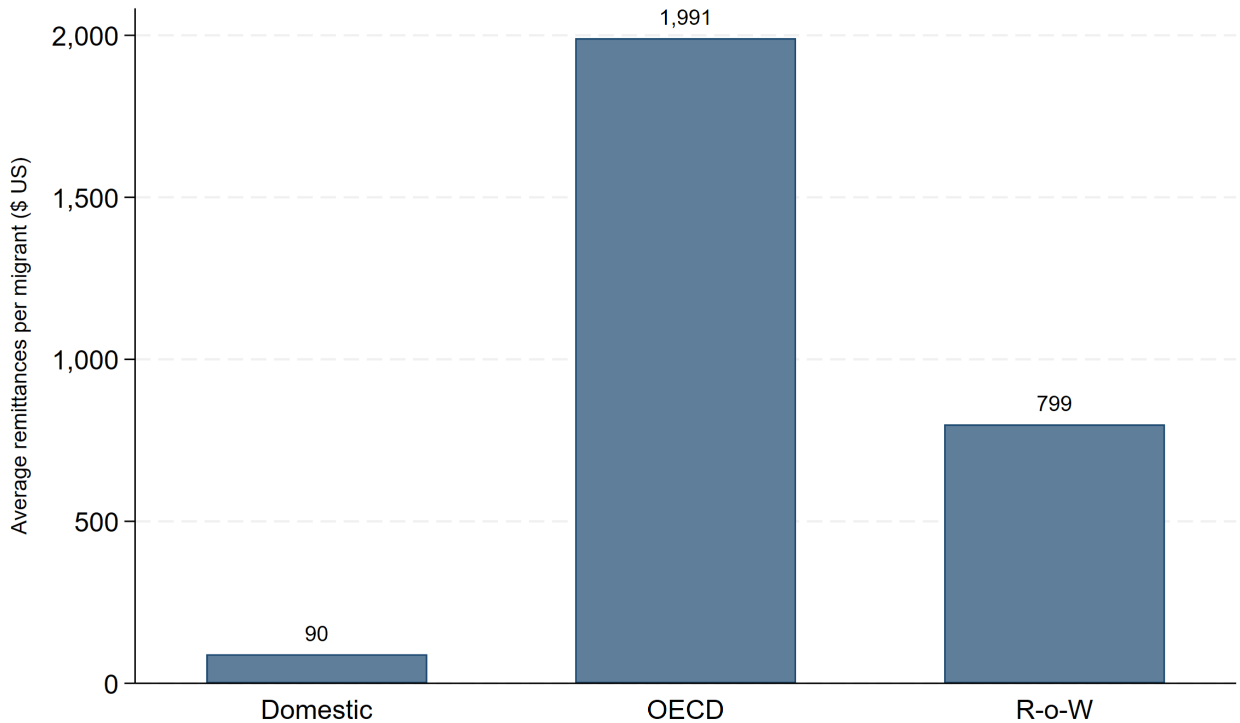
Notes: This figure shows the association between the in-migrants concentration in department and the average rental price at department level. In-migration concentration is measured as the number of In-migrants in i relative to all internal in-migrants in Senegal divided by the number of stayers (non-movers) in i relative to all stayers in Senegal. Circle size indicates the size of labour in i. Data on in-migrants and stayers are from the 2013 census, and those on rental price are from the 2018 EHCVM.

causal interpretation of the estimated β_1. In the last four columns, emigration concentration is instrumented using a gravity based IV strategy, consisting in the prediction of bilateral migration stocks using only bilateral exogenous drivers of migration (geographic distance, contiguity, colonial link), origin department characteristics (population density in 2000, mean distance to the coast), the interaction between geographical distance and destination categories (domestic, OECD, rest of the world), and destination fixed effects. The predicted values are then used to computed the instrumented emigration concentration by department. I estimate an elasticity of emigrants' concentration with respect to the share of remittances received to be positive and statistically significant. A 1% increase in the emigration concentration leads to a 1.08% increase in the share of remittances received. Once split by destination category, this elasticity stands at 1.09% for internal destinations, 1.37% for OECD destinations and 0.78% for the rest of the world. In a nutshell, irrespective of the destination of out-migrants, the higher the emigration concentration, the higher the share of remittances received. More interestingly, this effect gets stronger, the richer the destination.

3.C.1.2 Positive selection and education premium

On average, Senegalese workers with tertiary education are 4.9%age points more likely to emigrate as compared to their less educated counterparts. This trend of positive selection in emigration along the education dimension varies across destination categories. Emigration to the rest or the world exhibits almost neutral selection (roughly 0.12%age point), positive selection stands at 3.9%age points for emigration to the rest of the world and nearly three times higher (10.5%age points) for emigration to the OECD. Figure A.5 illustrates that, overall, departments with lower human capital endowment experience higher positive selection in emigration (panel A.5a). By destination, panel A.5b shows a negative association between pre-migration human capital and emigration rates, particularly stronger for internal destinations and the rest of the world. However, in the case of OECD destinations, positive selection increases with pre-migration human capital. This highlights a potential difference in skill demand across different types of destinations or in accessibility between OECD and non-OECD destinations for prospective migrants from different origin departments. The positive association between pre-migration human capital and emigration decisions to the OECD likely indicates a higher expected education premium in these destinations, serving as a significant incentive for education-driven emigration prospects. Panels A.5c and A.5d focus solely on internal destinations. While panel A.5c examines the relationship between positive selection in internal migration and pre-migration human capital, panel A.5d distinguishes between internal migration to the Dakar region (the wealthiest in the country) and internal migration to non-Dakar regions. Panel A.5c reveals a pattern similar to panel A.5a. However, panel A.5d highlights that the positive selection in internal migration is primarily driven by the

Figure A.3: Average remittances per migrant by destination category

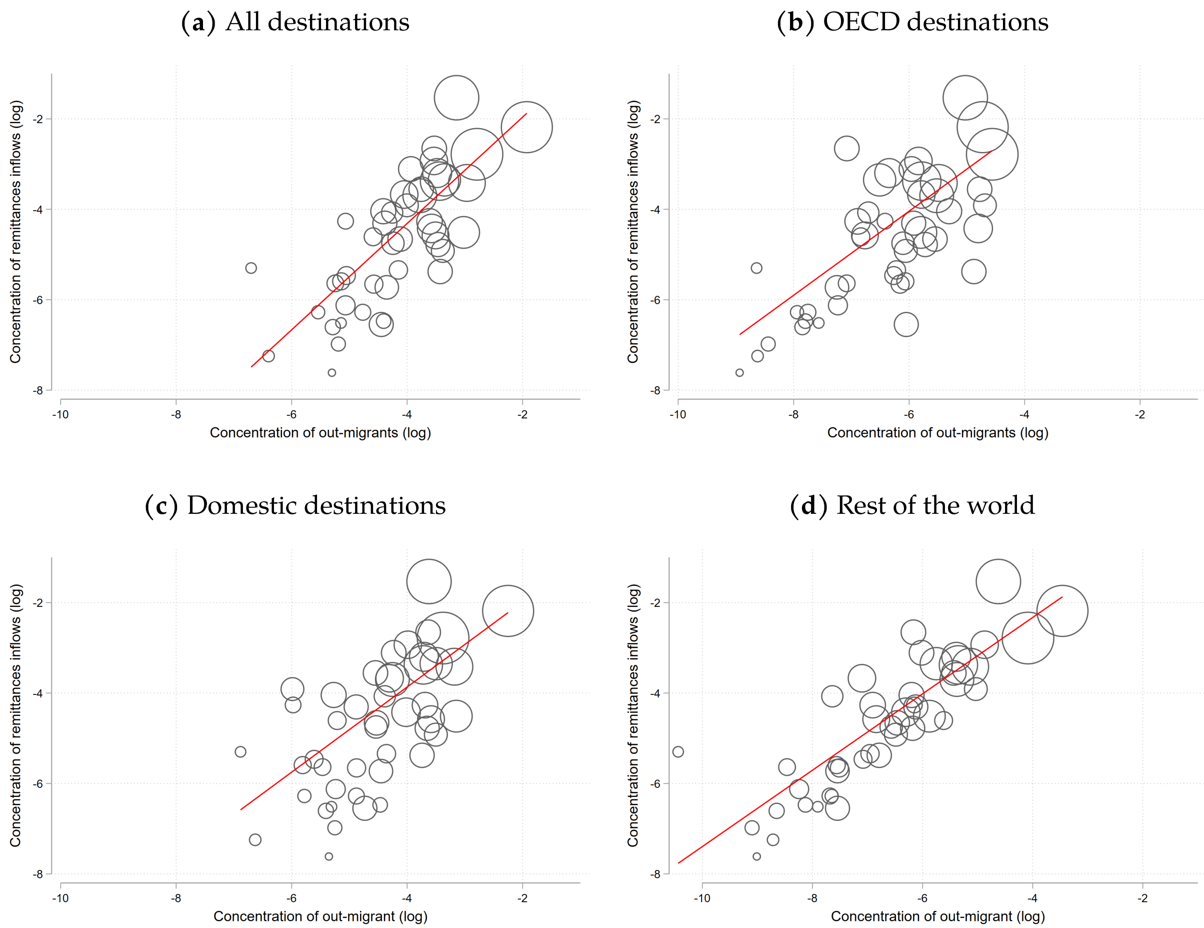


Notes: This figure displays the amount sent by an average migrant broken down by destination (domestic, OECD, rest of the world). Note that OECD here refers to 11 countries including Belgium, Canada, Switzerland, Germany, Spain, France, Greece, Italy, Portugal, Turkey, and United States. Although MRHSS provides more OECD destinations than those listed above, I restrict bilateral migration data to relevant foreign destinations considered as those that have hosted at least 500 Senegalese within the last five years prior to the census year (2013). The residual category is referred to as "Rest of the World". Note that this aggregation choice has meaningless impact on the estimations as very few Senegalese emigrants are there.

Dakar region, while emigration to non-Dakar regions consistently exhibit a negative selection regardless of pre-migration human capital. This analysis suggests that positive selection in emigration to non-OECD destinations contributes to human capital convergence across Senegalese departments (with poorer departments exhibiting higher positive selection). In contrast, positive selection in emigration to OECD destinations contributes to human capital divergence across departments (with richer departments exhibiting higher positive selection).

3.D Tables

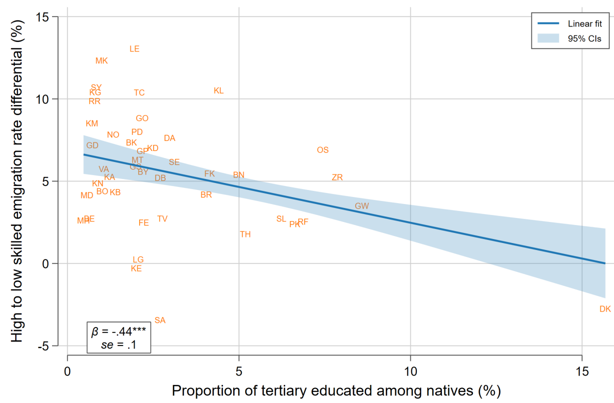
Figure A.4: Emigration concentration and size of remittances received



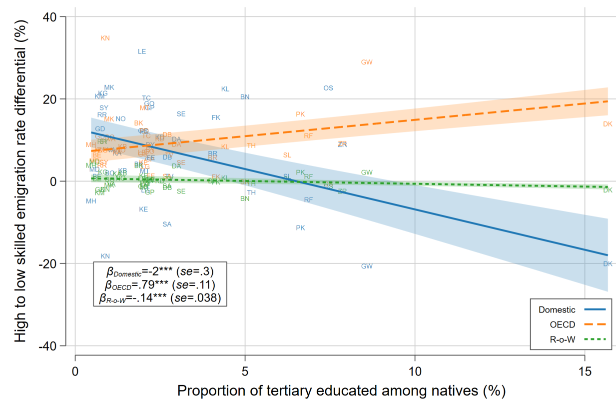
Notes: This figure displays the correlation between emigration concentration and the concentration of remittances inflows at departmental level across destination groups. Destination groups include domestic (panel A.4c), OECD (panel A.4b) and rest of the world destinations (panel A.4d). Each circle represents a department and its size indicates the size of labour force. Panel A.4a displays the aggregated correlation across destinations. Data on emigrants and Labour force are from the 2013 census, while remittances data are from 2010 MRHSS.

Figure A.5: Senegalese emigration exhibits positive selection along the education dimension

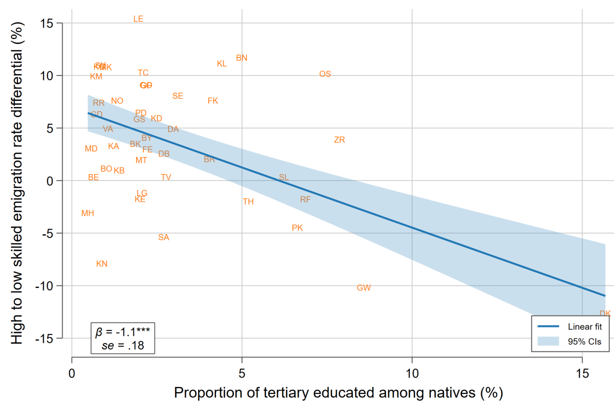
(**a**) All destinations



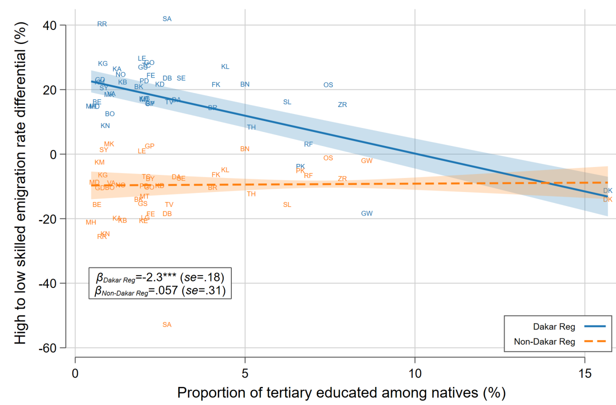
(**b**) By destination group



(**c**) Internal destinations



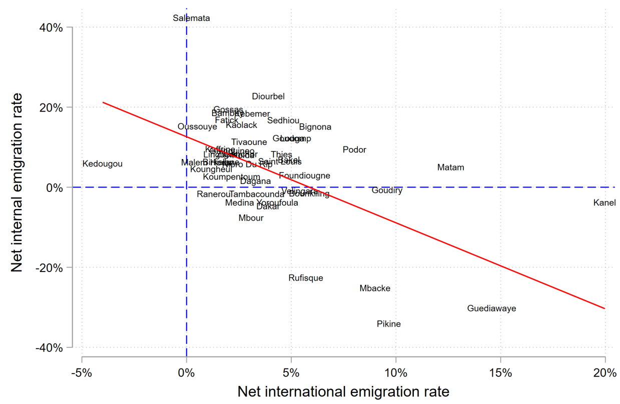
(**d**) Dakar vs. non-Dakar destinations



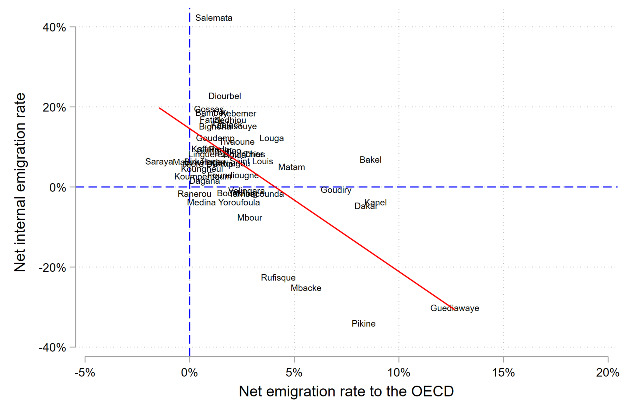
Notes: This figure depicts the relationship between selection in emigration along the education dimension and the ex-ante share of tertiary educated workers. Panel (A.5a) plots the correlation between selection in total emigration and the share of tertiary education among natives. Panel (A.5b), splits panel (A.5a) by destination category. Panel (A.5c) restricts the analysis to internal destinations, and panel (A.5d) splits panel (A.5c) between emigration to the region of Dakar (including Dakar, Pikine, Ruffisque, and Gwediawaye department of the Dakar region) and internal non-Dakar region departments. All data is at the department level. Fitted lines are conditional correlations in which internal destination characteristics are controlled for.

Figure A.6: Net migration across space and destinations

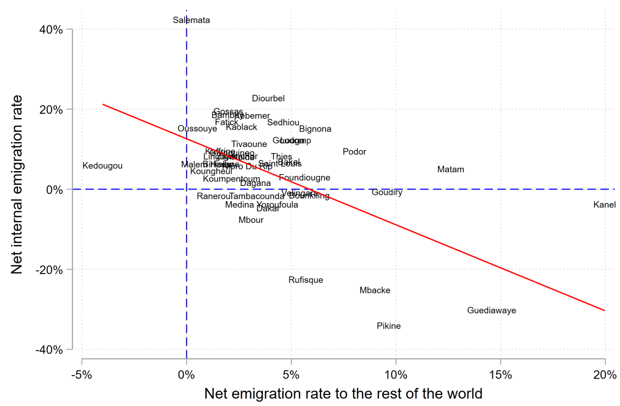
(**a**) Domestic vs. foreign destinations



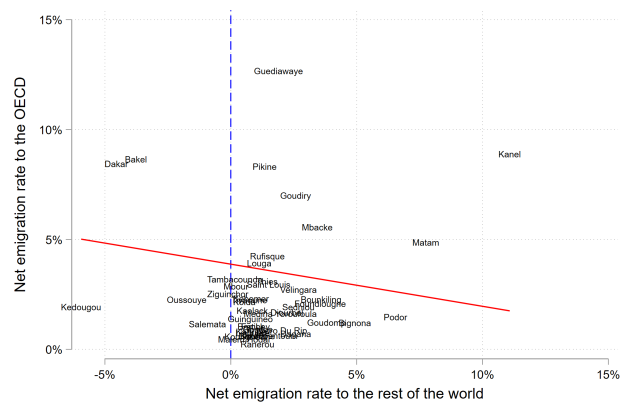
(**b**) Domestic vs. OECD destinations



(**c**) Domestic vs. RoW destinations



(**d**) OECD vs. RoW destinations

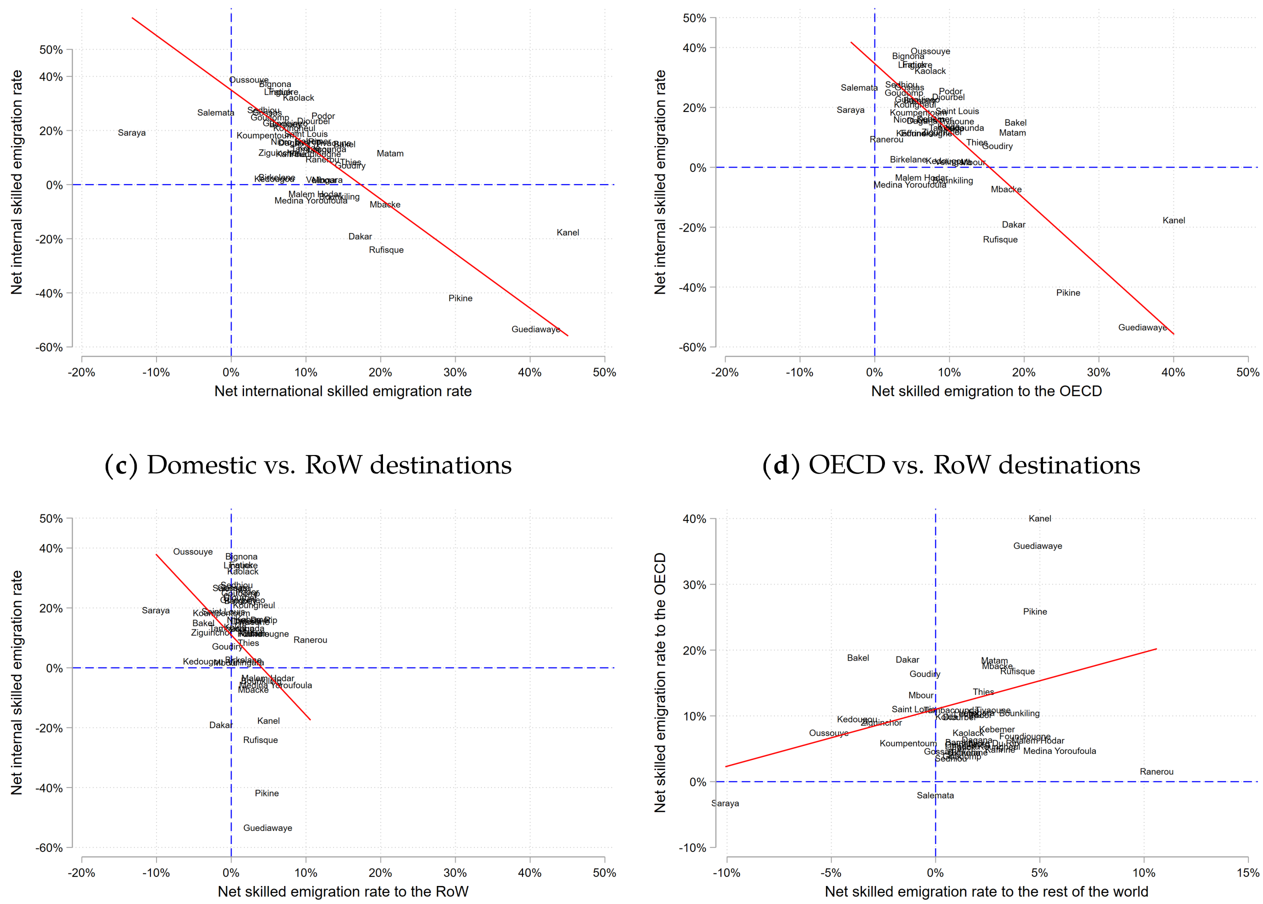


Notes: This figure depicts the relationship between exposure to internal migration and international migration. Panel (A.6a) compares the net internal out-migration rate (the difference between internal emigration and immigration rates) with the net international out-migration rate (the difference between international emigration and immigration rates). Panel (A.6b), shows the correlation between the net internal emigration rate and the emigration rate to OECD countries. Panel (A.6c) displays the correlation between the net internal emigration rate and emigration rates to the rest of the world. Panel (A.6d), plots the net emigration rate to OECD countries against the net emigration rate to the rest of the world. All data is at the department level. The OECD destinations consist of 11 countries: Belgium, Canada, Switzerland, Germany, Spain, France, Greece, Italy, Portugal, Turkey, and the United States. Further details on the selection of these 11 OECD countries are provided in the accompanying note of figure (A.3).

Figure A.7: Net high-skilled out-migration across space and destinations

(**a**) Domestic vs. foreign destinations

(**b**) Domestic vs. OECD destinations



(**c**) Domestic vs. RoW destinations

(**d**) OECD vs. RoW destinations

Notes: This figure depicts the relationship between exposure to internal high-skilled migration and international high-skilled migration. Panel (A.7a), compares the net internal high-skilled out-migration rate (the difference between internal high-skilled emigration and immigration rates) with the net international high-skilled out-migration rate (the difference between international high-skilled emigration and immigration rates). Panel (A.7b), shows the correlation between the net internal high-skilled emigration rate and the high-skilled emigration rate to OECD countries. Panel (A.7c) displays the correlation between the net internal high-skilled emigration rate and the high-skilled emigration rates to the rest of the world. Panel (A.7d), plots the net high-skilled emigration rate to OECD countries against the net high-skilled emigration rate to the rest of the world. All data is at the department level. The OECD destinations consist of 11 countries: Belgium, Canada, Switzerland, Germany, Spain, France, Greece, Italy, Portugal, Turkey, and the United States. Further details on the selection of these 11 OECD countries are provided in the accompanying note of figure (A.3).

Figure A.8: Distribution of yearly wages (department level)

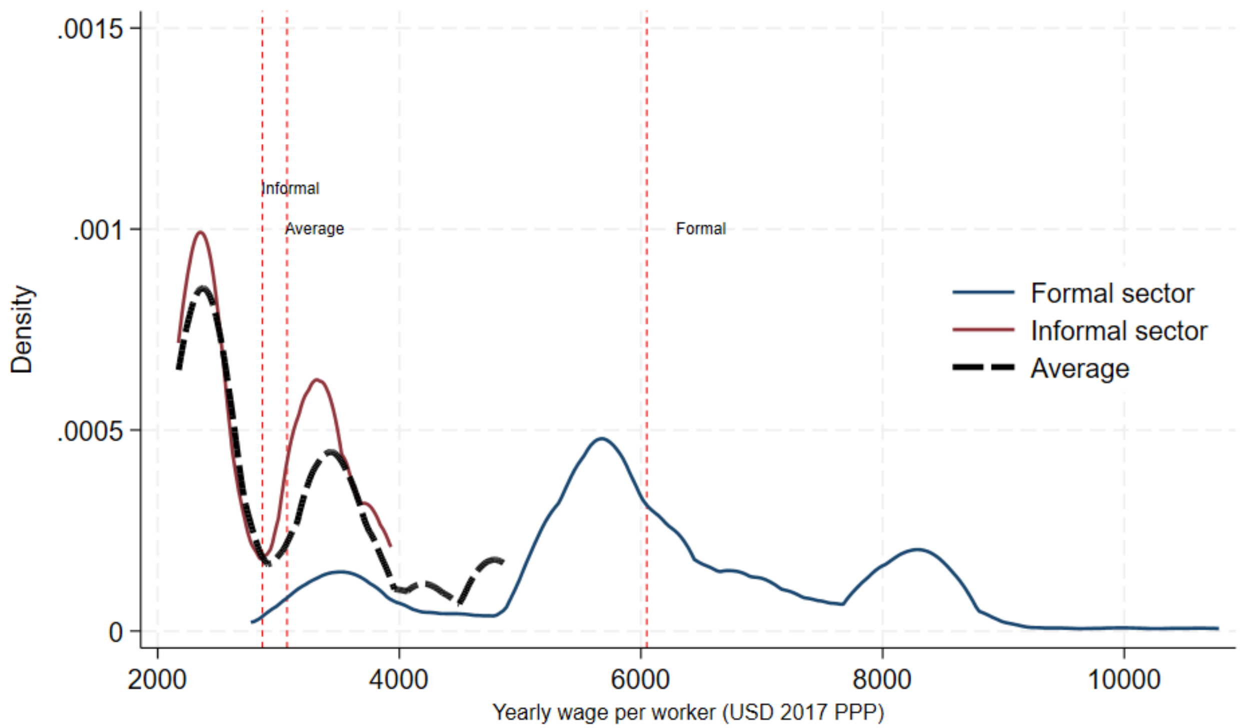
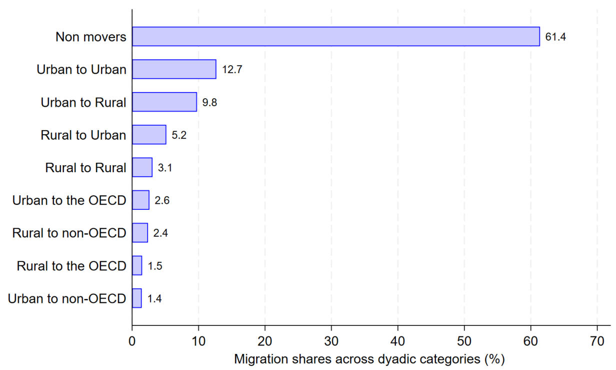
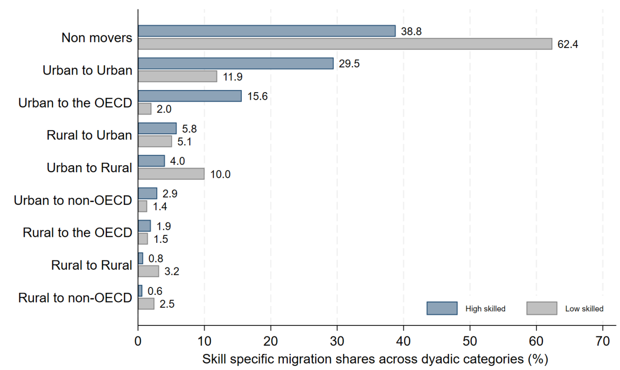


Figure A.9: Stylized facts - Urban-rural-formal-informal divide

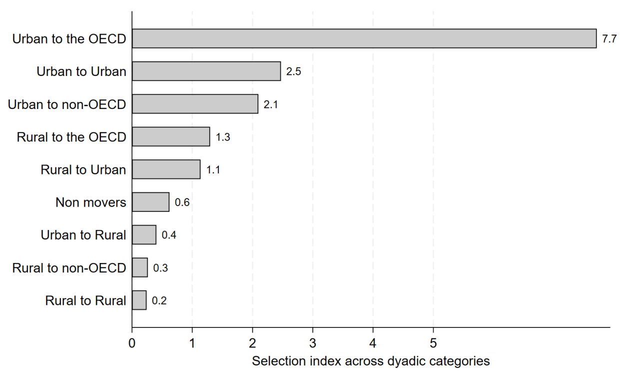
(**a**) Migration shares



(**b**) Migration shares by skill



(**c**) Intensity of positive selection



(**d**) Net migration and size of the formal sector

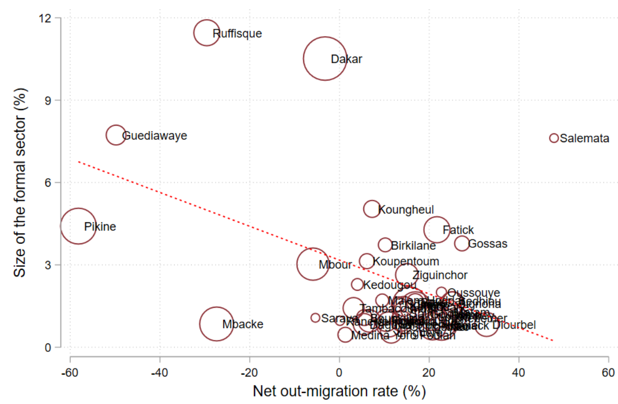
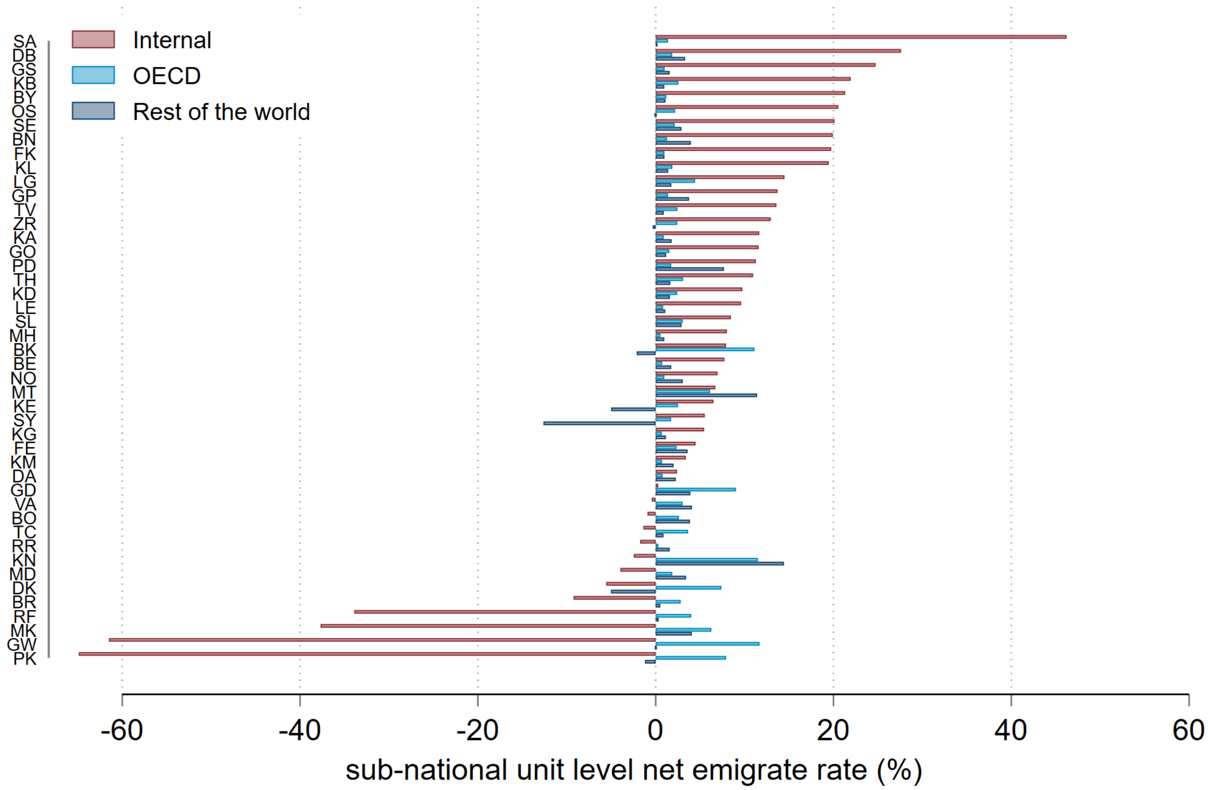


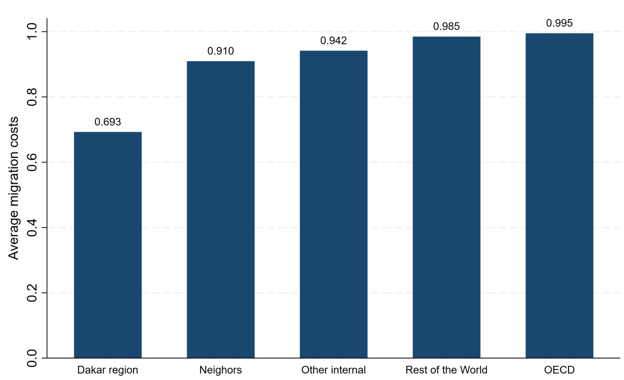
Figure A.10: Varying patterns of migration across space by destination



Notes: This figure depicts the level of net migration captured as the net out-migration rate which correspond to exits minus entries as a proportion of the native working age population broken down by destination category. All data are at the department level.

Figure A.11: Average migration costs

(**a**) Mean costs



(**b**) Mean costs by education

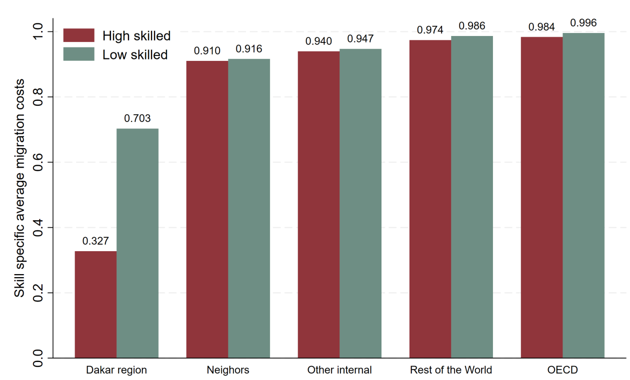
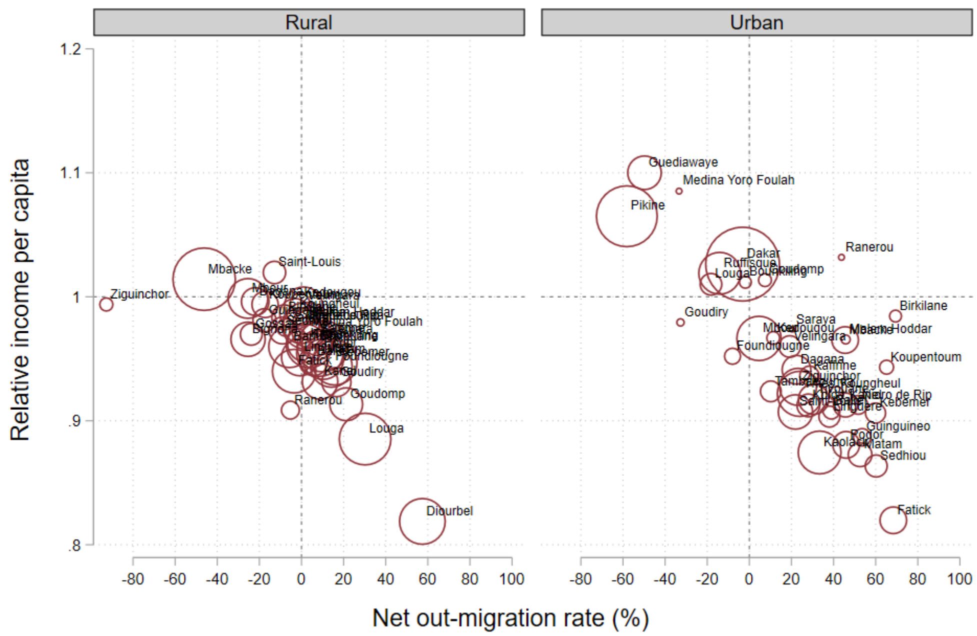
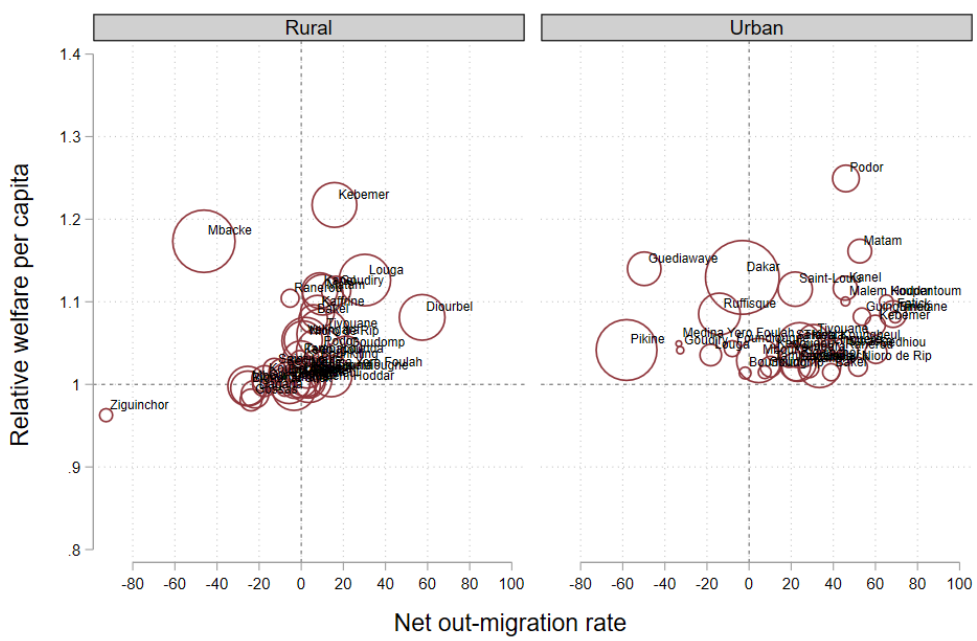


Figure A.12: Sub-national unit level effect of migration on productivity and welfare

(**a**) Effect on productivity



(**b**) Effect on welfare

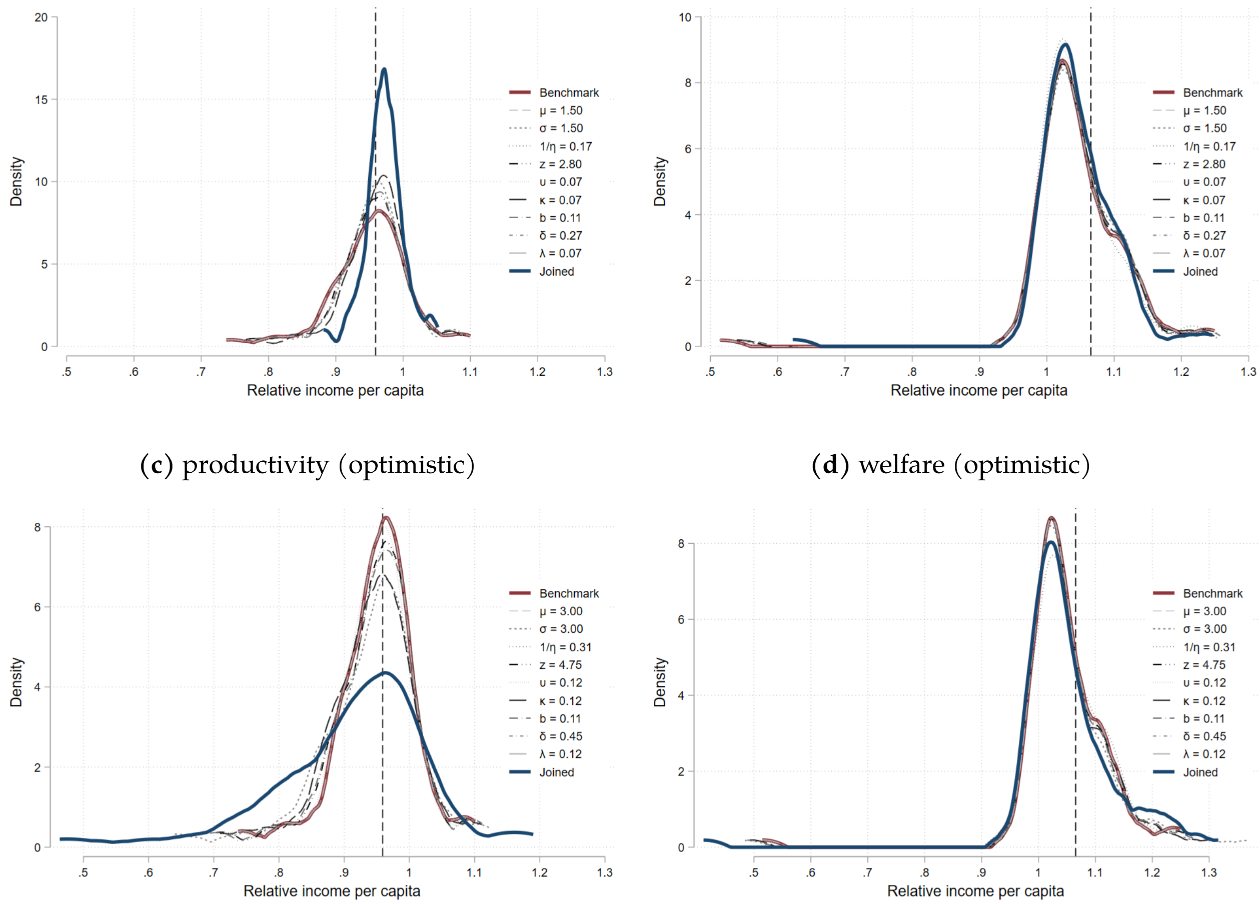


Notes: This Figure reports the local relative productivity (A.12a) and welfare (A.12b) per capita by area. Any relative change of less than one indicates a negative response, while the opposite holds for any value greater than one. The x-axis reports the department-area net out-migration rate in percentage points.

Figure A.13: Distributional effect of net migration across parameter values

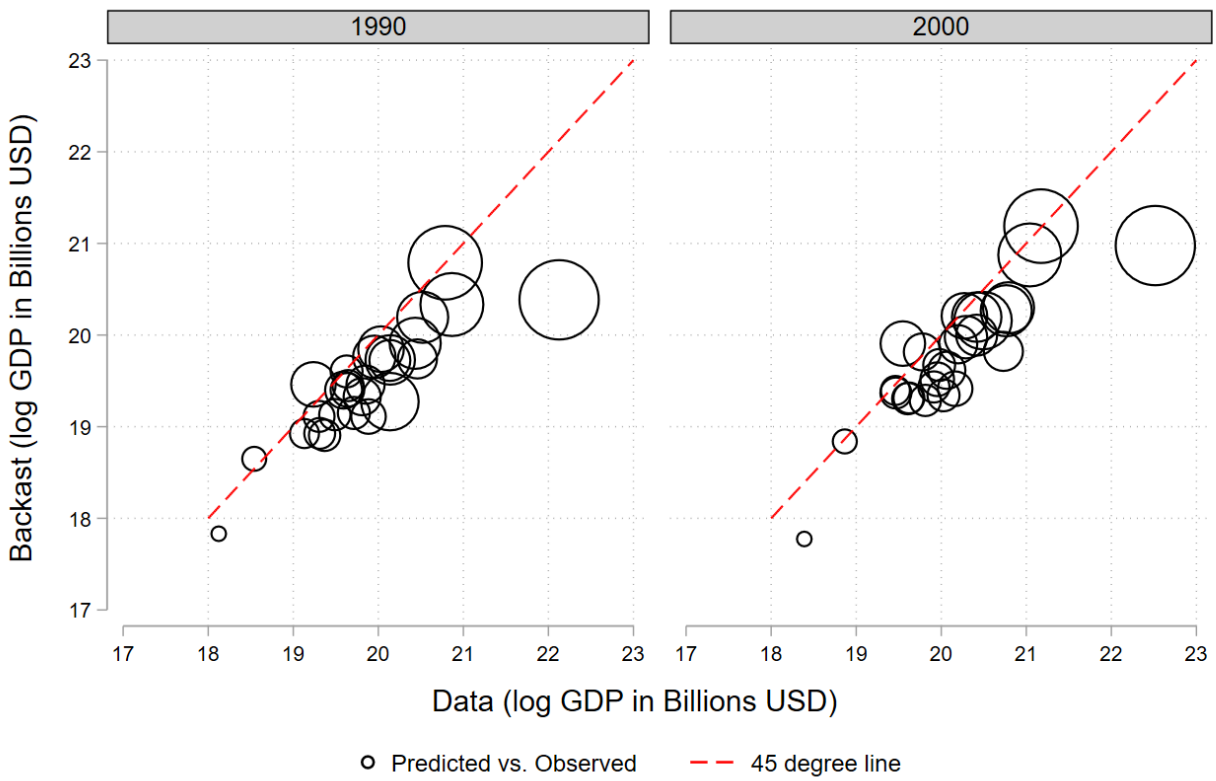
(**a**) productivity (restrictive)   (**b**) welfare (restrictive)

(**c**) productivity (optimistic)   (**d**) welfare (optimistic)



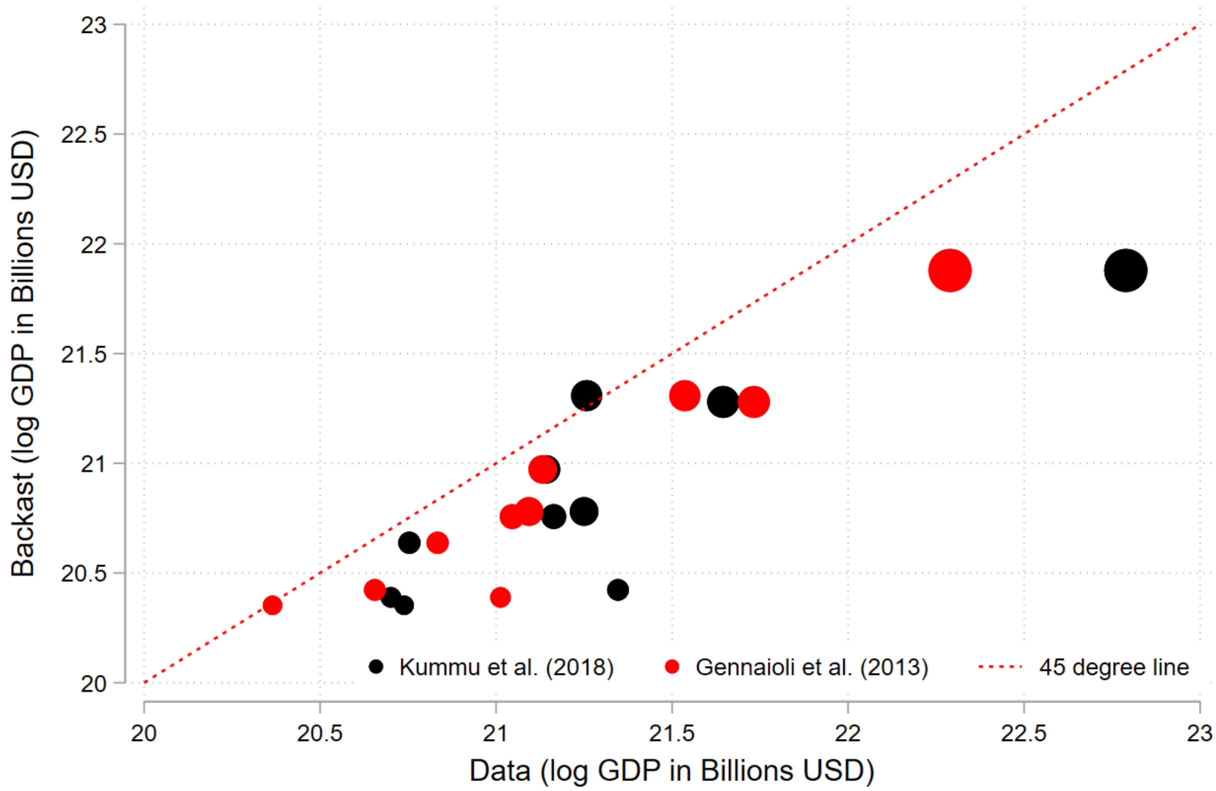
Notes: The figure illustrates the distribution of productivity and welfare responses to various parameter values are illustrated through the four panels. In each panel, the solid maroon and navy curves represent the distribution of relative changes for productivity and welfare under benchmark parameter values, as well as combined alternative values (lower and upper bounds) respectively. The intermediate dashed curves show the distribution of relative changes when each parameter is altered independently. Panels A.13a and A.13b present the distribution of relative changes using lower bound parameter values, whereas panelsA.13c and A.13d display the distribution of relative changes using upper bound parameter values. The dashed vertical line indicates the country-wide average impact of net migration on productivity and welfare under the benchmark parameter values.

Figure A.14: Department-level GDP Correlations, 1990–2000: Model vs. Data



Notes: Figure A.14 illustrates the correlation between department level GDP from Kummu et al. (2018) and model backasting for the years 1990, and 2000. The circle size represent the share of each department in the national labourforce. There are only 27 departments out of which 17 are identical to departments used in the quantitative exercise. The remaining 10 departments combine the following current departments: Pikine and Guediawaye; Podor, Matam, Kanel, Linguiere, and Ranerou; Saint Louis and Dagana; Bakel and Goudiry; Tambacounda and Koupentoum; Kedougou, Salemata, and Saraya; Kaffrine, Koungheul, Guinguineo, Birkilane, Gossas, and Malem Hodar; Kolda and Medina Yoro Foulah; Goudomp, Sedhiou and Bounkiling. The dashed red curve represents the 45 degree line.

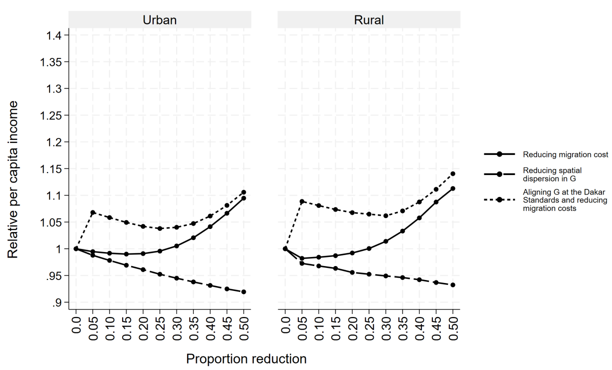
Figure A.15: Region-level GDP Correlations, 2000: Model vs. Data



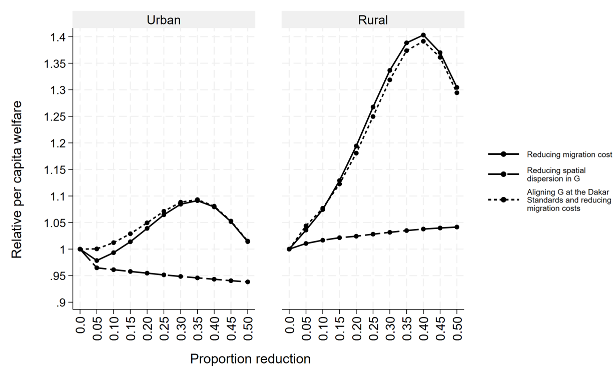
Notes: Figure A.15 illustrates the correlation between region level GDP from Kummu et al. (2018), and Gennaioli et al. (2013) and model backasting for the year 2000. The circle size represent the share of each region in the national labourforce. There are only 10 regions out of which 6 are identical to regions used in the quantitative analysis. The remaining 4 regions combine the following current regions: Saint Louis and Matam; Tambacounda and Kedougou; Fatick and Kaffrine; Kolda and Sedhiou. The dashed red curve represents the 45 degree line.

Figure A.16: Heterogeneous impact of policy interventions

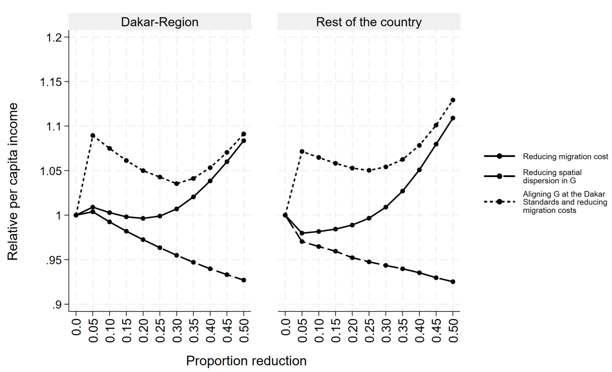
(**a**) productivity by area



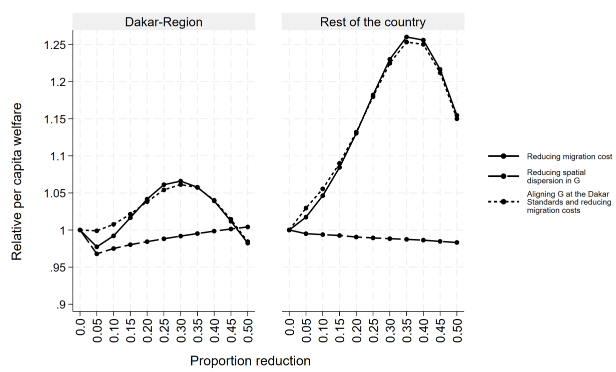
(**b**) Welfare by area



(**c**) productivity: Dakar *vs.* rest of the country



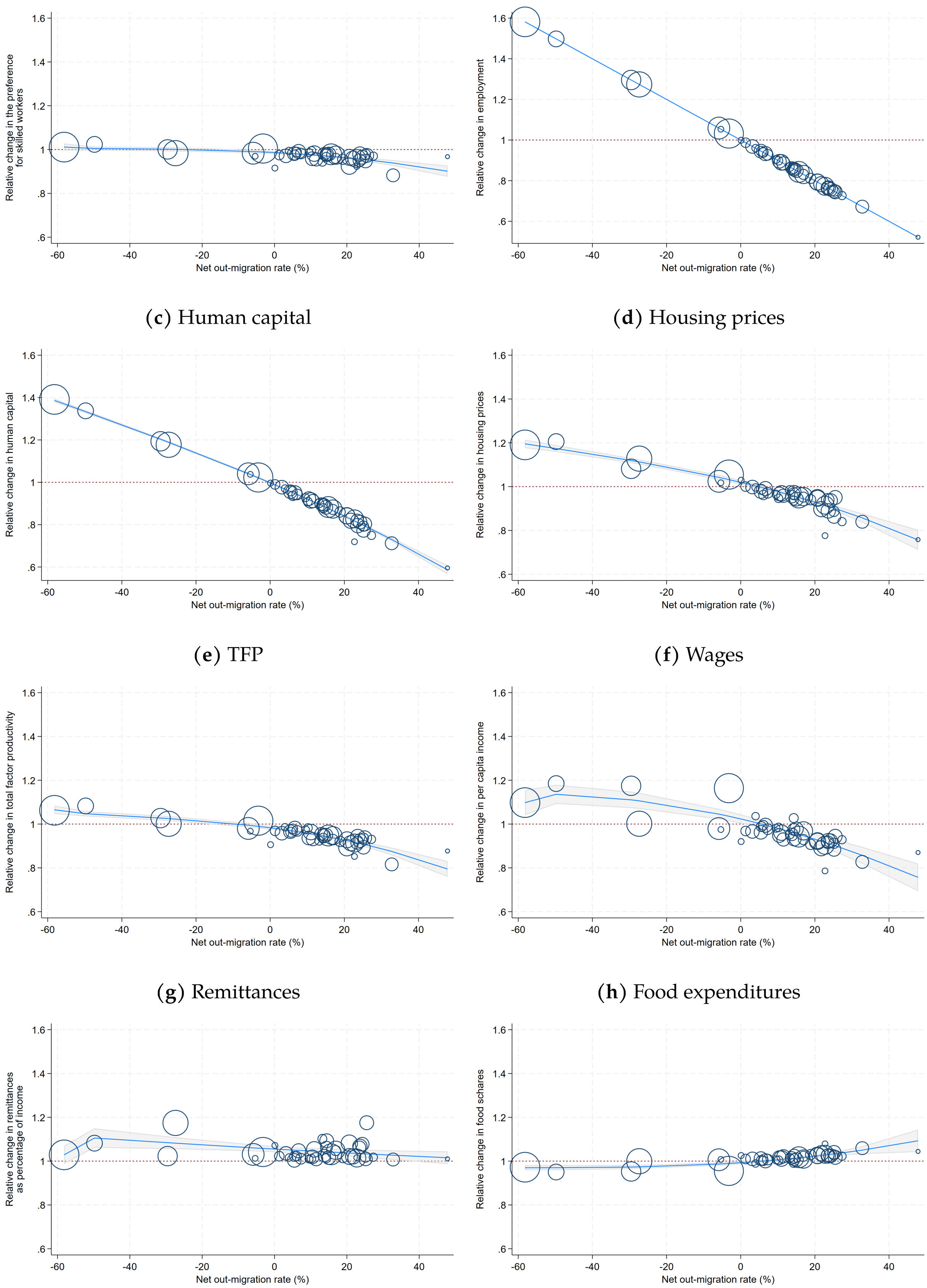
(**d**) Welfare: Dakar *vs.* rest of the country



Notes: This figure illustrates the productivity and welfare responses in urban *vs.* rural areas; and in the Dakar region *vs.* to the rest of Senegal from various counterfactual experiments. Each panel shows the potential distributional effects of three policy experiments. The solid curve illustrates the productivity and welfare responses from reducing migration costs. The long-dashed curve shows the potential distributional effects of reducing spatial disparities in access to education. The short-dashed curve shows the effects of simultaneously improving access to education across Senegal to match the standards in the Dakar region and reducing migration costs. Panels A.16a and A.16b present the productivity and welfare effects by area, while panels A.16c and A.16d compare the productivity and welfare effects in the Dakar region versus the rest of the country.

Figure A.17: Mechanisms by department – Benchmark

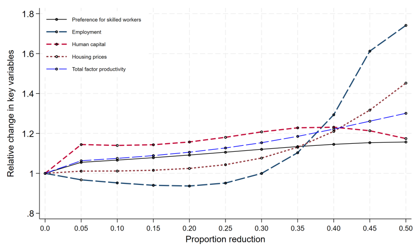
(**a**) Preference for high-skilled workers (**b**) Employment (**c**) Human capital (**d**) Housing prices (**e**) TFP (**f**) Wages (**g**) Remittances (**h**) Food expenditures



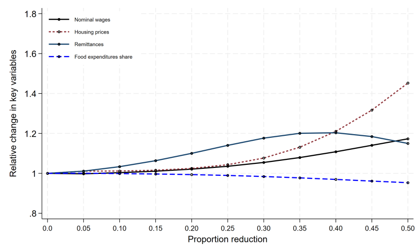
Notes: This figure breaks down the channels through which migration affects economic activity and welfare in Senegal by department. It shows how each channel operates at local level. Circle size represent the size of the department's population.

Figure A.18: Key mechanisms: policy experiments

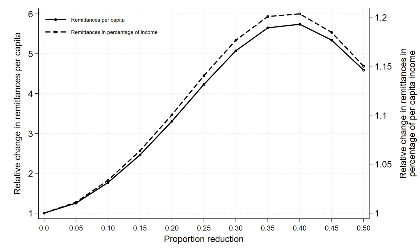
(**a**) Productivity channels



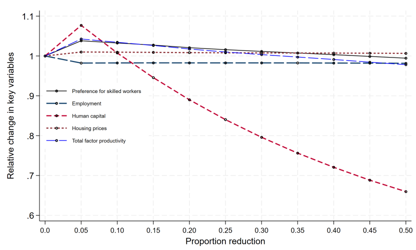
(**b**) Welfare channels



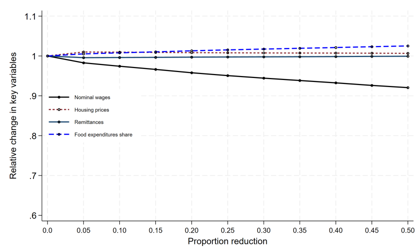
(**c**) Importance of remittances



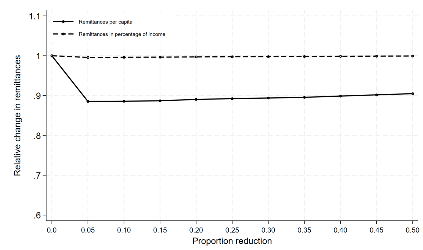
(**d**) Productivity channels



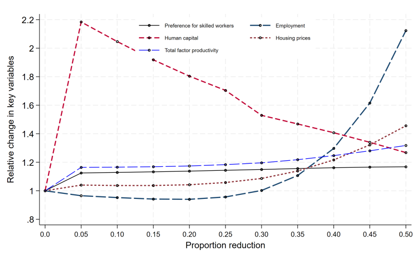
(**e**) Welfare channels



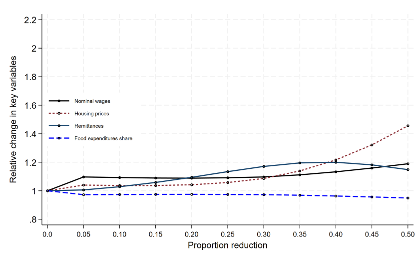
(**f**) Importance of remittances



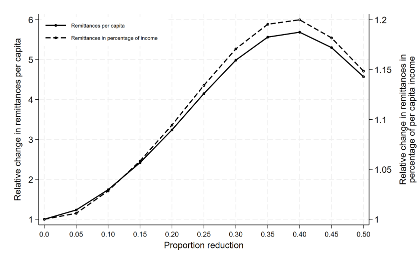
(**g**) Productivity channels



(**h**) Welfare channels



(**i**) Importance of remittances



Notes: This figure breaks down the channels through which reductions in migration costs affect economic activity and welfare. It shows how each channel operates at different intensities of migration cost reduction. Panel A.18a shows the channels through which the productivity effect operates. Panels A.18b and A.18c break down the main channels of the welfare effect of reducing migration costs between wages, cost of living and food expenditure shares on the one hand and remittances on the other. On panel A.18a, the solid black curve refers to relative changes in the preference for high-skilled workers, the navy blue long dashed curve shows relative changes in the size of employment, the cranberry dashed curve shows relative changes in human capital, the short dashed maroon curve shows relative changes in house prices and the long dashed blue curve shows relative changes in total factor productivity. In panels A.18b and A.18c, the short-dashed maroon curve plots the relative changes in housing prices, the dashed blue curve plots the relative changes in food shares, the solid black thin curve plots the relative changes in nominal wages, while the solid thick black curve plots the relative change in remittances.

Table A.1: In-migrants concentration in Senegal and housing price

	Dependent variable: In-migrants concentration (log)								
	OLS			IV-1			IV-2		
	All	High skilled	Low skilled	All	High skilled	Low skilled	All	High skilled	Low skilled
Rental price (log)	0.416***	1.402***	0.349**	0.900***	2.746***	0.803***	1.089***	2.675***	1.006***
	(0.119)	(0.106)	(0.127)	(0.287)	(0.371)	(0.298)	(0.257)	(0.379)	(0.265)
Size of the labor force (log)	1.332***	1.146***	1.340***	1.142***	0.617***	1.161***	1.067***	0.645***	1.081***
	(0.101)	(0.126)	(0.104)	(0.136)	(0.222)	(0.141)	(0.113)	(0.204)	(0.117)
Formality rate (%)	0.891	0.286	0.923	0.427	-1.002	0.488	0.246	-0.934	0.294
	(1.094)	(1.438)	(1.107)	(1.084)	(1.340)	(1.085)	(1.177)	(1.285)	(1.185)
Mean income per worker (log)	-0.240	0.212	-0.238	-0.460**	-0.400	-0.445**	-0.546**	-0.368	-0.537**
	(0.155)	(0.185)	(0.163)	(0.197)	(0.342)	(0.196)	(0.253)	(0.356)	(0.254)
Amenities (log)	-0.545*	1.169**	-0.570	-0.327	1.774***	-0.366	-0.241	1.742***	-0.274
	(0.303)	(0.434)	(0.330)	(0.583)	(0.592)	(0.605)	(0.658)	(0.611)	(0.684)
Constant	-18.46***	-27.70***	-18.16***	-17.23***	-24.30***	-17.01***	-16.75***	-24.48***	-16.49***
	(1.434)	(2.225)	(1.514)	(1.497)	(2.218)	(1.493)	(1.897)	(2.103)	(1.914)
N	45	45	45	45	45	45	45	45	45
R^2	0.942	0.952	0.936	0.922	0.856	0.918	0.903	0.866	0.898
Instrument	-			Share of unavailable land			Population density in 1990		
K. Paap F-stat (First stage)	-			23.61			26.04		

Notes: The dependent variable is the in-migrant concentration (the number of in-migrants in the Department relative to all in-migrants in Senegal divided by the number of stayers in the Department relative to all stayers in Senegal. Regressions use data from the 2013 Senegalese census, 2018 Harmonized Survey on Households Living Conditions (EHCVM), Global Human Settlement Layer (GHSL) for years 1990, and 2010. "Share of unavailable land" refers to the built-non water land area in each department, and "Population density in 1990" indicates the population per squared kilometer in each department in 1990. Observations are weighted by Department population. Standard errors in parentheses and are clustered at the region (GADM 1 level) level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.2: Area, sector and skill premium

	Dependent variable: Log yearly earnings							
	Earnings from all sources				Earnings from primary job			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age (in logs)	7.690***	7.209***	5.698***	5.836***	7.544***	7.051***	5.538***	5.684***
	(0.970)	(1.183)	(1.293)	(1.404)	(1.016)	(1.219)	(1.343)	(1.443)
Age × Age (in logs)	-0.987***	-0.937***	-0.712***	-0.744***	-0.968***	-0.916***	-0.691***	-0.724***
	(0.137)	(0.165)	(0.182)	(0.197)	(0.143)	(0.170)	(0.189)	(0.203)
Log total hours worked	0.040*	0.052**	0.089***	0.081***	0.042*	0.055**	0.091***	0.083***
	(0.024)	(0.022)	(0.023)	(0.022)	(0.025)	(0.023)	(0.023)	(0.022)
Female	-0.370***	-0.365***	-0.346***	-0.361***	-0.379***	-0.374***	-0.355***	-0.371***
	(0.049)	(0.047)	(0.051)	(0.052)	(0.052)	(0.049)	(0.054)	(0.055)
Rural	-0.275***			-0.177***	-0.290***			-0.192***
	(0.052)			(0.047)	(0.062)			(0.057)
Formal		0.881***		0.644***		0.886***		0.649***
		(0.064)		(0.072)		(0.065)		(0.068)
Low Skilled			-0.842***	-0.663***			-0.844***	-0.663***
			(0.069)	(0.072)			(0.067)	(0.069)
Constant	-1.085	-0.274	2.761	2.558	-0.829	-0.001	3.037	2.826
	(1.781)	(2.160)	(2.268)	(2.446)	(1.856)	(2.220)	(2.356)	(2.520)
Observations	4,359	4,359	4,359	4,359	4,350	4,350	4,350	4,350
Rsq-adj	0.27	0.33	0.35	0.39	0.27	0.33	0.35	0.39
Department FE	Y	Y	Y	Y	Y	Y	Y	

Notes: The dependent variable in this analysis is the log of labor earnings. The first four columns consider earnings from all sources (both primary and secondary jobs), while the last four columns focus solely on earnings from the primary job. The regressions utilize data from the individual module of the 2018 Harmonized Survey on Household Living Conditions (EHCVM). In the analysis, "Male" serves as the reference group for gender/sex, urban areas as the reference category for "milieu" of residence/work, "tertiary educated" as the reference group for education, and the "informal sector" as the reference group for the sector of work. Observations are weighted by person weight, with standard errors provided in parentheses and clustered at the department level. The estimation is limited to workers for whom the sector of employment (formal/informal) is clearly identified. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.3: The higher the level of emigration, the higher the remittances inflows

	Ordinary Least Squares				Instrumental variable			
	Dependent variable: Remittances concentration (log)							
Emigrant concentration (log) - All	1.106***				1.084***			
	(0.225)				(0.204)			
Emigrant concentration (log) - Domestic		0.767***				1.094***		
		(0.242)				(0.198)		
Emigrant concentration (log) - OECD			0.809***				1.374***	
			(0.192)				(0.455)	
Emigrant concentration (log) - ROW				0.912***				0.783***
				(0.207)				(0.256)
Proportion of urban population	0.353	1.264	0.126	-1.116	0.387	0.913	-1.240	-0.662
	(0.981)	(1.167)	(1.105)	(0.975)	(0.904)	(0.993)	(1.200)	(1.184)
Department size (log)	0.131	0.216	-0.111	0.0723	0.134	0.183	-0.393	0.104
	(0.269)	(0.312)	(0.326)	(0.174)	(0.249)	(0.286)	(0.334)	(0.178)
Mean distance to the coast (log)	-0.0619	-0.112	-0.0612	-0.206	-0.0689	0.0176	0.185	-0.236
	(0.261)	(0.339)	(0.338)	(0.237)	(0.248)	(0.289)	(0.372)	(0.227)
Constant	-0.939	-2.858	1.532	2.046	-1.038	-1.525	6.772	0.908
	(2.160)	(2.516)	(2.803)	(2.346)	(1.993)	(2.165)	(4.147)	(2.776)
Observations	45	45	45	45	45	45	45	45
Adjusted R^2	0.522	0.354	0.486	0.711	0.522	0.320	0.331	0.700
K. Paap F-stat (First stage)	-	-	-	-	22.42	13.17	268.22	607.72

Notes: The dependent variable is the log of remittances concentration index measured as the proportion of remittances received by a Senegalese department relative to the total amount of remittances inflows in the country in 2010. The main explanatory variable is the emigration concentration both for all destinations and by destination category (Domestic, OECD, Rest of the World). Because of the likely endogenous nature of intensity of emigration, emigration concentration has been instrumented using the gravity based strategy that has consisted in predicting bilateral migration stocks using only bilateral exogenous drivers of migration (geographic distance, contiguity, colonial link), origin characteristics (population density in 2000, distance to the coast), and the interaction between the geographical distance and destination categories. We control for destination fixed effects. This allows us to predict $\widehat{M_{ijs}}$. Following Angrist and Pischke (2009), we take the fitted value from the "zero stage" regression (gravity equation) in which M_{ijs} is regressed on a polynomial in $\widehat{M_{ijs}}$. The fitted values of bilateral stocks are then aggregated at origin department level by destination group to compute the predicted emigration concentration index. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.4: Mobility costs and productivity gains from migration in Senegal

	(1)	(2)	(3)
	Migration rate	Log wage at destination	Dyadic remittances per migrant
Log distance	-1.227***	0.252***	0.293**
	(0.131)	(0.059)	(0.124)
Sénegal river	1.810***	0.723***	0.067
	(0.552)	(0.123)	(0.591)
Coastal department		0.923***	
		(0.171)	
Log labor size		0.138***	
		(0.026)	
Log housing price		0.322	
		(0.213)	
Constant	2.829***	4.802***	5.744***
	(0.770)	(0.303)	(1.019)
Observations	3,555	3,555	2,626
Rsq-adj		0.72	
Origin-Destination category FE	Yes	Yes	Yes
Destination FE	Yes	No	Yes
Controls	No	Yes	No

Notes: The dependent variable in column (1) is the share of the working-age population born in the origin department i who migrated to destination j, which could be either another department within Sénegal or a foreign country. The dependent variable in column (2) is the log average wage in destination j. The amenity measure represents the structural residual associated with the choice of a specific destination j. "Coast" is a dummy variable which equals 1 if the origin location is open to the coast and destination is an OECD country and 0 otherwise. "$Sénegal\ river$" is a dummy that takes the value 1 if the department of origin is situated along the Senegal River and destination country is France and 0 otherwise. Detailed explanations about the role played by the Senegal River, as well as, coastal departments in the destination choice can be found in Bocquier et al. (2023). Columns (1) and (3) control for origin and destination-category pair fixed effects, while columns (2) consider origin fixed effects. Destination category fixed effects differentiate whether the chosen destination is internal, an OECD country, belongs to the rest of the world. Standard errors are clustered at the origin-destination category level in columns (1) and (3) and at destination level in column (2). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.5: Fréchet shape parameter

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS		IV		PPML		PPML-CFA	
ω_{ij} (logs)	1.865**	2.185***	2.075**	2.467***	1.691***	1.575***	3.586***	3.113***
	(0.767)	(0.770)	(0.640)	(0.629)	(0.194)	(0.283)	(0.327)	(0.238)
First stage residual							-6.211***	-4.967***
							(1.920)	(1.492)
Constant	1.375	1.890			-0.705	0.676	4.500***	5.107***
	(2.152)	(2.193)			(0.566)	(0.997)	(0.995)	(0.831)
Observations	3,320	3,320	3,320	3,320	3,555	3,555	3,555	3,555
R^2 adjusted	0.79	0.84	0.30	0.39				
Origin FE	Y	Y	Y	Y	Y	Y	Y	Y
Destination FE	Y	Y	Y	Y	Y	Y	Y	Y
Origin-Destination group FE	N	Y	N	Y	N	Y	N	Y
Bootstrap replications							1,000	1,000
K-Paap Fstat (First stage)			700.6	665.3			700.6	665.3

Notes: The dependent variable in columns 1 to 4 is the log of migration probabilities of the working-age population born in department of origin i and migrating to destination j, which could be either another department within Senegal or a foreign country. The dependent variable in columns 5 to 8 is the probability of migration in levels. The main explanatory variable ($\ln \omega_{ij}$) is the fitted value of the structural dyadic residual obtained from a first-stage regression in which migration probabilities are regressed on origin, destination, and origin-destination group fixed effects. Destination groups include domestic destinations, OECD destinations and foreign non-OECD destinations. The control variables include geographical distance, bilateral remittances and contiguity. Columns 7 and 8 also include the first stage residual as an additional control variable aimed at capturing the endogenous component of ω_{ij} in a nonlinear setting. Standard errors are clustered at the origin-destination group level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Remitting price elasticity to migration size

	(1)	(2)	(3)	(4)
	Dependent variable: Bilateral remitting cost (in logs)			
	Least Squares (OLS)		Instrumental variables (IV)	
Migration size (log)	-0.027***	-0.040***	-0.329**	-0.251***
	(0.009)	(0.011)	(0.136)	(0.082)
Foreign non OECD × Migration size		0.039**		0.162**
		(0.018)		(0.066)
OECD × Migration size		-0.031		0.076
		(0.030)		(0.105)
Observations	3,600	3,600	3,600	3,600
Adj. R-squared	0.84	0.84	0.38	0.56
Destination FE	Y	Y	Y	Y
Origin × destination group FE	Y	Y	Y	Y
K. Paap F stat (First stage)			13.28	14.27
Instrument			Migrants in destination j from origins other than i, i.e., $\neg i$ ($M_{\neg ij}$)	

Notes: The dependent variable in columns 1 to 4 is the log of bilateral remitting cost from destination j to home location i. The main explanatory variable is the bilateral migration size (M_{ij}). Destination groups include domestic destinations, OECD destinations and foreign non-OECD destinations. The control variables include geographical distance, average amount remitted per migrants and contiguity. Standard errors are clustered at the destination level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: Elasticity of housing prices to local economic density

	(1)	(2)	(3)	(4)
	Dependent variable: housing price (in logs)			
	Least Squares (OLS)	Instrumental Variables (IV)		
Economic density (log)	0.255***	0.242***	0.243***	0.306**
	(0.061)	(0.054)	(0.053)	(0.129)
Observations	45	45	45	45
R^2 adjusted	0.77	0.55	0.55	0.48
Region FE	Y	Y	Y	Y
Instrument		1990 pop. density × 1990 expected income	2013 pop. density × 2013 expected income	Mean distance to the Coast
K-Paap F (First stage)		43.83	41.10	6.75

Notes: The dependent variable is the aggregate regional demand per unit of land, captured as the labor force per unit of land multiplied by the average income per worker. To handle the endogeneity concern, I instrument the aggregate regional demand with three different instruments: (i) A Bartik-style expected income instrument based on national average income per capita in 1990 weighted by each department's share in the 1990 local population density. (ii) A similar approach but with 2013 expected income per worker. (iii) The population density in 1990. Standard errors are clustered at the origin-destination group level. Each specification includes the following control variables: log amenity level, log accessibility to cities, and mean travel time to main cities. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: Migration cost validation

	Overall		High skilled		Low skilled	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	0.0767***	0.0762***	0.0566***	0.0559***	0.0728***	0.0723***
	(0.00178)	(0.00178)	(0.00244)	(0.00244)	(0.00170)	(0.00170)
Contiguity	-0.00158	-0.00174	-0.0173***	-0.0167***	-0.00353	-0.00365
	(0.00445)	(0.00445)	(0.00611)	(0.00611)	(0.00424)	(0.00424)
Distance (log) × Capital region		0.171***		0.171***		0.162***
		(0.0210)		(0.0289)		(0.0200)
Distance (log) × ROW		-0.0818**		-0.0755		-0.0762**
		(0.0349)		(0.0479)		(0.0332)
Distance (log) × Neighbors		-0.00810		0.0258		-0.00655
		(0.0139)		(0.0190)		(0.0132)
Distance (log) × OECD		-0.0949		-0.0561		-0.0955
		(0.247)		(0.339)		(0.235)
Constant	0.368***	0.514***	0.472***	0.573**	0.394***	0.533***
	(0.0110)	(0.178)	(0.0151)	(0.245)	(0.0105)	(0.170)
Observations	10,527	10,527	10,527	10,527	10,527	10,527
R^2	0.534	0.537	0.631	0.632	0.541	0.545
Origin × Destination group FE	Y	Y	Y	Y	Y	Y
Destination FE	Y	Y	Y	Y	Y	Y

Notes: The dependent variable is the log of skill-specific bilateral migration cost between i and j.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Sensitivity analysis

	Parameter value			Relative productivity		Relative welfare	
	Benchmark	L. bound	U. bound	L. bound	U. bound	L. bound	U. bound
Benchmark				0.9591	0.9591	1.0654	1.0654
μ	2.30	1.50	3.00	0.9591	0.9591	1.0654	1.0654
σ	2.00	1.50	3.00	0.9643	0.9489	1.0650	1.0681
z	3.80	1.30	5.20	0.9644	0.9330	1.0643	1.0784
$1/\eta$	0.25	0.18	0.31	0.9591	0.9591	1.0641	1.0667
υ	0.10	0.05	0.15	0.9607	0.9574	1.0646	1.0662
δ	0.36	0.27	0.42	0.9592	0.9590	1.0655	1.0653
κ	0.10	0.05	0.15	0.9672	0.9511	1.0647	1.0667
λ	0.17	0.10	0.25	0.9591	0.9591	1.0654	1.0654
b	0.10	0.05	0.15	0.9616	0.9565	1.0647	1.0663
$\mu, \sigma, z, \eta, \upsilon, \delta, \kappa, \lambda$				0.9763	0.93097	1.0628	1.0899

Notes: The table displays the sensitivity of the estimated impact of net migration on per capita income and welfare in Senegal. It includes various combinations of parameter values, covering both upper (U.) and lower (L.) bounds. These ranges account for individual variations in parameter values as well as simultaneous variations across all parameters.

Chapter 4

Local exposure to development aid projects and migration decisions: *Evidence from Senegal*

Abstract

This paper investigates the impact of foreign aid targeting youth employment on migration decisions within Senegal over the period 2004 and 2013, using geographically disaggregated aid and migration data. By applying a gravity model of migration and leveraging political proximity to the ruling leader as a source of exogenous variations, I find that doubling employment aid per young adult (aged 18-35) reduces internal migration by approximately 15.3%. While foreign aid projects show no significant effect on overall international migration, they do reduce migration to transit countries by 14.3%, particularly among men aged 18-25. These findings emphasize the short- to medium-term deterrent effects of improved economic conditions on internal migration and migration to transit countries. Overall, the results underscore the potential of development aid to mitigate migration pressures in developing countries, especially when aid programs tangibly improve the living standards of targeted populations.

4.1 Introduction

Donors often assume that development aid can help reduce emigration by addressing its root causes in recipient countries. For example, during the African refugee crisis in 2015, the European Commission explored development assistance as a strategy to curb migration (European-Commission, 2015). Similarly, in 2021, in response to the influx of unaccompanied minors and families from Central America, the United States designed an aid policy aimed at deterring migration from the region (National-Security-Council, 2021). Substantial budgets have since been allocated to address these underlying factors in both Africa and Central America. However, the effectiveness of development aid in deterring emigration remains uncertain, given the complex relationship between economic conditions in recipient countries and migration decisions.

This paper aims to investigate whether development aid succeeds in deterring emigration from receiving locations as expected by many donors. Focusing on Senegal, it investigates the impact of local exposure to development aid projects on internal (region-to-region) and international (region-to-abroad) migration decisions. This is done by combining two rich data sources: (i) the 2013 General Population and Housing Census of Senegal, a uniquely detailed dataset that measures internal and international migration at a fine spatial level and (ii) AidData, which identifies the geo-locations of implemented aid projects, the amounts committed and disbursed, the timing of disbursements, the project titles, and the sectors involved.

Indeed, from a theoretical perspective, the relationship between development aid and emigration is unclear. According to the standard random utility framework, an individual's decision to migrate depends on the attractiveness of the destination relative to the origin, accounting for migration costs. In this context, a positive economic shock, such as an inflow of development aid, can have two opposite effects. Firstly, by improving the conditions at origin, it can reduce the attractiveness of the destination. This would increase the utility of staying and thus reducing the incentive to migrate. Secondly, aid can alleviate budget constraints that may have previously prevented the poor from migrating, ultimately leading to increased emigration. The net effect of development aid on emigration is therefore determined by the dominant mechanism at play. If the first mechanism (development channel) dominates, then more aid is expected to deter emigration, while the reverse is true if the second mechanism dominates (credit constraint channel). Determining the prevailing mechanism is an empirical question that can be strongly influenced by the way development aid is used. The theoretical ambiguity surrounding the relationship between development aid and emigration is mirrored in the empirical literature.

A first strand of literature, led by Berthélemy et al. (2009), argues that development aid inflows, whether bilateral or multilateral, foster emigration. Bilateral aid, for example, can provide information on the economic situation and labor market features of the donor country, which in turn can encourage emigration to that country. This mechanism is known as the information channel (Berthélemy et al., 2009). Alternatively, total aid flows can improve economic conditions in recipient areas, but this can also lead to more emigration by alleviating budget constraints and reducing the costs of migration (M. A. Clemens, 2014; Lucas, 2014; Menard and Gary, 2018; Gazeaud et al., 2023). Nevertheless, this literature relies on migrant stocks and cross-sectional data, and is limited by the fact that many migrants may have emigrated long before aid flows. Moreover, it fails to control for multilateral resistance to migration, proven to play a crucial role in estimating the migration response to any type of shock in a gravity setting (Bertoli and Moraga, 2013).

A second strand, building on Berthélemy et al. (2009), overcomes the shortcomings highlighted above. It shows that development aid flows deter emigration in recipient countries through an increase in income (Marchal et al., 2022), improved public services for the poor (Lanati and Thiele, 2018a), improved conditions in rural areas (Gamso and Yuldashev, 2018), and investment in "early impact" aid projects (Lanati and Thiele, 2018a) in the sense of M. A. Clemens et al. (2012).[87] This body of literature relies on aggregated country-level aid and migration data, which masks regional heterogeneity and the uneven distribution of aid projects. Furthermore, internal migration has been largely disregarded, despite being the dominant form of human mobility (UNDP, 2009) and a potential stepping stone toward international migration (Beine and Parsons, 2015; Marchiori et al., 2012; Otoiu et al., 2014). An exception is Lanati et al. (2023), who rely on detailed geo-located aid data and census data from Malawi documenting district-to-district migration to investigate the link between development aid and internal migration.

This paper overcomes the above mentioned limitations by combining local level exposure to aid projects by sector at fine spatial level and dyadic migration decisions that combine internal and international migration. My approach thereby captures the full structure of internal and international migration patterns. Indeed, census data documents internal and international migration at sub-national level (administrative unit level 2 also referred to as "*department*") and AidData, identifies the geo-locations of implemented projects, the amount committed and disbursed, the timing of the disbursement, the title of the project and the

[87] In M. A. Clemens et al. (2012), *early-impact* aid refers to aid that can reasonably be expected to affect growth within a few years, such as budget support or project aid for real sector investment. *Late-impact* aid includes flows whose growth effects might only appear decades later or not at all, such as aid for health, education, humanitarian relief, and technical cooperation.

sector. Combining these two datasets makes it possible to associate local migration decisions (experienced at the sub-national level) with local exposure to aid projects.

Despite the spatial granularity in the data (sub-national level), a problem nevertheless arises: the expected effect of all aid projects on migration (whether internal or international) is likely heterogeneous. Indeed, depending on the sector in which aid is invested, the short-term effect might differ from the long-term effect. Moreover, some projects may only have an effect in the long term, while others may already have an impact in the short term, particularly employment-related projects. As discussed by M. A. Clemens and Postel (2018), for the exposure to aid to affect migration incentives, it is essential that the sectors targeted are those that matter the most in the migration decision. The European Commission, in its Emergency Trust Fund for Africa (EUTF), identifies job creation, specifically for youth and women; provision of basic services; migration management; and governance as the key sectors. This paper examines how local employment-related projects affects the migration decisions of target groups, particularly youth age 18-35 (McKenzie, 2017). The choice of this group makes it possible to focus on projects that directly affect the living conditions of the exposed individuals and to identify more precisely the mechanisms through which the estimated effect operates.

The challenges in determining the causal effect of local exposure to employment projects on the migration of target groups are twofold. On the one hand, the decision to implement an employment project in a particular department is not random, but depends on the conditions to which migration responds as well, such as high unemployment. On the other hand, the dynamics of disbursements may respond to contemporaneous economic shocks that also affect migration. To address these challenges, I use an Instrumental Variable (IV) strategy that combines political proximity to the president in office at the time of the commitment (Dreher et al., 2019) and the synthetic disbursement profile (Kraay, 2012; Kraay, 2014) as a source of exogenous variation.

The contribution of this work is fourfold. First, evaluates the impact of local exposure to employment aid on the migration decisions of targeted groups in Senegal at a fine-spatial level. This allows for a precise identification of the mechanisms through which the resulting effect operates. Second, this paper examines internal and international migration jointly, allowing to empirically document the difference, if any, in the timing of the response of internal and international emigration to positive shocks. Third, this work contributes to the debate on aid effectiveness, particularly in exposed areas and among the targeted groups. This is novel given the highly aggregated nature of previous literature which typically assessed at the macro level. Fourth, while literature generally focuses on either regular or irregular flows of international emigrants, I can differentiate between final destinations and likely transit countries, which, to some extent account for illegal migration. In this way, I can examine whether exposure to employment projects reduces demand for these transit countries, which, in the Senegalese context tend to be the first step toward the Italian and Spanish coasts.

Using a standard gravity model with a rich set of fixed effects, and exploiting political proximity to the incumbent leader as a source of exogenous variation, I find that: (i) Exposure to employment-related aid projects reduces internal migration of young adults by about 15.3%. Moreover, the deterrent effect is slightly stronger for women (16.5%) than for men (15.0%). Furthermore, the more educated the young adult, the stronger the effect. (ii) Local exposure to employment-related aid projects does not affect international migration overall. Nevertheless, it reduces migration to transit countries by about 14.3%. This disincentive effect is driven by the men aged 18-25. (iii) Local exposure to employment aid reduces international emigration of young migrating for job-seeking motives. Doubling employment aid per young adult reduces migration to high-income countries, transit countries and the rest of the world by about 8.1%, 15.6% and 5.7% respectively. This strongly indicates that by improving the job prospects of young adults, exposure to aid projects targeted at employment reduces the attractiveness of both internal destinations and transit countries. The development channel seems therefore dominant for internal destinations and transit countries.

The remainder of the paper is organized as follows: Section 4.2 describes the data and the employment project framework. Section 4.3 describes the methodology and identification strategy. Section 4.4 presents and discusses the benchmark results on the impact of exposure to employment aid on internal and international migration and how heterogeneous this effect is along the age, gender, and education dimensions. Section 4.5 concludes.

4.2 Data

4.2.1 Migration

I use the 2013 Senegalese population census to derive my measure of migration flows. The census includes questions on the current and past location of residence for more than 13 million people. By comparing current and past location of residence, I can accurately measure the flow of internal migrants over two periods: 2004-2008 and 2009-2013. The census also includes questions on household members who have left the country in the last five years. This allows me to generate consistent flow data by place of residence at departure and current country of residence. In the empirical exercise, I will focus on individuals aged 18 and over.

4.2.1.1 Internal migration

In the census, individuals were asked where they lived 1, 5 and 10 years ago. By aggregating individual observations to the level of Senegal's 45 departments, I compute 2 waves of migration flows between departments. The Senegalese census is unique in that it allows multiple waves of migration data to be computed from a single census round, as it asks about previous residence at different points in time. Combining different census waves often raises issues related to changing administrative boundaries, especially when interested in relatively disaggregated spatial units. If not properly accounted for, this can lead to serious measurement errors and artificially high migration rates compared to real rates. In my setup, all locations were coded at one point in time. This ensures consistency and prevents artificial variation due to measurement error in my panel setup. The choice of department (ADMIN 2 level) as the observation unit in this paper is guided by the consistency of administrative boundaries over the period considered which does not hold for more disaggregated geographical units (ADMIN 3 or 4). Also, there is high risk of large commuting flows across lower geography. Indeed, commuting flows between departments are limited, with the exception of the Dakar region characterized by smaller departments in size, and better infrastructures (Bocquier et al., 2023).

I construct a retrospective panel of two repeated 5-year migration flows between departments: First, I count the number of individuals residing in department j in 2013 who were located in department i 5 years earlier (i.e. in 2009). Second, I count the number of individuals who were residing in department j in 2009 (5 years earlier) and were residing in department i in 2004 (10 years ago). The periodic department-to-department bilateral migration flows are computed as:

$$M_{ijT} = \sum_{\lambda=1}^{\Lambda} D_{\lambda jT} \left[department_{T-5} = i\right] \quad \forall \; i \neq j, \tag{4.1}$$

Where D is a dummy variable that takes the value 1 if the individual λ currently residing in department j moved from department i during the last time window T and $T-5$ for $T = 2013$ and $T = 2009$.

By aggregating the dyadic migration flows between departments by origin and dividing them by the number of natives in the age group of interest at the beginning of the period, Figure 4.2.1 describes the intensity of internal migration by department for the first wave in panel 4.2.1a and the second wave in panel 4.2.1b. There is considerable heterogeneity in internal migration across Senegalese departments (see Annex A.1). The most affected departments are in the regions of Diourbel, Fatick, Ziguinchor and Kedougou. These regions

Figure 4.2.1: Spatial distribution of internal migrants by origin department

(**a**) 2004-2008 (**b**) 2009-2013

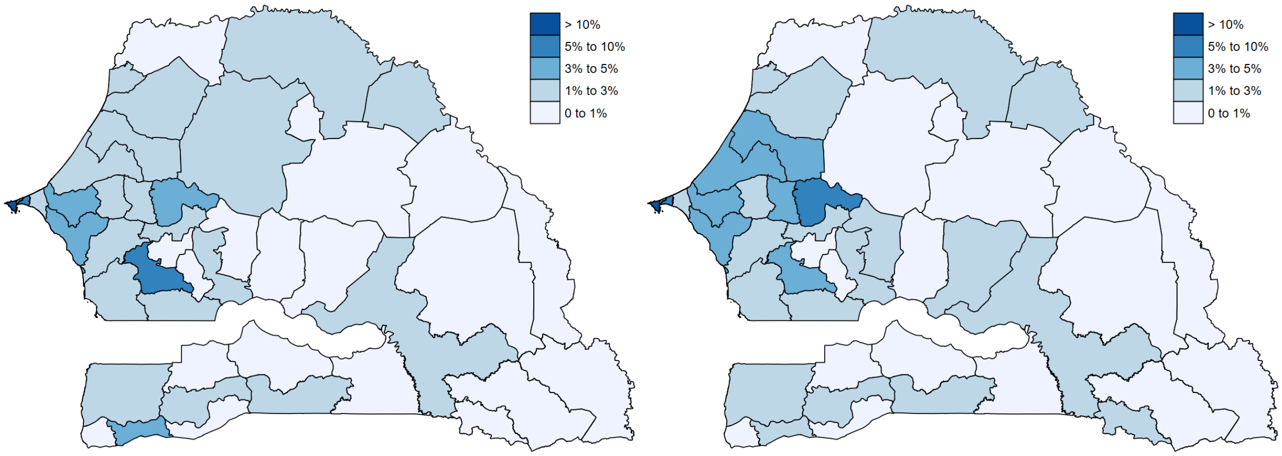


Table 4.2.1: Internal migration rates by age group and education level in Senegal

	Wave 1 (2004-2008)					Wave 2 (2009-2013)				
	All	NFE	LS	MS	HS	All	NFE	LS	MS	HS
Flows										
All (0+)	263,631	140,952	85,677	18,686	18,316	456,830	290,219	123,773	22,699	20,139
18+	214,150	109,508	68,749	17,729	18,164	304,757	180,115	84,262	20,555	19,825
Age group	Emigration rate (2004-2008)					Emigration rate (2009-2013)				
18+	4.9%	3.6%	6.6%	10.3%	15.1%	6.9%	5.9%	8.1%	11.9%	16.4%
18-25	6.2%	4.8%	7.6%	11.3%	18.6%	8.9%	7.5%	9.9%	16.2%	23.5%
26-35	5.7%	4.0%	6.9%	12.3%	18.3%	7.5%	6.3%	8.1%	12.3%	18.6%
36-45	4.3%	3.1%	5.7%	9.5%	12.8%	6.0%	5.3%	6.6%	9.6%	13.3%
46-55	3.4%	2.6%	4.9%	7.3%	9.7%	5.2%	4.7%	6.0%	8.4%	9.7%
56-65	2.7%	2.2%	4.4%	5.5%	6.3%	4.4%	4.2%	4.8%	6.2%	6.6%
66+	1.9%	1.9%	2.5%	2.7%	3.4%	3.8%	3.8%	3.5%	3.6%	3.9%

Note: Table 4.2.1 shows internal flows of migrants aged 0+ and 18+ at departure. It is then restricted to internal migrants aged 18+ at departure. HS = tertiary education, MS = upper secondary education, LS = lower secondary or primary education, NFE are migrants with no formal education.

are followed by Dakar, Thies, Louga and partly Saint-Louis. The departments in the centre of Senegal are relatively unaffected by internal migration, with an emigration rate below 3%. Regarding the characteristics of migrants, Table 4.2.1 shows a negative selection along the age dimension and a positive selection along the education dimension. The more educated working-age Senegalese are, the more likely they are to move within the country. Conversely, the older working-age Senegalese are, the less likely they are to move internally. Internal migration is dominated by young adults in the 18-25 and 26-35 age groups. Spatial patterns remain fairly consistent between the two waves, with a clear tendency towards higher migration rates in the more urbanised departments around Dakar, Touba and Ziguinchor.

The number of observations for the two waves varies considerably. This is mainly due to demographic forces: We can only assign individuals to former places of residence if they were already of working age at the time of observation. 7.2 million Senegalese were younger than 15 in 2009 (5 years before the 2013 census), while 6.2 million were not yet in the labour force in 2004 (10 years before the 2013 census) and therefore dropped out of the sample to calculate migration flows between 2009-2013 and 2004-2008, respectively. Furthermore, I only observe individuals who are physically present in Senegal in 2013, thus missing those who have died. Note also that households in which all members have migrated internationally are not captured. These measurement issues are mitigated in the empirical analysis by (i) using rates as the dependent variable, thus eliminating measurement inaccuracies that arise in both the numerator and denominator, and (ii) a wave fixed effect that accounts for any structural differences between the two waves.

4.2.1.2 International migration

In the 2013 census, Household heads were also asked whether any of the household members had migrated abroad in the last 5 years. If so, when they left, where they went and what their main motive was. Migration motives include job search, studies, family or marriage, and a residual category "Other". Starting in 2013 and going back to 2008, this set of information makes it possible to construct retrospectively an annual panel of the department-to-abroad matrix of bilateral migration flows. This is done by aggregating flows between origin department and destination country. Yearly bilateral flows are calculated as follows:

$$M_{ikt} = \sum_{\lambda=1}^{\Lambda} \mathbb{1}_{\lambda kt} \tag{4.2}$$

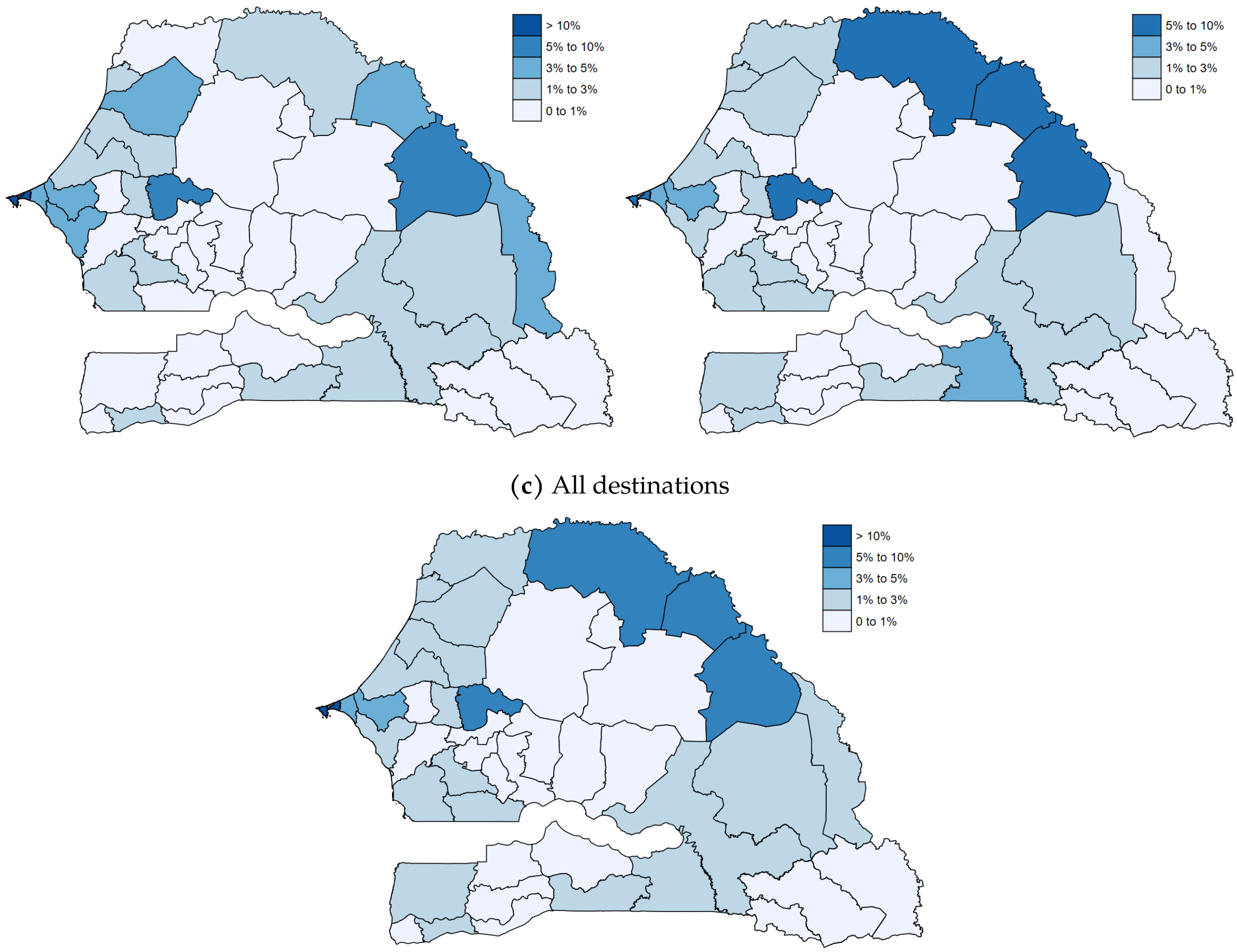
Where $\mathbb{1}$ is an indicator variable that takes the value 1 for each individual λ identified by the household head as having migrated from the source department i to the destination country k during the year $t = 2008, ..., 2013$. The ideal situation would be to explicitly consider all destination countries reported in the census. However, there are many destinations with very few migrants. Of the 174 destinations reported in the Census, 83 have fewer than 10 migrants in the period 2008-2013, while 124 have fewer than 100 migrants in the same period. As these destinations may bias the estimates, in particular due to the number of corridors involved, all those with less than 600 migrants over the entire period were combined into a residual destination called "Rest of the world".[88] This category accounts for 5.6% of the total international migration flows reported in the Census.

The spatial distribution of international emigrants varies substantially across Sene-

[88] In other words, I focus on destinations in which at least 100 migrated on average to each year.

Figure 4.2.2: Spatial distribution of international migration by origin department

(**a**) To the OECD (**b**) To non-OECD



(**c**) All destinations

galese departments, as depicted on Figure 4.2.2. Dakar plays a crucial role as the main source of international migrants. The next largest regions of origin include Thiès, Saint-Louis, Ziguinchor, Diourbel, Kaolack and Fatick. Departments along the Senegal River also account for a significant proportion of emigration, including Matam, Kanel and Podor. This higher propensity to move abroad is mainly explained by the better accessibility of Dakar and neighbouring regions. As for the departments situated along the Senegal River, the high emigration pressure is maintained by the persistence of ancient migratory routes used by Senegalese sailors, traders and soldiers in the early 20^{th} century (see Bocquier et al. (2023) for more details).

As shown in the top panel of Table 4.2.2, about 3.2% of the Senegalese aged 18 and more emigrated abroad between 2008 and 2013. There is a strong positive selection along

Table 4.2.2: International emigration by age and education

	All	NFE	LS	MS	HS
Flows (2008-2013)					
All (0+)	156,470	71,305	52,595	15,857	16,713
18+	143,176	65,073	46,651	14,945	16,507
Age at departure	international emigration rate				
18+	3.2%	2.1%	4.3%	8.0%	12.0%
18-25	3.4%	2.0%	3.7%	11.5%	19.7%
26-35	4.7%	3.3%	5.7%	9.2%	13.5%
36-45	3.0%	2.2%	4.5%	5.6%	7.4%
46-55	1.8%	1.4%	2.6%	3.1%	4.2%
56-65	1.1%	0.9%	2.4%	2.3%	3.7%
66+	0.5%	0.3%	1.6%	1.9%	3.6%
Destinations	Relative importance of destination groups				
Africa	38.3%	51.1%	36.4%	18.7%	10.6%
EU and Non EU OECD	47.6%	39.1%	48.7%	60.8%	65.9%
Transit countries	5.9%	3.9%	6.8%	8.5%	8.6%
Rest of the World	8.3%	5.9%	8.1%	11.9%	14.9%
Motives	Relative importance of migration motives				
Job seeking	77.6%	88.5%	82.8%	59.4%	36.0%
Study	10.2%	0.8%	3.2%	25.5%	53.5%
Family or marriage	8.7%	7.7%	9.5%	11.4%	7.8%
Others	3.5%	3.0%	4.4%	3.8%	2.7%

Note: This table shows international migration flows from Senegal between 2008 and 2013. It is then restricted to those aged 18 and over at the time of departure. HS = tertiary educated, MS = upper secondary educated, LS = lower secondary or primary educated, NFE are migrants with no formal education. European countries refers to countries in Europe and non-EU OECD refers to OECD countries other than those in the European Union. Rest of the world refers to destination countries that do not belong to any of the groups defined above.

the education dimension, as the probability of moving abroad rises sharply with education level. 12.0% of university graduates emigrated abroad between 2008 and 2013, compared with 4.3% of Senegalese with only lower secondary or primary education, and to 2.1% with no formal education.[89] This dimension of positive selection is even stronger when focusing only on individuals aged 18-25 at the time of departure, as the university graduates are six times more likely to emigrate than their counterparts with no formal education. This pattern is similar to that documented in Table 4.2.1 for internal migration. Moreover, this positive

[89] Senegalese aged 18 and more with no formal education are almost four times less likely to emigrate than university graduates.

selection holds regardless of the age group considered.

Furthermore, as shown in the middle panel of Table 4.2.2, international out-migration from Senegal is particularly directed towards Europe. Emigration to Europe is concentrated among major destinations such as Italy, France and Spain. They represent about 44.0% of the international emigration documented in the 2013 census. This suggests that Europe remains the main destination, even overtaking African destinations (combining neighbouring and non-neighbouring countries). OECD countries account for about 47.6% of Senegalese out-migration flows.

More interestingly, as shown in the bottom panel of Table 4.2.2, around three out of four Senegalese aged 18 and over who emigrate abroad do so for job-seeking reasons, around one fifth for study reasons, 8.7% for family and marriage reasons and 3.5% for other reasons. In conclusion, Senegalese out-migration in the period 2008-2013 is characterised by positive selection along the education dimension, negative selection along the age dimension, and emigration is mainly to Europe and dominated by people moving for job search.

4.2.2 Development aid

The lack of converging results in the aid-migration literature, could be, to some extent, due to the scarcity/lack of reliable data on the areas where aid-funded projects are implemented. Indeed, the usual approach in the literature has been to use aggregate aid data at the country level to assess whether global migration responds to it (Berthélemy et al., 2009; Gamso and Yuldashev, 2018; Lanati and Thiele, 2018a; Lanati and Thiele, 2018b; Marchal et al., 2022) . This approach raises concerns because aid projects tend to target only part of the population. More interestingly, the total envelope of aid received by a country does not reach all individuals in the same way. Indeed, individuals can be expected to react differently to project-related aid than to technical assistance. Moreover, whether project-related aid is invested in building bridges, roads, schools or directly funding employment programs will create very different incentives for people (M. A. Clemens et al., 2012; M. A. Clemens and Postel, 2018). Documenting aid projects at a detailed geographical level is therefore clearly an advantage. This section discusses the novel geo-referenced data on aid projects within Senegal, which I merge with data from the 2013 Senegalese census,[90] allowing both internal and international migration flows to be mapped with high resolution spatial detail. The datasets are summarised in tables 4.2.3 and 4.2.4 and described in detail in the appendices.

The aid data used for the analysis is based on the quasi-universe of projects reported

[90] See the description of migration data in Sections 4.2.1.1 and 4.2.1.2.

by the Senegalese Aid Management Platform (AMP) for the period 2002-2017. AMP reports funded projects by donor(s), targeted sector, amounts committed and disbursed, start and end dates of each project, among other information. Using this information, I construct the amount of aid per capita equivalent received by each individual in each Senegalese department over two time windows (before 2009 and 2009-2013).[91] This information is then broken down by sector.

The final dataset includes 1,582 projects representing $18.9 billion in commitments and $7.4 billion in disbursements. Of the 1,582 projects, 406 could be geo-referenced by AidData, representing $7.3 billion in commitments and $3.4 billion in disbursements. The geo-referenced projects cover 1,124 locations with seven levels of accuracy.[92]

I first exclude poorly geo-referenced projects (82 locations) as well as projects that started after 2012 (9 locations).[93] Of the remaining 1,033 locations covered, 37.7% have an exact geo-referenced location, while 62.3% provide only the coordinates of the centroid of regions. Based on the titles of the projects, about 2.6% (mainly infrastructure) of the latter are manually assigned to specific departments, while the rest are distributed among the departments of the associated regions using a methodology that I detail in section 4.3. As reported in Table 4.2.3, accurately located includes precision levels 1, 2 and 3; located at ADM1 defines level 4, while imprecisely located includes levels 5, 6 and 7.

Table 4.2.3: Summary of geo-coded aid projects in Senegal

	Amount in $US Million			Relative size	
	Committed	Disbursed	Share disbursed	Committed	Disbursed
Total	7,203	3,223	44.7%		
Exactly located	3,785	1,385	36.6%	52.6%	43.0%
Located at ADM1	2,062	1,160	56.3%	28.6%	36.0%
Imprecisely located	1,355	678	50.0%	18.8%	21.0%
Aid kept	5,847	2,545	43.5%	81.2%	79.0%

Note: This table presents the distribution of geo-coded aid projects in Senegal during the period covered by this analysis. It breaks down the universe of geo-coded projects by the precision level of geo-coding. The table reports the total amount initially committed by the donor(s), the amount disbursed, and the proportion of disbursement relative to the total commitment. For each geo-coding precision level, it also provides the relative size of both the committed and disbursed amounts.

[91] I exclude projects that started after 2013 because they should not affect past migration decisions.

[92] Level 1 refers to projects whose exact locations are known, Level 2 refers to projects whose exact locations are within 25 kilometres of the reported coordinates, Level 3 refers to projects whose reported coordinates are the centroids of a department (GADM Admin 2); Level 4 refers to projects whose reported coordinates are the centroids of a region (GADM Admin 1); Level 5 refers to projects whose reported coordinates are more than 25 km from the exact location, Level 6 refers to projects whose coordinates represent only the entire country, and Level 7 refers to projects whose reported coordinates are the headquarters of an administrative division.

[93] Precision levels 5, 6 and 7.

Table 4.2.4: Decomposition of geo-localized aid by sector

	Amount in $US Million					
	Exactly located		Geo-localized at ADM1		Total	
	Prior 2008	2008-2013	Prior 2008	2008-2013	Prior 2008	2008-2013
All sectors	314.1	1,070.9	281.3	878.9	595.4	1,949.8
Education	0.7	6.4	7.8	101.6	8.5	107.9
Employment	5.0	39.6	8.0	38.4	13.0	78.0
Health	44.3	119.4	82.7	164.3	127.0	283.7
Infrastructure	222.9	765.5	92.1	252.9	315.1	1,018.5
Agriculture	0.9	10.8	50.6	95.3	51.5	106.1
Other	40.2	129.3	40.1	226.3	80.3	355.6
	Relative size of each sector					
Education	0.2%	0.6%	2.8%	11.6%	1.4%	5.5%
Employment	1.6%	3.7%	2.8%	4.4%	2.2%	4.0%
Health	14.1%	11.2%	29.4%	18.7%	21.3%	14.5%
Infrastructure	71.0%	71.5%	32.8%	28.8%	52.9%	52.2%
Agriculture	0.3%	1.0%	18.0%	10.8%	8.7%	5.4%
Other	12.8%	12.1%	14.3%	25.8%	13.5%	18.2%

Note: This table presents the distribution of disbursements for geo-coded aid projects implemented in Senegal, broken down by time windows and sectors. It also reports the relative size of each sector within each time window. It differentiates between exactly geo-located projects and those whose exact geo-location is unknown, but the administrative unit 1 level of implementation is known.

Focusing on geo-referenced projects, and using the start and end dates of each project, I divide them into two time windows: before 2008 and between 2008 and 2013. I further brake down aid projects by sector, including education, employment, health, infrastructure, agriculture and a residual group called 'other'. As reported in Table 4.2.4, about 52% of the total amount disbursed is for infrastructure-related projects, about 20% for health projects and 18% for health-related projects.

4.3 Econometric specification

To assess the impact for implementing foreign aid projects on the local migration decisions, the empirical specification relies on a structural gravity model derived from the Random Utility Maximisation framework that has become standard in the migration literature to identify the key determinants of bilateral migration (Beine et al., 2011; Grogger and Hanson, 2011; Ortega and Peri, 2013; Beine and Parsons, 2015). This framework considers that migration flows between two locations: origin, i, and destination j depend on the relative attractiveness of j over i net of the mobility cost between the two locations. The implied standard empirical specification to be tested is given as the ratio between the probability to move away from home and that of choosing to stay in the home location given by :

$$\frac{M_{ijt}}{M_{iit}} = \exp\left(\alpha_{ij} + \alpha_{jt} + Z'_{it}\beta + Y'_{ijt}\gamma\right)\mu_{ijt},$$

where M_{ijt} is the migration flows from origin location i to destination location j measured at time t. M_{iit} is the number of individuals from i who decide not the move away from home at t, that I will refer to in the remaining of the paper as *stayers*. The α_{ij}, and α_{jt} are the origin-destination pair, and destination-time fixed effects. They control for all the unobserved dyadic factors as well as pull factors likely to affect the migration flows between the two locations in t. Y'_{ijt} is the set of dyadic-time varying controls, and Z_{it} is the set origin-time controls. Since the variable of interest here is the amount of foreign aid disbursed per young adult, the vector Z_{it} can be split between aid per young adult and the other origin-specific time-varying factors. μ_{ijt} is the error term. The benchmark specification becomes:

$$\frac{M_{ijt}}{M_{iit}} = \exp\left(\alpha_{ij} + \alpha_{jt} + \delta \ln Aidpc_{it} + Z'_{it}\beta + Y'_{ijt}\gamma\right)\mu_{ijt}, \tag{4.3}$$

Equation (4.3) provides the general specification that is adapted first to internal migration and then to international migration.

4.3.1 Internal migration

I first regress department-to-department migration flows on local development aid disbursed per young adult during the period under consideration. Using panel observations of bilateral flows. As discussed in section 4.2, internal migration flows are retrospectively built over the period 2003-2013 with 5 years interval. In other words, when equation 4.3 applies to internal migration, M_{ijt} is the number of young adults who moved from department i to department j between t and $t-5$, where $t = \{2008, 2013\}$. M_{iit} is the number of non-migrants (stayers) in department i; this is the number of persons whose department of residence did not change between t and $t-5$. $Aidpc_{it}$ is the per capita aid disbursed in department i between t and $t-5$. The vector X'_{it} comprises the set of origin-time controls including nighttime light intensity (a proxy for development or economic activity), number of deaths from conflict (a proxy for instability or safety), climate shocks measured by negative deviation is SPEI (a proxy for economic and social vulnerability). Z'_{ijt} includes the network, i.e. the number of people born in i living in j at the beginning of the period. $\alpha_{i,j}$ is an origin-destination pair fixed effect that captures all time-invariant factors affecting bilateral migration flows. $\alpha_{j,t}$ captures any pull factors of potential destinations, such as economic opportunities, climatic shocks or aid payments.

4.3.2 International migration

I then regress bilateral migration flows from Senegalese department i to foreign countries k on local development aid paid per capita during the period under consideration. As discussed in Section 4.2, international migration flows are retrospectively built as internal migration flows, but on a yearly basis over the period 2008-2013. However, the data structure does not allow to control for Z'_{ijt} factors because there is no network for any department-abroad destination. Thus, the canonical specification in equation 4.3 is slightly modified to have:

$$\frac{M_{ikt}}{M_{iit}} = \exp\left(\nu_{ik} + \nu_{kt} + \delta \ln Aidpc_{it-1} + Y'_{it-1}\lambda\right)\varphi_{ikt}, \tag{4.4}$$

where M_{ikt} is the yearly number of individuals that moved from department i to destination country k, in year $t = \{2008, 2009, 2010, 2011, 2012, 2013\}$. M_{iit} is the number of stayers in department i. $Aidpc_{it-1}$ is the lagged value of aid disbursed per capita in department i. The vector Y'_{it-1} contains the set of origin specific-time varying controls (nighttime light intensity, climate shocks, conflicts). ν_{ik} is an origin-destination pair fixed effect capturing all time-invariant factors affecting bilateral migration flows. ν_{kt} captures all pull factors of potential destinations, such as economic opportunity, climatic shocks and immigration policy. φ_{ikt} is the error term.

4.3.3 Endogeneity of foreign aid and identification strategy

Despite the rich structure of the fixed effects used in equations 4.3 and 4.4, there are still origin-time unobserved factors that can affect both migration and development aid and consequently bias the estimated effect. There are two main threats to identification.

First, the allocation of aid projects across departments is likely not to be random. An obvious concern is that local development aid and migration propensities may be jointly determined by unobserved socioeconomic conditions. It is plausible that aid projects are committed into departments where people are the most in need. If migration serves as a way to escape economic hardships (adaptation strategy), departments with higher migration rates can be expected to receive a higher share of development aid projects. While these concerns are to some extend alleviated by origin-time controls, I cannot rule out the potential bias occurring from additional origin - time unobserved factors that might jointly affect migration and aid. Hence, I draw on the literature on the political economy of aid allocation and apply an instrumental variable strategy to further alleviate these concerns. Masaki (2018); De Mesquita and Smith (2009); Francken et al. (2012), show that the geographical allocation of foreign aid funded projects in recipient countries responds to the political proximity with the incumbent leader. In the case of Tanzania, Masaki (2018) argues that foreign aid is mainly implemented in areas where opposition to the ruling party is strong. Francken et al. (2012) in the case of Madagascar show that aid projects are mainly directed to areas with stronger political support for the government. Although the early case points to *clientelism*,[94] the latter case points out the idea of *favoritism*.[95] Whether clientilism or favoritism is active in Senegal, the vote shares in favor of the ruling leader countrywide at the time of the commitment are likely to be a good predictor of actual spatial allocation of aid projects. Building on this, I use vote shares in favor of the leader in office at the moment of commitment, combined with behaviour changes in aid-allocation between pre- and post-election years, as an instrument for the actual geographical location of aid projects. The identifying assumption is that while aid location is likely to be explained by political support/proximity to the ruling leader, it should be orthogonal to migration decision within Senegal (see Appendix 4.3.1).

Second, there is another dimension of endogeneity arising from the timing of the disbursement. There is often a delay between commitments and disbursements as aid financed projects take many years to be implemented. As described by Kraay (2012), disbursements are associated to different stages in the project's implementation, leading to the spreading of the original amount committed over several years instead of the full disbursement at the year of the commitment. This suggests that the disbursement schedule might be affected by contemporaneous economic shocks that either delay or speed it up. As contemporaneous economic shocks affect migration, this makes the disbursement endogenous. To cope with this dimension of endogeneity, I construct a synthetic disbursement profile. In line with Kraay (2012); Kraay (2014), for each project, I discard all the disbursements that occur the year of the commitment as this may be a response to a contemporaneous economic or political shocks that is also endogenous to migration. I exploit these disbursement lags together with the disbursement profile over the life-cycle of aid funded projects to built a measure of yearly disbursements. The lagged disbursements will be a valid instrument for actual disbursements if and only if (i) the decision to commit by the donor does not anticipate future economic or political shocks and (ii) lagged disbursements also do not respond to contemporaneous economic shocks. While (i) is likely to be plausible, the decision to disburse a fraction of the committed amount may respond to contemporaneous shocks leading to acceleration or deceleration in disbursements. A conflict for instance might delay and/or disrupt the planned disbursements while a huge drought episode or floods might instead accelerate the planned disbursement. Either of these alternatives will lead to a correlation between lagged disbursements and contemporaneous economic or political shocks and consequently

[94] Political elites use aid to obtain the electoral support in less favorable areas.
[95] Aid being used by political elites to compensate for the electoral support of areas.

migration decisions.

To handle the endogeneity concern remaining in the lagged disbursement, I assign a typical disbursement profile by computing a simple average of yearly disbursements by department for all the projects implemented in the same economic sector. In line with Kraay (2014), this average disbursement profile only reflects the combination of department-sector aid implementation decision from previous years based on averages taken across several projects in each economic sector. The identifying assumption here is that these average disbursements do not anticipate future shocks on migration. If this assumption holds, then changes in average disbursements will be uncorrelated with the error terms of equations 4.3 and 4.4. I then apply this typical disbursement profile (shares) to the committed amount predicted using political proximity with the ruling leader in office at the time of commitment (shift). I can therefore use variations in the synthetic disbursement profile as an instrument for the changes in the actual disbursements when estimating the migration response to exposure to foreign aid funded projects. In summary, my instrumental variable is built in three steps as follow:

Step 1- Spatial allocation of aid. I predict the amount of aid project to be allocated in a given department, in a given economic sector using the vote shares in favor of the leader in office at the time of commitment using the following equation:

$$\begin{aligned} \ln C_{its} =& \mu_i + \mu_t + \mu_s + \delta \sum_{\tau=1}^{t-1} \ln C_{is,\tau} + \lambda_1 \ln VS_{it} \\ &+ \sum_{k=1,2} \lambda_2^k \ln VS_{it} \times D_t^k + \sum_{x=2,3} \lambda_3^x Donor_{i,s}^x \\ &+ \sum_{x=2,3} \lambda_4^x VS_{it} \times Donor_{is}^x + X_{it}^{'}\beta + \epsilon_{ist}, \end{aligned} \tag{4.5}$$

where C_{its} is the amount committed in department i at time t in sector s. VS_{it} is vote shares in favor of the leader in the office at the commitment date, D_t^k is a dummy variable for pre- and post election year. $Donor_{is}^x$ denotes the donor type (bilateral, multilateral or with Senegalese government participation), and ϵ_{ist} refers to the error term. $X_{it}^{'}$ denotes the vector of department specific time-varying controls and includes population density, average precipitation, nighttime lights intensity, normalized difference vegetation index (NDVI) that captures local characteristics likely to influence the decision to allocate development aid.[96] The predicted amount per department-sector $\widehat{C}_{is} \equiv \sum_t \widehat{C}_{is}$ is derived from the estimation of equation 4.5.

Table 4.3.1: Political proximity and spatial allocation of foreign aid

	Amount committed (logs)					
	(1)	(2)	(3)	(4)	(5)	(6)
Vote shares (log)	2.272***	2.652***	2.883***	2.334***	3.234**	2.963**
	(0.745)	(0.705)	(0.769)	(0.784)	(1.259)	(1.310)
Vote shares (log)× pre-election			-0.800			-0.347
			(0.636)			(0.703)
Vote shares (log)× post-elect				1.282*		1.151
				(0.661)		(0.733)
Vote shares (log)×multilateral					-0.085	-0.084
					(1.764)	(1.760)
Vote shares (log)×Senegal					-2.016	-2.006
					(1.907)	(1.915)
Observations	4,984	4,485	4,827	4,827	4,827	4,827
Department FE	Y	Y	Y	Y	Y	Y
Economic sector FE	Y	Y	Y	Y	Y	Y
year FE	Y	Y	Y	Y	Y	Y
Department-year controls	N	Y	Y	Y	Y	Y
Donor FE	Y	Y	Y	Y	Y	Y

Notes: This table report OLS estimates with standard errors robust to heteroskedasticity and clustered at department level. Column (1) includes no controls. Columns (2)-(6) controls for cumulative amount committed in a department up to the previous year, the proportion of population in the department who belong to the ethnic group of the ruling leader, the local population density, the yearly average precipitation, the yearly normalized vegetation index (NDVI) and the yearly average nighttime light intensity. ***, **, and * denote significance at the 1% $p < 0.01$, 5% $p < 0.1$ and 10% level respectively.

Table 4.3.1 presents estimates of the effect of political proximity, as proxied by vote shares, with the ruling leader in office at the time of the commitment, on the decision to allocate aid across departments in Senegal. Regardless of the specification, the results indicate a strong positive relationship between vote shares and the amount of aid allocated. Specifically, a 1% increase in the vote share for the ruling leader within a department leads to a 2.2% to 3.2% increase in the amount of aid allocated to that department. These findings strongly suggest the presence of *favoritism*. However, although not statistically significant, the pre-

[96] Results reported in appendix 4.3.1 confirm that the vote shares in favor of the incumbent leader at the time of commitment within a department significantly increase the likelihood that more aid will be allocated to that department. Interestingly, this pattern of favoritism appears to fluctuate slightly around presidential election years. Although not statistically significant, the findings suggest that, before election years, leaders tend to allocate more aid to departments where they have lower electoral support, whereas after elections, aid allocation tends to favor departments with higher electoral backing.

and post-election year dummies interacted with vote shares suggest that ruling leaders may strategically use aid to secure votes. The interaction between the pre-election dummy is negative, while the post-election interaction with vote shares is positive, implying that before elections, leaders tend to use aid to buy support in departments originally hostile to them, whereas after the elections, aid serves as a reward for departments that supported the leader. I acknowledge, however, that government support is not exclusively channeled through foreign aid; other funding sources may also be directed to departments. This concern is partially addressed in the analysis, as aid projects in which the government participates financially are included in the dataset. Additionally, even if some of these projects are not observed, the fact that pre- and post-election periods seem to influence aid allocation in opposite directions provides reassurance about the robustness of our instrument.

Step 2- Synthetic disbursement shares. I discard all the disbursements that take place the year of the commitment and keep only lagged disbursements, $D_{pis,t-1}$. I compute a simple average of all $D_{pis,t-1}$, by economic sector $(1/P \times \sum_{p=1}^{P} D_{pis,t-1})$ that I then express as a share of sector-areas-year total lagged disbursements $(\sum_{t=1}^{T} \sum_{p} D_{pis,t-1})$ as

$$Share_{ist} = \frac{1/P \times \sum_{p} D_{pis,t-1}}{\sum_{t} \sum_{p} D_{pis,t-1}} \tag{4.6}$$

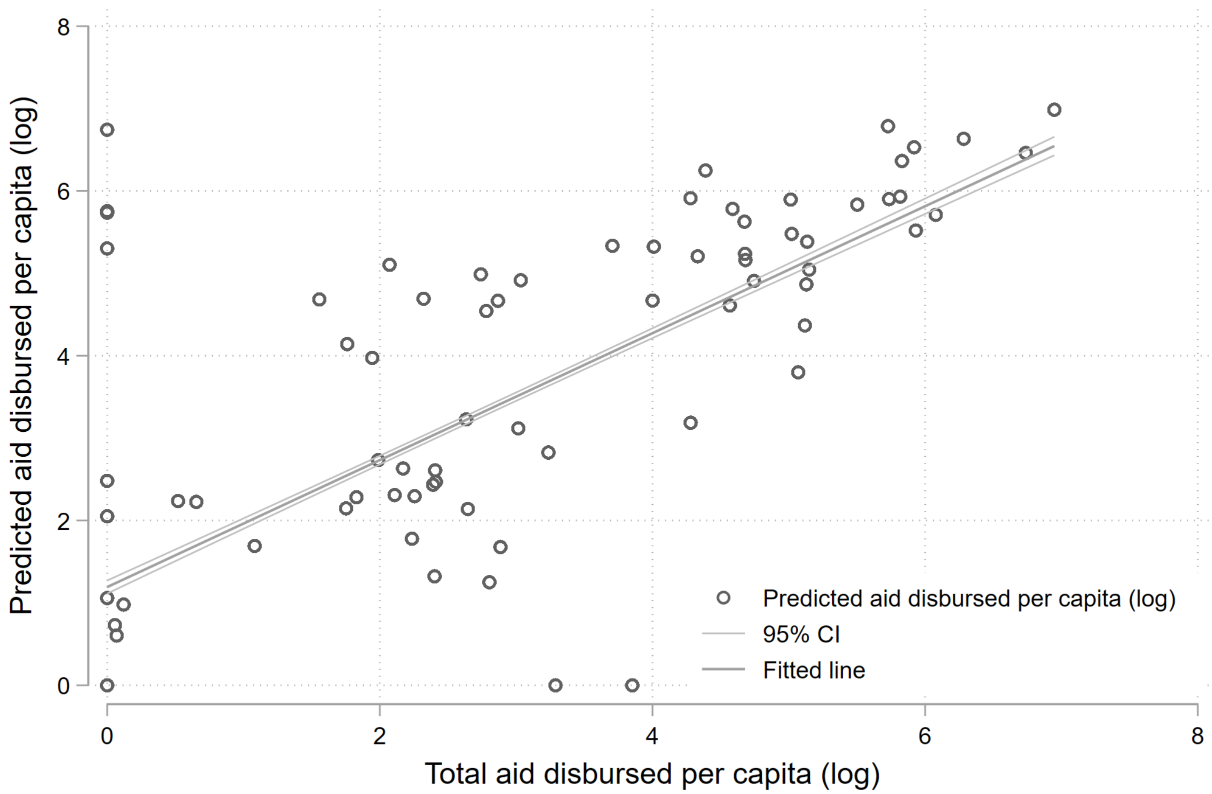
where p denotes the project, s the economic sector, and i the department, and $\sum_{t} Share_{ist} = 1$.

Step 3- Instrument. Based on the predicted spatial aid $(\widehat{C}_{is})$, and the average disbursement profile $Share_{ist}$, the instrument used, which boils down to be a *shift-share*, is obtained as:

$$IV_{ist} = Share_{ist} \times \widehat{C}_{is} \tag{4.7}$$

where $Share_{ist}$ is the component of my instrument that deals with the endogeneity of the timing of the disbursement while $\widehat{C}_{is}$ is the component of my instrument that deals with the endogeneity of the spatial allocation of aid projects. Figure 4.3.1 illustrates the correlation between my predicted project aid per capita (shift-share) and the observed level of project aid per capita. The correlation coefficient between the instrument and aid per capita is 0.72, demonstrating the strong predictive power of the instrument.

Figure 4.3.1: Aid per capita versus instrument



4.4 Main results

4.4.1 Baseline results

Table 4.4.1 reports the baseline estimates of equations 4.3 and 4.4 for internal and international migration respectively. Columns (1) and (2) report the estimation for internal migration, while columns (3) and (4) report those for international migration. Panel A reports the migration response of exposure to total foreign aid at the departmental level in Senegal. Columns (1) and (3) report the Pseudo-Poisson Maximum Likelihood (PPML) estimates, while columns (2) and (4) report the Instrumental Variable (IV) estimates when endogeneity concerns are resolved. The dependent variable is the ratio between the probability of moving from i to j and the probability of remaining/staying in i. This ratio of probabilities boils down to the migrants-to-stayers ratio.[97]

[97] The migrants-to-stayers ratio is given as : $\frac{m_{ij}}{m_{ii}} \equiv \frac{M_{ij}}{N_i} / \frac{M_{ii}}{N_i} \equiv \frac{M_{ij}}{M_{ii}}$ where N_i is the number of natives, M_{ii} is the number of stayers and M_{ij} is the number of movers such that $N_i = M_{ii} + M_{ij}$

The PPML estimates in columns (1) and (3) suggest a negative association between exposure to foreign aid and internal migration, but no significant association between exposure to foreign aid and international migration. However, this result cannot be interpreted with confidence, given the potential endogeneity of foreign aid. Even if the rich structure of fixed effects used in the specifications completely control for origin-destination and destination-time factors that could affect both migration and foreign aid, unobserved origin-time factors could still bias the PPML coefficients. As a first step, I control for origin-time factors such as conflicts, level of development and weather shocks in the origin department.[98] However, there may still be unobserved factors that simultaneously affect both the implementation and the disbursement schedule of aid projects and the migration decision. For example, a contemporaneous local shock is likely to alter both the initially planned disbursement schedule, the decision to implement a project in that specific department, and the decision to migrate from that department. Any failure to control for such a shock will bias the estimates reported in columns (1) and (3). Therefore, I rely on the instrumental variable approach presented in section 4.3.3 above, where I instrument the spatial allocation of aid projects and the actual disbursement profile with the combination of political proximity to the ruling president at the time of commitment (Masaki, 2018; Dreher et al., 2019) and synthetic disbursements in the sense of Kraay (2012); Kraay (2014). In the first stage, reported in panel (B), the coefficient of the instrumental variable (predicted aid disbursement per capita) is positive and statistically significant as expected, and the K-Paap F statistic is between 11 and 16, indicating the relevance of the instrument. The results of the second stage are reported in columns (2) and (4) and suggest that there is no significant migration response to exposure to total development aid, be it internal or international. However, as highlighted by M. A. Clemens and Postel (2018); M. A. Clemens (2014); M. A. Clemens et al. (2012), this inability to find a statistically meaningful effect could well be explained by the variety of aid projects with different objectives, different targets and different potential effects.

Interpreting these results is challenging. First, it could be that total project-related aid is allocated to five sectors and one residual sector: education, employment, health, infrastructure, agriculture and the residual group. As pointed out by M. A. Clemens et al. (2012), there are aid projects that are likely to affect the economic and social conditions of recipient locations in a reasonably short period of time, referred to as "early-impact" projects such as real sector investment projects, youth employment, energy, agriculture. Other projects likely affect economic and social conditions after a very long period of time, referred to as "late-impact" projects such as investment in education, health, humanitarian spending. At this stage, even focusing on "early-impact" aid *à la* Clemens, for example, raises important

[98] These controls are lagged as they are initial conditions that are likely to affect both the decision to implement aid projects in a given location and/or the pattern of disbursements and the decision to migrate.

challenges for the interpretation of coefficients, especially when the outcome variable is migration. Depending on whether infrastructure-related projects are in the construction or the operation stage, the expected impact on migration is likely to be different. At the construction stage, infrastructure-related projects are likely to reduce migration by creating more jobs, while at the exploitation stage, the constructed infrastructure is likely to create greater connectivity between locations and then potentially higher migration. Second, investments in youth employment, if successful, are likely to improve the economic conditions of the exposed individuals/locations in the relatively short term. As a result, assessing projects whose impact on migration decisions is directly related to their impact on economic conditions seems to be more helpful in understanding the migration response of affected locations when such projects are implemented. That is what I explore in the next Section (Section 4.4.2).

4.4.2 Employment aid projects and migration

4.4.2.1 Benchmark findings

To better understand how migration decisions respond to improved economic conditions (higher income or better employment opportunities), I restrict the analysis to a subset of aid projects with high employment potential, which I will refer to as "*employment-aid*" throughout the rest of the paper. It consists of 47 projects covering four types of interventions: (i) multifunctional platforms, (ii) youth employment promotion, (iii) vocational training, and (iv) rural employment. Multi-functional platforms provide energy-related services with the aim of developing local entrepreneurship and income-generating activities. Youth employment promotion refers to the creation of integrated agricultural and aquaculture enterprises and to ease access to credit through local financial institutions. Vocational training promotes skills development, often followed by the provision of technical equipment to trainees. Rural employment refers to direct financial and technical support for the creation of micro-enterprises and the promotion of rural youth initiatives to expand their economic opportunities. I assume that this subset of projects has, on average, a real impact on income and employment opportunities in the locations concerned. In addition, I restrict the sample to young individuals aged 18-35, as they are the main target group of such interventions (McKenzie, 2017) and the most mobile group in the period considered (panels A.2a and A.2b of Appendix A.9).

Table 4.4.2 reports the main benchmark results on how the migration decisions of 18-35 year old respond to employment related aid projects. Columns (1) and (3) of panel A show a negative and significant association between exposure to employment aid projects and the migration of young people. The first stage results reported in panel B show that, as expected, the coefficient of the instrument is positive and statistically significant at the 1%

Table 4.4.1: Baseline findings - total aid

	Panel A: Migration response to total aid			
	Dependent variable: Migrants to stayers ratio (aged 18-35)			
	(1)	(2)	(3)	(4)
	Internal migration		International migration	
	PPML	IV	PPML	IV
Total aid per capita (log)	-0.105***	-0.099	0.001	-0.030
	(0.037)	(0.061)	(0.001)	(0.026)
First stage $\widehat{residual}$		-0.007		0.033
		(0.063)		(0.026)
Observations	3,888	3,888	6,636	6,636
Destination-time FE	Yes	Yes	Yes	Yes
Origin-destination FE	Yes	Yes	Yes	Yes

	Panel B: First stage regressions	
	Dependent variable: Total aid per capita (log)	
	Internal migration	International migration
	OLS	OLS
Predicted total aid per capita (log)	0.519***	0.350***
	(0.128)	(0.108)
Observations	90	270
Controls	Y	Y
Department- FE	Y	Y
Time FE	Y	Y
K-Paap F statistics	16.3	10.5

Notes: Table 4.4.1 reports PPML estimates with standard errors robust to heteroskedasticity and clustered at origin-destination pair. Standard errors have been obtained by bootstrap with a 1,000 replications. Aid per capita refers in columns 1 and 2 to the aggregated disbursements per capita between $t-1$ and $t-5$. In the last two columns, Total aid per capita refers to the amount disbursed during the previous year $t-1$. Standardized Precipitation Evapo-transpiration Index (SPEI), night-time light intensity capture respectively weather shocks and development level of the department of origin in $t-5$ and $t-1$ for internal and international migration regressions. I also proxy for conflicts by controlling for the number of victims killed.

and 5% levels, indicating the relevance of the chosen instrument. When the endogeneity of foreign aid is accounted for, using employment as the instrumental variable strategy, the effect initially documented for international migration disappears (column 4 of the panel A), suggesting that exposure to the employment aid projects does not significantly affect international migration decisions in Senegal. However, as reported in column (2) of panel A, doubling the volume of employment aid per young adult aged 18-35 reduces the probability of internal migration across departments by about 15.3%. Although this result indicates the existence of a development channel for internal migration[99], the latter does not seem to affect international migration. One possible explanation lies in the timing of international migration, which is likely to cost more in monetary and non-monetary terms than internal migration. Given the lower costs of internal migration, the former should respond more quickly to a positive economic shock than the latter. A second possible explanation for the overall lack of impact of employment aid on international migration flows is that such projects target specific groups. In particular, they focus on the young and implicitly the somewhat more educated, as these groups are more responsive to both employment and migration opportunities. Moreover, people may respond differently to such an economic shock, depending on why they migrate and where they are willing and able to go. In the next section, I perform a wide range of heterogeneity checks including exploring the effect by age groups, education, migration motive and destination groups.

4.4.2.2 Heterogeneity analysis

To further detail heterogeneous impacts within the general targeted population of employment aid found in Section 4.4.2, I split the sample into four broad categories: (i) migration flows by education attainment (tertiary educated, upper secondary, lower secondary, primary and finally those without formal education); (ii) by age group (18-25 and 26-35); (iii) by migration motive (work, family or marriage, studies and a residual category). Finally by destination (neighboring countries, transit countries, Europe, African non-neighboring and non-transit countries).

Employment aid and migration along the education dimension – I turn first to the heterogeneity of the benchmark results with respect to the educational attainment, knowing that the Senegalese migration flow is positively selected, as shown in Figures 4.2.1 and 4.2.2 for internal and international migration respectively. Starting with internal migration, the results reported in panel A of Table 4.4.3 show that the negative effect described in the benchmark is persistent across education levels. Interestingly, the estimated effects increase as individuals in the target group (18-35) have higher levels of education. Indeed, point estimates suggest that doubling the amount of employment aid per young adult aged 18-35 reduces the probability of internal migration by 14.8% for those with primary or lower secondary education, 19.7% for those with upper secondary education and 20.2% for those with tertiary education. However, exposure to employment aid has no effect on migration of young adults with no formal education. In a nutshell, the higher the education level of young adults, the stronger the deterrent effect of employment aid on internal migration decisions. This can possibly be

[99] The development channel refers to the deterrent effect of improved economic conditions at origin on the decision to migrate.

Table 4.4.2: Baseline findings - employment aid

	Panel A: Migration response to employment aid			
	Dependent variable: Migrants to stayers ratio			
	(1)	(2)	(3)	(4)
	Internal migration		International migration	
	PPML	IV	PPML	IV
Employment aid per capita (log)	-0.096***	-0.166**	-0.026*	0.009
	(0.035)	(0.065)	(0.015)	(0.054)
First stage $\widehat{residual}$		0.097		-0.038
		(0.078)		(0.056)
Observations	3,888	3,888	6,636	6,636
Destination-time FE	Y	Y	Y	Y
Origin-destination FE	Y	Y	Y	Y

	Panel B: First stage regressions	
	Dependent variable: Employment aid per capita (log)	
	Internal migration	International migration
	OLS	OLS
Predicted employment aid per capita (log)	0.303***	0.256**
	(0.090)	(0.115)
Observations	90	270
Controls	Y	Y
Department- FE	Y	Y
Time FE	Y	Y
K-Paap F statistics	11.4	6.1

Notes: Table 4.4.2 report PPML estimates with standard errors robust to heteroskedasticity and clustered at origin-destination pair. Standard errors are obtained by bootstrap with a 1,000 replications. Aid per capita refers, in columns 1 and 2, to the aggregated disbursements per capita between $t-1$ and $t-5$. In the last two columns, Total aid per capita refers to the amount disbursed during the previous year $t-1$. Standardized Precipitation Evapo-transpiration Index (SPEI), night-time light intensity capture respectively weather shocks and development level of the department of origin in $t-5$ and $t-1$ for internal and international migration regressions. I also proxy for conflicts by controlling for the number of victims killed.

explained by the fact that more educated people are more responsive to the opportunities created by employment-related projects. Looking at projects promoting youth employment or rural development for instance, the level of education is key to benefiting from these projects, as access to financial support requires the production of documents such as a business plan and exploitation cycle, which may be challenging for the less educated, and especially those with no formal education.

Turning to international migration, the results reported in panel B suggest that the international migration decision of youth does not respond to exposure to employment projects, regardless of education level. The first possible explanation for the lack of a deterrent effect could be related to the easing of budget constraints, coupled with the large location premium when comparing economic conditions at origin with those at destination. Since Europe is the main destination for Senegalese migrants, the income gains from emigration to Europe, at least in the short term, far outweigh the income gains that can be expected from employment projects in the departments of origin. The second explanation relates to the accessibility of long-term employment projects. As mentioned above, it is likely that the less educated are less qualified for some of the projects with a long-term perspective, such as rural employment through easy access to credit or youth employment promotion. To sum up, along the educational dimension, employment aid reduces the likelihood of internal mobility and this effect increases with education. On the other hand, employment aid does not seem to have a significant impact on international migration.

Employment aid and migration along the age dimension – I turn to how heterogeneous these results are along the age dimension. I divide the young adults aged 18-35 into two groups: those aged 18-25 and those aged 26-35. As shown in panel A of Table 4.4.4, the deterring effect of employment aid on internal migration decisions remains significant irrespective of the age group, but is stronger for those aged 26-35. Specifically, doubling of employment aid per young adult reduces internal migration by 14% for those aged 18-25, and by 16.3% for those aged 26-35. I further investigate how the estimated effect by age group is heterogeneous across education and gender groups in Appendix A.7. The effect for individuals aged 18-25 is driven by the less educated (illiterate and those with primary and lower secondary education), while the opposite is true for individuals aged 26-35. In this group, the higher the level of education, the greater the deterrent effect of employment aid on internal migration. In other words, the average effect estimated across education categories is driven by those aged 26-35. Moreover, the effect is stronger for women than for men, irrespective of the age range (see Panel A.7c of Appendix A.7).

In terms of international migration, I find no migration response to employment aid, regardless of age group, gender and education level, as reported in panel B of Table 4.4.4 and shown in panels A.7c and A.7d of Appendix A.7. So far, my results suggest that a positive economic shock caused by exposure to employment aid projects does not significantly affect international migration decisions in Senegal. However, it is important to recognize that the estimated effect here likely reflects short- to medium-term changes—specifically, the change in annual bilateral international migration flows compared to the average annual change in employment aid per young adult aged 18–35 over six years. If the short-term effects persist or if the aid generates dynamic effects or economic spillovers that last several years, there may be significant long-term impacts. Indeed, to the extent that exposure to employment aid projects enhances the labor market outcomes of young adults —and if these improvements

Table 4.4.3: Migration response to employment aid by education level (18-35)

	Dependent variable: Migrant to stayer ratio				
	All	Illiterate	Lower sec./prim	Upper secondary	Tertiary
	(1)	(2)	(3)	(4)	(5)
	Panel A– Internal migration				
	Panel A1– PPML				
Aid to employment p.c (log)	-0.096***	-0.078*	-0.092**	-0.061	-0.098*
	(0.035)	(0.041)	(0.038)	(0.045)	(0.050)
	Panel A2– IV				
Aid to employment p.c (log)	-0.166**	-0.108	-0.160**	-0.219**	-0.226**
	(0.065)	(0.080)	(0.075)	(0.086)	(0.097)
$\widehat{residual}$	0.097	0.045	0.085	0.203*	0.165
	(0.078)	(0.101)	(0.082)	(0.104)	(0.120)
Observations	3,888	3,748	3,840	2,988	2,882
	Panel B–International migration				
	Panel B1 – PPML				
Aid to employment p.c (log)	-0.026*	-0.050**	-0.021	-0.065	-0.038
	(0.015)	(0.022)	(0.025)	(0.045)	(0.033)
	Panel B2 – IV				
Aid to employment p.c (log)	0.014	0.060	0.041	-0.164*	-0.044
	(0.048)	(0.077)	(0.063)	(0.098)	(0.095)
$\widehat{Residual}$	-0.041	-0.115	-0.074	0.120	0.021
	(0.048)	(0.075)	(0.060)	(0.091)	(0.108)
Observations	6,636	5,958	5,814	4,223	3,492
Origin-time controls	Y	Y	Y	Y	Y
Destination-time FE	Y	Y	Y	Y	Y
Origin-destination FE	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
Bootstrap replications	1,000	1,000	1,000	1,000	1,000

Notes: Table 4.4.3 report PPML and IV estimates with standard errors robust to heteroskedasticity and clustered at origin-destination pair. Standard errors are obtained by bootstrap with a 1,000 replications. Employment aid per capita in Panel (A) refers to the aggregated amount disbursed per capita between $t-1$ and $t-5$ while it refers in panel (B) to the average amount disbursed per capita between $t-3$ and $t-1$). Each specification controls for Standardized Precipitation Evapo-transpiration Index (SPEI), nighttime light intensity in $t-5$ and $t-1$ that proxy respectively initial weather shocks and development level of the department of origin for internal and international migration regressions. I also control for conflicts proxies by the number of victims killed due to conflicts.

are sustained over time— the migration decisions of these individuals may change in the future.

As argued in the discussion of the benchmark results, given that most Senegalese international out-migrants go to Europe and non-European OECD countries (see Table 4.2.2), there is a huge place premium given the income differential between the Senegalese departments and those high income destination countries, which is such that short-term local

Table 4.4.4: Migration response to employment aid by age

	Dependent variable: Migrant to stayer ratio					
	18-35	18-25	26-35	18-35	18-25	26-35
	(1)	(2)	(3)	(4)	(5)	(6)
	PPML			IV		
	Panel A– Internal migration					
Aid to employment p.c. (log)	-0.096***	-0.083***	-0.108***	-0.166**	-0.152**	-0.178***
	(0.035)	(0.032)	(0.040)	(0.065)	(0.060)	(0.073)
$\widehat{residual}$				0.097	0.097	0.101
				(0.078)	(0.068)	(0.092)
Observations	3,888	3,790	3,552	3,888	3,790	3,552
	Panel B– International migration					
Aid to employment p.c. (log)	-0.026*	-0.034*	-0.0185	0.009	0.000	0.018
	(0.015)	(0.020)	(0.015)	(0.054)	(0.079)	(0.051)
$\widehat{residual}$				-0.038	-0.037	-0.039
				(0.056)	(0.085)	(0.053)
Observations	6,636	6,790	6,390	6,636	6,790	6,390
origin-time controls	Y	Y	Y	Y	Y	Y
Destination-time FE	Y	Y	Y	Y	Y	Y
Origin-destination FE	Y	Y	Y	Y	Y	Y
Replications	1,000	1,000	1,000	1,000	1,000	1,000

Table 4.4.4 reports PPML and IV (PPML-CFA) estimates with standard errors robust to heteroskedasticity and clustered at origin-destination pair. Standard errors have been obtained by bootstrap with a 1,000 replications. Employment aid per capita in Panel (A) refers to the aggregated amount disbursed per capita between $t-1$ and $t-5$ while it refers in panel (B) to the average amount disbursed per capita between $t-3$ and $t-1$). Each specification controls for Standardized Precipitation Evapo-transpiration Index (SPEI), nighttime light intensity in $t-5$ and $t-1$ that proxy respectively initial weather shocks and development level of the department of origin for internal and international migration regressions. I also control for conflicts proxies by the number of victims killed due to conflicts.

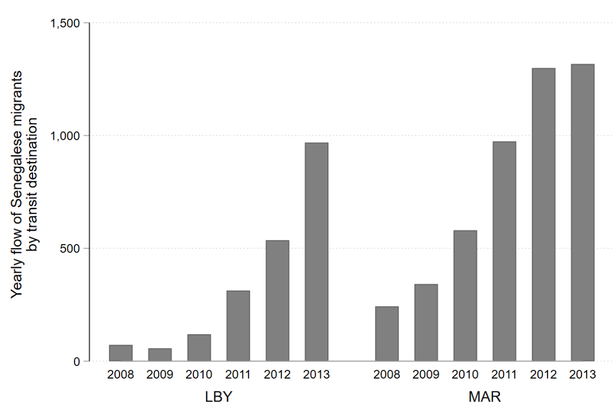
improvements in economic conditions are unlikely to offset this, making international migration very attractive. To get a sense of whether such a mechanism is at work in the data, I categorize destination countries into four groups: African countries (group 1), European countries plus Canada and the United States (group 2), transit countries including Libya, Tunisia, Algeria and Morocco (group 3), and the rest of the world (group 4). Having a category called "*transit countries*" is relevant in my setting for two reasons. First, given that information on international migrants is provided by household members, it is likely that the number of migrants includes those who use the illegal route to migrate, especially to Europe which mostly runs through the intermediate countries of destination are Libya, Tunisia, Algeria and Morocco. Second, given the risk associated to illegal migration, young adults who usually choose to out-migrate illegally via transit countries might be more sensitive to better conditions at origin than those able to emigrate formally. This makes it possible to examine whether the use of desperate channels to migrate illegally could be reduced by better economic opportunities at the location of origin.

Employment aid and migration to transit countries – Ideally, transit countries should encompass Libya and Tunisia for the central Mediterranean route to the south of Italy and, alternatively, Morocco and Algeria for the Western Mediterranean route to the south of Spain. By restricting the sample of destination countries to those with at least 600 Senegalese over the covered period, only Morocco and Libya are kept. However, I do not lose much as Morocco and Libya emerge as the 7^{th} and 12^{th} most common/realized destinations, for Senegalese young adults migrants aged 18-35 at the time of departure. They respectively hold the 3^{rd} and 8^{th} positions among important African destinations, with their prominence only challenged by neighboring countries. Moreover, these destinations exhibit increasing importance over the covered period, as illustrated in Figure 4.4.1a, in particular among young men, as depicted in Figure 4.4.1b.

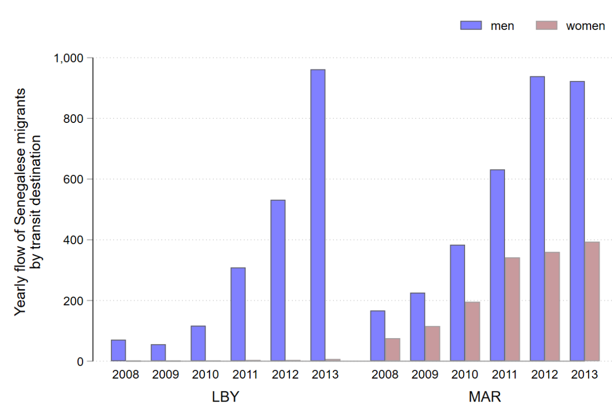
The results on how international migration responds to exposure to foreign aid are presented in Appendix A.8. As reported in Appendices A.8a, A.8b, and A.8c, doubling exposure to employment aid projects reduces youth's migration to transit countries by roughly 14.3%. More interestingly, this deterring effect is stronger for the younger cohort aged 18-25, -16% against -12.5% for those aged 26-35. Appendices A.8d to A.8i show that the deterring effects of employment aid on migration to transit countries are primarily driven by men. Doubling the exposure of young men to employment aid leads to a 16.6% reduction in their emigration to transit countries (18.4% for the 18-25 age group against 14.7% for the 26-35 age group). However, results in appendices A.8g, A.8h, and A.8i suggest no meaningful effect on women, likely explained by their lower inclination towards engaging in illegal migration routes (see figure 4.4.1b of Figure 4.4.1).

Figure 4.4.1: migration flows to transit countries

(**a**) Aggregate flows



(**b**) Flows by gender



Impact of employment aid along destinations and migration motives – I now turn to the reasons why young people migrate abroad. Here, I only consider international migration, leaving aside internal migration for two reasons. First, although the 2013 Senegalese census includes a question on the migration motive of internal migrants, it only covers migration in the last five years (i.e. only the 2008-2013 wave). As the estimate of internal migration in response to foreign aid also covers the 2003-2007 wave, the migration motive for this wave is missing, making it impossible to assess this dimension. Second, for international migration, the year and the motive of migration are reported for each migrant; this makes it possible to construct annual dyadic migration flows by origin department, destination country and migration motive, useful for investigating whether migration response to foreign aid is heterogeneous across migration motives. Indeed, while people moving for family or religious reasons may not be affected by economic conditions, those moving for job search may have less reason to migrate if they have access to these jobs locally. As shown in panel A.9a of Appendix A.9, doubling exposure to employment support projects in Senegalese departments reduces the incentive to migrate for job-seeking motives not only to transit countries but also to Europe and the rest of the world, although this effect is stronger for migration to transit countries. On the other hand, as shown in panels A.9b, A.9c and A.9d, international migration decisions for educational, family and other reasons are not affected by exposure to employment support projects.

4.5 Concluding remarks

This study investigates the impact of foreign aid on migration decisions in Senegal, with a particular focus on the role of employment-related aid in deterring or fostering internal and international migration. While foreign aid is often seen as a tool for reducing emigration from recipient areas, the mechanisms at play can operate in opposite ways, making the estimation of the net effect an empirical question. The existing literature has produced mixed results, in part due to the use of aggregate data at the country level that fails to account for the heterogeneity in the location and impact of development aid projects. This study uses spatially dis-aggregated data on aid and migration at the department level in Senegal to provide new insights into this issue. The results indicate that employment-related aid has a significant negative impact on internal migration on young adults aged 18-35, particularly among women and the most educated. Specifically, doubling employment-related aid per young adult aged 18-35 leads to a 15.3% decrease in internal migration, with the effect being stronger for women (16.5%) than men (15.0%). In contrast, employment-related aid does not have a significant impact on international migration overall. However, it does reduce emigration to transit countries by roughly 14.3%, particularly among young men aged 18-25.

Consequently, when I break down migration across motives, employment aid reduces the migration incentives of the young adults who migrate for job seeking motives.

Overall, these findings suggest that employment-related aid projects can have a significant deterrent effect on internal migration in recipient areas. This effect is likely driven by the economic benefits of employment-related aid projects, which improve economic conditions of young adults, and reduce their incentives to migrate internally. The lack of a significant impact on international migration decisions suggests that the indirect effects of employment-related aid on reducing the attractiveness of destinations with large wage premia is limited. However, it increases the opportunity cost of engaging in risky, and illegal migration journey via transit countries.

While this study provides new insights into the impact of foreign aid on migration decisions, additional research is needed to fully understand the long-term effects of aid projects and to identify the individuals and households that benefit most from these projects. Nevertheless, these findings have important implications for policy makers and donors who seek to use foreign aid as a tool for reducing emigration from recipient areas. By targeting projects with high employment potential for the youth, donors may be able to promote economic development and reduce internal migration. Although there is no direct effect of employment aid on international migration decisions overall, they still indirectly reduce international migration through reduced use of illegal routes by making their opportunity cost higher. Employment aid also deters the willingness of young individuals, and especially young job seekers, to migrate to transit countries.

Bibliography

Abarcar, P. and C. Theoharides (2021). “Medical Worker Migration and Origin-Country Human Capital: Evidence from U.S. Visa Policy”. In: *Review of Economics and Statistics* forthcoming, pp. 1–46.

Aggarwal, S. (2018). “Do Rural Roads Create Pathways Out of Poverty? Evidence from India”. In: *Journal of Development Economics* 133, pp. 375–395.

Ahlfeldt, G. M., S. J. Redding, D. M. Sturm, and N. Wolf (2015). “The economics of density: Evidence from the Berlin Wall”. In: *Econometrica* 83(6), pp. 2127–2189.

Albert, C. and J. Monras (2022). “Immigration and spatial equilibrium: the role of expenditures in the country of origin”. In: *American Economic Review* 112(11), pp. 3763–3802.

Angrist, J. D. and J.-S. Pischke (2009). *Mostly harmless econometrics: An empiricist’s companion*. Princeton university press.

Antman, F. M. (2011). “The intergenerational effects of paternal migration on schooling and work: What can we learn from children’s time allocations?” In: *Journal of Development Economics* 96(2), pp. 200–208.

Arslan, C., J.-C. Dumont, Z. Kone, Y. Moullan, C. Ozden, C. Parsons, and T. Xenogiani (2015). “A new profile of migrants in the aftermath of the recent economic crisis”. In: *OECD Social Employment and Migration Working Papers* 160.

Ba, C., J. Bourgoin, and D. Diop (2017). “The fluidity of internal migration as an answer to local constraints”. In: *In: Mercandalli, S. and Losch, B. (eds.). Rural Africa in motion: Dynamics and drivers of migration South of the Sahara*, pp. 32–33.

Bah, T. L., C. Batista, F. Gubert, and D. McKenzie (2023). “Can information and alternatives to irregular migration reduce “backway” migration from The Gambia?” In: *Journal of Development Economics* 165, p. 103153.

Barro, R. J. (2001). “Human capital and growth”. In: *American economic review* 91(2), pp. 12–17.

Baseler, T. (2023). “Hidden income and the perceived returns to migration”. In: *American Economic Journal: Applied Economics* 15(4), pp. 321–352.

Batista, C., A. Lacuesta, and P. C. Vicente (2012). "Testing the 'brain gain' hypothesis: Micro evidence from Cape Verde". In: *Journal of Development Economics* 97(1), pp. 32–45.

Beauchemin, C., M.-L. Flahaux, and B. Schoumaker (2020). "Three sub-Saharan migration systems in times of policy restriction". In: *Comparative Migration Studies* 8(19).

Beine, M., F. Docquier, and H. Rapoport (2008). "Brain drain and human capital formation in developing countries: winners and losers". In: *The Economic Journal* 118(528), pp. 631–652.

Beine, M., F. Docquier, and Ç. Özden (2011). "Diasporas". In: *Journal of Development Economics* 95(1), pp. 30–41.

Beine, M., F. Docquier, and H. Rapoport (2001). "Brain drain and economic growth: theory and evidence". In: *Journal of Development Economics* 64(1), pp. 275–289.

Beine, M., F. Docquier, and H. Rapoport (2010). "On the robustness of brain gain estimates". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 143–165.

Beine, M. and C. Parsons (2015). "Climatic factors as determinants of international migration". In: *The Scandinavian Journal of Economics* 117(2), pp. 723–767.

Bell, M., E. Charles-Edwards, A. Bernard, and P. Ueffing (2018). "Global trends in internal migration". In: *Internal migration in the developed world: are we becoming less mobile?* Ed. by T. C. T. Champion and I. Shuttleworth. Routledge: United Kingdom.

Belot, M. V. and T. J. Hatton (2012). "Immigrant Selection in the OECD". In: *The Scandinavian Journal of Economics* 114(4), pp. 1105–1128.

Benavente, A. and C. Panchaud (2008). "Lutte contre la pauvreté et éducation pour l'inclusion: transformer l'école en Afrique subsaharienne". In.

Bergman, P., R. Chetty, S. DeLuca, N. Hendren, L. F. Katz, and C. Palmer (2024). "Creating moves to opportunity: Experimental evidence on barriers to neighborhood choice". In: *American Economic Review* 114(5), pp. 1281–1337.

Berthélemy, J.-C., M. Beuran, and M. Maurel (2009). "Aid and migration: Substitutes or complements?" In: *World Development* 37(10), pp. 1589–1599.

Bertoli, S. and J. F.-H. Moraga (2013). "Multilateral resistance to migration". In: *Journal of development economics* 102, pp. 79–100.

Bhagwati, J. and K. Hamada (1974). "The brain drain, international integration of markets for professionals and unemployment: a theoretical analysis". In: *Journal of Development Economics* 1(1), pp. 19–42.

Biavaschi, C., M. Burzyński, B. Elsner, and J. Machado (2020). "Taking the skill bias out of global migration". In: *Journal of Development Economics* 142, p. 102317.

Bocquier, P., N. Cha'ngom, F. Docquier, and J. Machado (2023). "The within-country distribution of brain drain and brain gain effects: A case study on Senegal". In: *Journal of Demographic Economics*, pp. 1–28.

Bouche, D. (1974). "The French school and Muslims in Senegal from 1850 to 1920". In: *Revue d'histoire* 61, pp. 218–235.

Brauw, A. de and J. Giles (2017). "Migrant Opportunity and the Educational Attainment of Youth in Rural China". In: *Journal of Human Resources* 52(1), pp. 272–311.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014a). "Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh". In: *Econometrica* 82, pp. 1671–1748.

Bryan, G., S. Chowdhury, and A. M. Mobarak (2014b). "Underinvestment in a profitable technology: The case of seasonal migration in Bangladesh". In: *Econometrica* 82(5), pp. 1671–1748.

Bryan, G. and M. Morten (2019). "The aggregate productivity effects of internal migration: Evidence from Indonesia". In: *Journal of Political Economy* 127(5), pp. 2229–2268.

Burzyński, M., C. Deuster, and F. Docquier (2020). "Geography of skills and global inequality". In: *Journal of Development Economics* 142, p. 102333.

Burzyński, M., C. Deuster, F. Docquier, and J. De Melo (2022). "Climate change, inequality, and human migration". In: *Journal of the European Economic Association* 20(3), pp. 1145–1197.

Caballero, M. E., B. Cadena, and B. K. Kovak (2021). *The International Transmission of Local Economic Shocks Through Migrant Networks*. NBER Working Papers 28696. National Bureau of Economic Research, Inc.

Caiumi, A. and G. Peri (2024). *Immigration's Effect on US Wages and Employment Redux*. Tech. rep. National Bureau of Economic Research.

Castelló-Climent, A. and A. Mukhopadhyay (2013). "Mass education or a minority well educated elite in the process of growth: The case of India". In: *Journal of Development Economics* 105, pp. 303–320.

Cha'ngom, N., C. Deuster, F. Docquier, and J. Machado (2023). "Selective Migration and Economic Development: A Generalized Approach". In.

Chand, S. and M. A. Clemens (2019). *Human Capital Investment under Exit Options: Evidence from a Natural Quasi-Experiment*. IZA Discussion Papers 12173. Institute of Labor Economics (IZA).

Clemens, M. and E. R. Tiongson (2017). "Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work". In: *Review of Economics and Statistics* 99(3), pp. 531–543.

Clemens, M. A. (2014). "Does development reduce migration?" In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Clemens, M. A. and H. M. Postel (2018). "Deterring emigration with foreign aid: An overview of evidence from low-income countries". In: *Population and Development Review* 44(4), p. 667.

Clemens, M. A., S. Radelet, R. R. Bhavnani, and S. Bazzi (2012). "Counting chickens when they hatch: Timing and the effects of aid on growth". In: *The Economic Journal* 122(561), pp. 590–617.

Conte, B. (2022). "Climate change and migration: the case of africa". In.

Cucu, F. (2019). "Roads, Internal Migration and the Spatial Sorting of US High-Skilled Workers". In: *Manuscript, Université Libre de Bruxelles (ECARES)*.

De Mesquita, B. B. and A. Smith (2009). "A political economy of aid". In: *International Organization* 63(2), pp. 309–340.

Delogu, M., F. Docquier, and J. Machado (2018). "Globalizing labor and the world economy: the role of human capital". In: *Journal of Economic Growth* 23(2), pp. 223–258.

Desmet, K., D. K. Nagy, and E. Rossi-Hansberg (2018). "The geography of development". In: *Journal of Political Economy* 126(3), pp. 903–983.

Diamond, R. (2016). "The determinants and welfare implications of US workers' diverging location choices by skill: 1980–2000". In: *American Economic Review* 106(3), pp. 479–524.

Dinkelman, T., G. Kumchulesi, and M. Mariotti (2021). *Labor Migration, Capital Accumulation, and the Structure of Rural Labor Markets*. GLM|LIC Working Paper 22. Institute of Labor Economics.

Dinkelman, T. and M. Mariotti (2016). "The Long-Run Effects of Labor Migration on Human Capital Formation in Communities of Origin". In: *American Economic Journal: applied Economics* 8(4), pp. 1–35.

Djajić, S., F. Docquier, and M. S. Michael (2019). "Optimal education policy and human capital accumulation in the context of brain drain". In: *Journal of Demographic Economics* 85(4), pp. 271–303.

Docquier, F., O. Lohest, and A. Marfouk (2007). "Brain drain in developing countries". In: *The World Bank Economic Review* 21(2), pp. 193–218.

Docquier, F. and J. Machado (2016). "Global Competition for Attracting Talents and the World Economy". In: *The World Economy* 39(4), pp. 530–542.

Docquier, F., J. Machado, and K. Sekkat (2015). "Efficiency gains from liberalizing labor mobility". In: *The Scandinavian journal of economics* 117(2), pp. 303–346.

Dreher, A., A. Fuchs, R. Hodler, B. C. Parks, P. A. Raschky, and M. J. Tierney (2019). "African leaders and the geography of China's foreign assistance". In: *Journal of Development Economics* 140, pp. 44–71.

Duranton, G. and D. Puga (2004). "Micro-foundations of urban agglomeration economies". In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2063–2117.

European-Commission (2015). "Governance and Procedure: EU Trust Fund for Africa for stability and addressing root causes of irregular migration and displaced persons". In: *European Union*.

Felbermayr, G. J., B. Jung, and F. Toubal (2010). "Ethnic networks, information, and international trade: Revisiting the evidence". In: *Annals of Economics and Statistics/Annales d'Économie et de Statistique*, pp. 41–70.

Fernández Sánchez, M. (2022). *Mass Emigration and Human Capital over a Century: Evidence from the Galician Diaspora*. Tech. rep. Luxembourg Institute of Socio-Economic Research (LISER).

Fields, G. S. (1990). "Labour market modelling and the urban informal sector: Theory and evidence". In.

Fields, G. S. (2009). "Segmented labor market models in developing countries". In.

Fields, G. S. (2011). "Labor market analysis for developing countries". In: *Labour economics* 18, S16–S22.

Francken, N., B. Minten, and J. F. Swinnen (2012). "The political economy of relief aid allocation: evidence from Madagascar". In: *World Development* 40(3), pp. 486–500.

Gamso, J. and F. Yuldashev (2018). "Does rural development aid reduce international migration?" In: *World Development* 110, pp. 268–282.

Gazeaud, J., E. Mvukiyehe, and O. Sterck (2023). "Cash transfers and migration: Theory and evidence from a randomized controlled trial". In: *Review of Economics and Statistics* 105(1), pp. 143–157.

Gennaioli, N., R. La Porta, F. Lopez-de-Silanes, and A. Shleifer (2013). "Human capital and regional development". In: *The Quarterly journal of economics* 128(1), pp. 105–164.

Gibson, J., D. McKenzie, and S. Stillman (2011). "The Impacts of International Migration on Remaining Household Members: Omnibus Results from a Migration Lottery Program". In: *The Review of Economics and Statistics* 93(4), pp. 1297–1318.

Gollin, D., D. Lagakos, and M. E. Waugh (2014). "The agricultural productivity gap". In: *Quarterly Journal of Economics* 129(2), pp. 939–993.

Grogger, J. and G. H. Hanson (2011). "Income maximization and the selection and sorting of international migrants". In: *Journal of Development Economics* 95(1), pp. 42–57.

Hanushek, E. and L. Woesmann (2008). "The Role of Cognitive Skills in Economic Development". In: *Journal of Economic Literature* 46(3), pp. 607–668.

Hanushek, E. and L. Woesmann (2021). "Education and Economic Growth". In: *Oxford Research Encyclopedia of Economics and Finance* 31, Oxford University Press.

Hao, T., R. Sun, T. Tombe, and X. Zhu (2020). "The effect of migration policy on growth, structural change, and regional inequality in China". In: *Journal of Monetary Economics* 113, pp. 112–134.

Haque, N. U. and S.-J. Kim (1995). ""Human capital flight": Impact of migration on income and growth". In: *Staff Papers* 42(3), pp. 577–607.

Hsieh, C.-T., E. Hurst, C. I. Jones, and P. J. Klenow (2019). "The allocation of talent and us economic growth". In: *Econometrica* 87(5), pp. 1439–1474.

Hsieh, C.-T. and E. Moretti (2019). "Housing constraints and spatial misallocation". In: *American Economic Journal: Macroeconomics* 11(2), pp. 1–39.

Imbert, C., J. Monras, M. Seror, and Y. Zylberberg (2023). "Floating population: migration with (out) family and the spatial distribution of economic activity". In: Federal Reserve Bank of San Francisco.

Iranzo, S. and G. Peri (2009). "Migration and trade: Theory with an application to the Eastern–Western European integration". In: *Journal of International Economics* 79(1), pp. 1–19.

Javorcik, B. S., Ç. Özden, M. Spatareanu, and C. Neagu (2011). "Migrant networks and foreign direct investment". In: *Journal of development economics* 94(2), pp. 231–241.

Jones, B. F. (2014). "The human capital stock: a generalized approach". In: *American Economic Review* 104(11), pp. 3752–77.

Katz, E. and H. Rapoport (2005). "On human capital formation with exit options". In: *Journal of Population Economics* 18(2), pp. 267–274.

Kerr, S. P., W. Kerr, Ç. Özden, and C. Parsons (2016). "Global talent flows". In: *Journal of Economic Perspectives* 30(4), pp. 83–106.

Khanna, G. and N. Morales (2021). *The IT Boom and Other Unintended Consequences of Chasing the American Dream*. mimeo. University of Michigan.

Khanna, G., E. Murathanoglu, C. Theoharides, and D. Yang (2022). *Abundance from abroad: migrant income and long-run economic development*. Working Paper 29862. NBER.

King, R., R. Skeldon, and J. Vullnetari (2008). "Internal and international migration: Bridging the theoretical divide". In.

Klugman, J. (2009). "Human development report 2009. Overcoming barriers: Human mobility and development". In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

Kosack, E. (2021). "Guest Worker Programs and Human Capital Investment – The Bracero Program in Mexico, 1942–1964". In: *Journal of Human Resources* 56(2), pp. 570–592.

Kraay, A. (2012). "How large is the government spending multiplier? Evidence from World Bank lending". In: *The Quarterly Journal of Economics* 127(2), pp. 829–887.

Kraay, A. (2014). "Government spending multipliers in developing countries: evidence from lending by official creditors". In: *American Economic Journal: Macroeconomics* 6(4), pp. 170–208.

Kummu, M., M. Taka, and J. H. Guillaume (2018). "Gridded global datasets for gross domestic product and Human Development Index over 1990–2015". In: *Scientific data* 5(1), pp. 1–15.

Lagakos, D., M. Mobarak, and M. E. Waugh (2023). "The Welfare Effects of Encouraging Rural-Urban Migration". In: *Econometrical* forthcoming.

Lanati, M., M. Sanfilippo, and F. Santi (2023). "Aid and internal migration in Malawi". In: *World Development* 162, p. 106134.

Lanati, M. and R. Thiele (2018a). "Foreign assistance and migration choices: Disentangling the channels". In: *Economics letters* 172, pp. 148–151.

Lanati, M. and R. Thiele (2018b). "The impact of foreign aid on migration revisited". In: *World development* 111, pp. 59–74.

Lessault, D. and M.-L. Flahaux (2013). "Regards statistiques sur l'histoire de l'émigration internationale au Sénégal". In: *Revue européenne des migrations internationales* 29(4).

Lucas, R. E. (2014). "Migration and economic development: an introduction and synopsis". In: *International handbook on migration and economic development*. Edward Elgar Publishing.

Marchal, L., C. Naiditch, B. Simsek, et al. (2022). *How Foreign Aid Affects Migration: Quantifying Transmission Channels*. Centre d'économie de la Sorbonne.

Marchiori, L., J.-F. Maystadt, and I. Schumacher (2012). "The impact of weather anomalies on migration in sub-Saharan Africa". In: *Journal of Environmental Economics and Management* 63(3), pp. 355–374.

Masaki, T. (2018). "The political economy of aid allocation in Africa: Evidence from Zambia". In: *African Studies Review* 61(1), pp. 55–82.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior". In: *Frontiers in econometrics*. Ed. by P. Zarembka. Academic Press: New York. Chap. 4, pp. 105–142.

McKenzie, D. (2017). "How effective are active labor market policies in developing countries? a critical review of recent evidence". In: *The World Bank Research Observer* 32(2), pp. 127–154.

McKenzie, D. and H. Rapoport (2011). "Can Migration Reduce Educational Attaintment? Evidence from Mexico". In: *Journal of Population Economics* 24(4), pp. 1331–1358.

Meghir, C., A. M. Mobarak, C. Mommaerts, and M. Morten (2022). "Migration and Informal Insurance: Evidence from a Randomized Controlled Trial and a Structural Model". In: *Review of Economic Studies* 89(1), pp. 452–480.

Menard, A. and A. Gary (2018). "Aid, trade and migration: How do bilateral flows interact?" In: *The World Economy* 41(2), pp. 431–456.

Mobarak, A., I. Sharif, and M. Shrestha (2023). "Returns to International Migration: Evidence from a Bangladesh-Malaysia Visa Lottery". In: *American Economic Journal: Applied Economics* forthcoming.

Mokyr, J. (2005). "The intellectual origins of modern economic growth". In: *Research and Technological Innovation*. Springer, pp. 17–80.

Mokyr, J. and H.-J. Voth (2009). "Understanding growth in early modern Europe". In: *Cambridge Economic History of Europe* 1, pp. 7–42.

Monte, F., S. J. Redding, and E. Rossi-Hansberg (2018). "Commuting, migration, and local employment elasticities". In: *American Economic Review* 108(12), pp. 3855–3890.

Mountford, A. (1997). "Can a brain drain be good for growth in the source economy?" In: *Journal of Development Economics* 53(2), pp. 287–303.

Mountford, A. and H. Rapoport (2011). "The brain drain and the world distribution of income". In: *Journal of Development Economics* 95(1), pp. 4–17.

Mountford, A. and H. Rapoport (2016). "Migration policy, African population growth and global inequality". In: *The World Economy* 39(4), pp. 543–556.

National-Security-Council (2021). "U.S. Strategy for Addressing the Root Causes of Migration in Central America". In: *Washington, DC: White House.* Available at, p. 4.

Ortega, F. and G. Peri (2013). "The effect of income and immigration policies on international migration". In: *Migration Studies* 1(1), pp. 47–74.

Otoiu, A., E. Titan, and R. Dumitrescu (2014). "Internal and international migration: Is a dichotomous approach justified?" In: *Procedia-Social and Behavioral Sciences* 109, pp. 1011–1015.

Ottaviano, G. I. and G. Peri (2012). "Rethinking the effect of immigration on wages". In: *Journal of the European Economic Association* 10(1), pp. 152–197.

Page, B. (2020). "Remittances". In: *International Encyclopedia of Human Geography* 2nd edn. Pp. 403–409.

Palma, A. de and K. Kilani (2007). "Invariance of conditional maximum utility". In: *Journal of Economic Theory* 132(1), pp. 137–146.

Pan, Y. (2017). "The Impact of Removing Selective Migration Restrictions on Education: Evidence from China". In: *Journal of Human Resources* 52(3), pp. 859–885.

Porcher, C., E. Morales, and T. Fujiwara (2024). *Measuring Information Frictions in Migration Decisions: A Revealed-Preference Approach*. Tech. rep. National Bureau of Economic Research.

Pratap, S. and E. Quintin (2006). "Are labor markets segmented in developing countries? A semiparametric approach". In: *European Economic Review* 50(7), pp. 1817–1841.

Rapoport, H. and F. Docquier (2006). "The economics of migrants' remittances". In: *Handbook of the economics of giving, altruism and reciprocity* 2, pp. 1135–1198.

Robin, N. (1996). *Atlas des migrations ouest-africaines vers l'Europe, 1985-1993*. Montpellier: IRD Éditions.

Robin, N. (2000). *Facteurs d'attraction et de répulsion à l'origine des flux migratoires internationaux: rapport national Sénégal*. IRD et Eurostat.

Rosenthal, S. S. and W. C. Strange (2004). "Evidence on the nature and sources of agglomeration economies". In: *Handbook of regional and urban economics*. Vol. 4. Elsevier, pp. 2119–2171.

Rosenzweig, M. R. (1988). "Labor markets in low-income countries". In: *Handbook of development economics* 1, pp. 713–762.

Saiz, A. (2010). "The geographic determinants of housing supply". In: *The Quarterly Journal of Economics* 125(3), pp. 1253–1296.

Shrestha, S. A. (2017). "No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants". In: *The Economic Journal* 127(600), pp. 495–521.

Squicciarini, M. P. and N. Voigtländer (2015). “Human capital and industrialization: Evidence from the age of enlightenment”. In: *The Quarterly Journal of Economics* 130(4), pp. 1825–1883.

Stark, O., C. Helmenstein, and A. Prskawetz (1997). “A brain gain with a brain drain”. In: *Economics letters* 55(2), pp. 227–234.

Stark, O. and Y. Wang (2002). “Inducing human capital formation: migration as a substitute for subsidies”. In: *Journal of Public Economics* 86(1), pp. 29–46.

Theoharides, C. (2018). “Manila to Malaysia, Quezon to Qatar International Migration and Its Effects on Origin-Country Human Capital”. In: *Journal of Human Resources* 53(4), pp. 1022–1049.

Tombe, T. (2015). “The missing food problem: Trade, agriculture, and international productivity differences”. In: *American Economic Journal: Macroeconomics* 7(3), pp. 226–258.

Tombe, T. and X. Zhu (2019). “Trade, migration, and productivity: A quantitative analysis of china”. In: *American Economic Review* 109(5), pp. 1843–72.

UNDP (2009). “Human development report 2009. Overcoming barriers: Human mobility and development”. In: *Overcoming Barriers: Human Mobility and Development (October 5, 2009). UNDP-HDRO Human Development Reports*.

United Nations (2000). *Cross-national comparisons of internal migration: an update on global pattern and trends*. United Nations: Population Division, Technical Paper no. 2013/1.

Vidal, J.-P. (1998). “The effect of emigration on human capital formation”. In: *Journal of Population Economics* 11(4), pp. 589–600.

Vollrath, D. (2009). “How important are dual economy effects for aggregate productivity?” In: *Journal of Development Economics* 88(2), pp. 325–334.

Yang, D. (2011). “Migrant remittances”. In: *Journal of Economic perspectives* 25(3), pp. 129–152.

Appendix

4.A Tables

Table A.1: Internal migration rate by department and education level (18+)

	Wave 1 (2004-2008)					Wave 2 (2009-2013)				
	All	NFE	LS	MS	HS	All	NFE	LS	MS	HS
Dakar	10.3%	11.0%	9.6%	10.3%	11.0%	15.6%	18.3%	13.7%	13.7%	16.2%
Pikine	4.8%	4.1%	5.1%	6.2%	10.0%	5.7%	4.7%	6.2%	7.7%	11.5%
Rufisque	3.1%	2.5%	2.9%	5.2%	9.3%	3.1%	2.5%	2.8%	4.9%	9.0%
Guediawaye	10.1%	10.3%	9.8%	9.3%	11.3%	10.8%	11.1%	10.4%	10.7%	10.7%
Bignona	4.8%	2.5%	5.8%	13.2%	25.7%	5.1%	3.3%	5.9%	12.1%	17.7%
Oussouye	5.5%	2.6%	5.6%	13.5%	27.6%	5.5%	3.1%	5.8%	12.9%	20.0%
Ziguinchor	8.6%	6.0%	8.4%	14.0%	25.2%	9.1%	7.0%	8.6%	15.3%	23.6%
Bambey	5.5%	4.7%	8.7%	13.3%	21.5%	4.5%	3.9%	6.8%	11.1%	21.6%
Diourbel	7.7%	6.7%	10.3%	15.1%	25.6%	12.2%	12.1%	10.9%	15.6%	20.8%
Mbacke	3.9%	3.4%	8.4%	9.7%	15.4%	5.6%	5.1%	10.4%	11.5%	14.8%
Dagana	2.6%	1.7%	3.6%	8.2%	17.3%	3.5%	3.0%	3.8%	8.0%	14.5%
Podor	2.5%	1.9%	4.9%	8.8%	20.9%	6.8%	6.6%	6.7%	11.7%	21.4%
Saint Louis	4.5%	2.8%	3.9%	11.2%	24.1%	4.2%	2.8%	4.1%	9.5%	20.9%
Bakel	3.3%	2.3%	7.0%	18.0%	29.4%	5.8%	5.0%	9.0%	19.4%	23.3%
Tambacounda	3.9%	2.3%	8.2%	17.6%	32.0%	4.6%	2.9%	9.1%	20.9%	29.7%
Goudiry	1.7%	1.4%	5.4%	17.2%	15.3%	5.7%	5.3%	8.6%	16.3%	23.7%
Koumpentoum	2.5%	2.2%	5.4%	9.6%	14.5%	9.6%	8.7%	18.6%	23.1%	25.0%
Kaolack	6.6%	5.1%	7.5%	13.7%	25.3%	8.0%	7.1%	8.3%	14.6%	20.6%
Nioro Du Rip	2.8%	2.1%	5.1%	10.4%	20.0%	6.4%	5.6%	10.4%	13.7%	17.8%
Guinguineo	4.8%	3.4%	7.8%	14.5%	23.4%	6.6%	4.2%	11.3%	21.4%	44.8%
Mbour	3.7%	2.6%	4.7%	8.4%	17.4%	3.9%	2.9%	5.0%	7.7%	12.9%
Thiès	4.6%	3.2%	5.8%	10.2%	17.4%	4.5%	3.2%	5.4%	10.6%	16.1%
Tivaouane	3.4%	2.7%	5.4%	8.2%	14.5%	9.6%	9.6%	8.7%	10.9%	14.7%
Kebemer	5.0%	4.5%	7.8%	11.0%	21.2%	12.4%	12.0%	14.8%	17.9%	19.5%
Linguère	2.9%	2.3%	5.5%	11.5%	22.2%	3.4%	2.7%	7.2%	11.1%	20.%
Louga	3.5%	2.9%	5.0%	8.8%	17.7%	4.8%	4.2%	6.5%	9.6%	13.9%
Fatick	5.2%	3.4%	6.9%	16.7%	29.5%	4.9%	3.6%	6.2%	15.4%	21.9%
Foundiougne	3.3%	2.4%	4.3%	9.5%	21.8%	3.7%	3.3%	3.6%	11.0%	15.7%
Gossas	7.6%	6.3%	12.2%	16.3%	27.2%	10.4%	7.0%	22.6%	36.8%	46.5%
Kolda	5.0%	3.2%	8.0%	16.2%	27.9%	5.9%	4.0%	9.5%	18.4%	25.7%
Velingara	1.7%	1.1%	4.0%	9.0%	21.0%	2.9%	2.3%	5.1%	11.7%	17.2%
Medina Yoroufoula	2.0%	1.7%	4.2%	11.5%	32.5%	5.6%	5.4%	6.4%	17.9%	33.7%
Matam	3.3%	2.5%	7.4%	12.8%	26.2%	3.7%	2.7%	7.8%	18.7%	31.3%
Kanel	1.4%	1.1%	4.1%	7.5%	10.4%	1.4%	1.2%	3.5%	8.7%	14.2%
Ranerou	2.5%	1.9%	10.0%	28.0%	44.9%	2.5%	1.9%	9.2%	31.4%	46.4%
Kaffrine	5.1%	4.3%	7.6%	15.4%	25.7%	5.8%	5.0%	8.9%	16.4%	24.2%
Birkelane	3.1%	2.7%	6.0%	13.4%	14.8%	4.0%	3.9%	5.2%	7.4%	12.9%
Koungheul	2.5%	2.0%	7.8%	12.5%	25.3%	3.1%	2.7%	7.0%	13.8%	20.9%
Malem Hodar	3.3%	3.1%	4.9%	10.8%	6.8%	22.5%	22.0%	25.0%	42.6%	42.5%
Kedougou	4.6%	3.2%	6.7%	14.9%	31.3%	4.7%	3.1%	6.8%	18.9%	32.7%
Salemata	11.2%	7.7%	19.3%	33.5%	39.1%	39.5%	35.6%	46.1%	68.0%	85.6%
Saraya	2.7%	2.0%	4.5%	20.7%	25.0%	6.7%	6.6%	6.1%	13.9%	30.3%
Sedhiou	5.2%	3.5%	9.2%	14.5%	24.4%	6.6%	5.3%	9.3%	15.1%	21.8%
Bounkiling	1.8%	1.3%	4.7%	11.0%	13.7%	4.7%	3.7%	11.8%	13.5%	16.2%
Goudomp	3.1%	2.1%	7.3%	7.6%	14.5%	4.0%	2.8%	9.2%	9.2%	12.9%

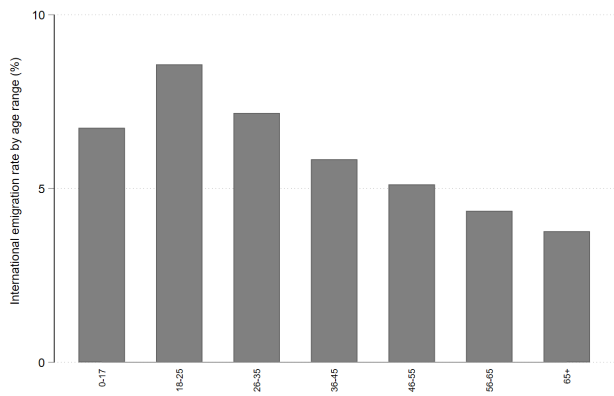
Table A.2: International emigration rate by destination

	Flows 18+	Emigration rate by destination 18+				
Department	Flows 18+	All	Africa	HIC	Transit	RoW
Dakar	18,766	4.3%	0.6%	2.7%	0.3%	0.6%
Pikine	14,672	3.7%	1.0%	2.1%	0.3%	0.3%
Rufisque	4,418	2.7%	0.9%	1.3%	0.2%	0.3%
Guediawaye	5,556	4.9%	1.0%	3.0%	0.4%	0.5%
Bignona	1,603	2.0%	1.1%	0.7%	0.1%	0.2%
Oussouye	296	1.9%	0.6%	1.0%	0.2%	0.1%
Ziguinchor	1,718	2.1%	0.8%	1.0%	0.1%	0.2%
Bambey	1,304	1.3%	0.4%	0.7%	0.1%	0.2%
Diourbel	2,307	2.6%	1.0%	1.0%	0.1%	0.5%
Mbacke	9,877	3.5%	1.0%	2.1%	0.1%	0.3%
Dagana	2,370	2.7%	2.2%	0.3%	0.0%	0.1%
Podor	7,904	6.1%	5.1%	0.7%	0.0%	0.3%
Saint Louis	3,200	3.4%	1.8%	1.3%	0.1%	0.2%
Bakel	2,735	5.6	1.3%	4.2%	0.0%	0.1%
Tambacounda	2,376	2.9%	1.0%	1.5%	0.3%	0.1%
Goudiry	2,443	6.6%	2.2%	3.5%	0.7%	0.1%
Koumpentoum	440	1.0%	0.6%	0.3%	0.1%	0.0%
Kaolack	3,035	1.9%	0.6%	1.0%	0.1%	0.2%
Nioro Du Rip	1,459	1.3%	0.6%	0.5%	0.1%	0.1%
Guinguineo	458	1.2%	0.4%	0.7%	0.1%	0.1%
Mbour	4,204	1.9%	0.5%	1.0%	0.2%	0.2%
Thiès	5,713	2.7%	0.8%	1.4%	0.2%	0.3%
Tivaouane	3,266	1.9%	0.4%	1.1%	0.1%	0.3%
Kebemer	1,982	1.9%	0.4%	1.3%	0.0%	0.1%
Linguère	814	0.9%	0.4%	0.4%	0.0%	0.1%
Louga	4,131	3.1%	0.8%	2.1%	0.1%	0.2%
Fatick	1,116	1.0%	0.3%	0.4%	0.1%	0.2%
Foundiougne	1,900	2.2%	0.8%	1.1%	0.1%	0.2%
Gossas	372	1.1%	0.4%	0.5%	0.0%	0.1%
Kolda	1,992	2.7%	0.8%	1.1%	0.7%	0.1%
Velingara	3,877	4.2%	2.2%	1.2%	0.6%	0.2%
Medina Yoroufoula	948	2.3%	1.1%	0.7%	0.3%	0.2%
Matam	9,812	10.1%	7.1%	2.5%	0.0%	0.5%
Kanel	10,454	12.8%	7.6%	4.5%	0.0%	0.6%
Ranerou	146	0.9%	0.7%	0.1%	0.0%	0.1%
Kaffrine	684	1.0%	0.5%	0.4%	0.0%	0.1%
Birkelane	335	1.0%	0.4%	0.4%	0.0%	0.1%
Koungheul	464	0.9%	0.4%	0.3%	0.1%	0.1%
Malem Hodar	179	0.5%	0.2%	0.2%	0.0%	0.0%
Kedougou	424	1.8%	0.6%	1.1%	0.0%	0.1%
Salemata	111	1.0%	0.3%	0.6%	0.0%	0.0%
Saraya	156	1.1%	0.4%	0.6%	0.0%	0.1%
Sedhiou	1,168	2.4%	0.9%	1.1%	0.3%	0.2%
Bounkiling	992	2.2%	0.8%	1.0%	0.2%	0.1%
Goudomp	999	2.1%	0.8%	0.6%	0.5%	0.1%

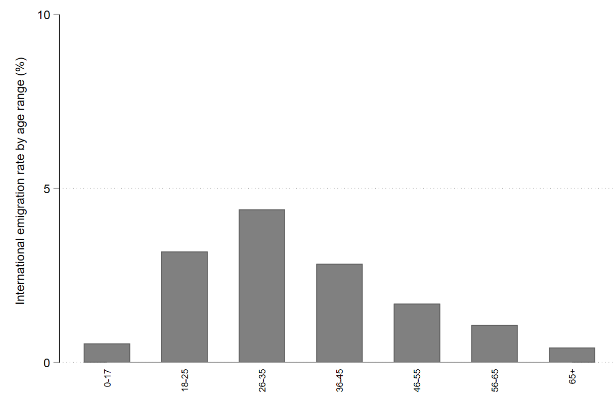
4.B Figures

Figure A.1: internal and international migration rate by age and education

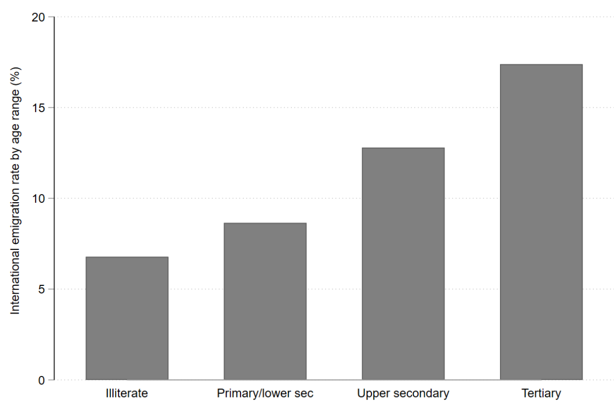
(**a**) Internal (age range)



(**b**) International (age range)



(**c**) Internal (Education)



(**d**) International (Education)

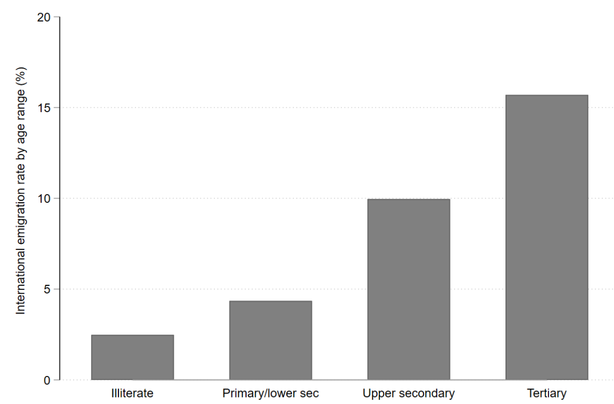
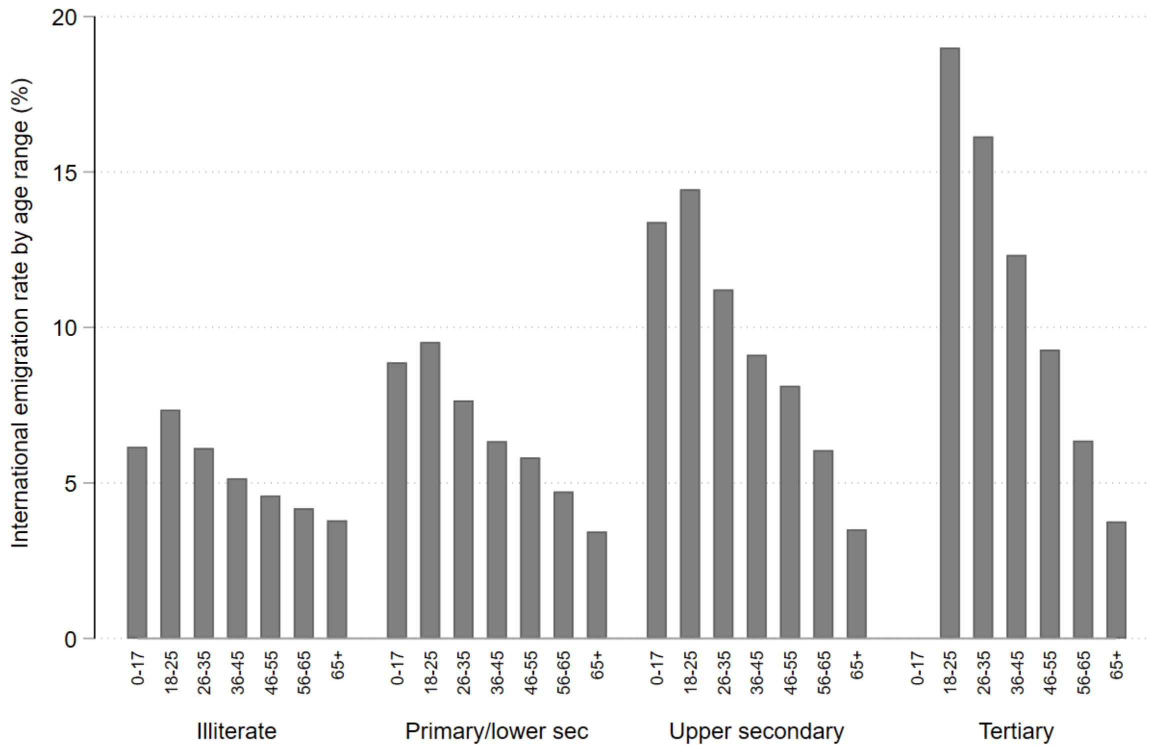


Figure A.2: Internal and international migration rate across age and education

(**a**) Internal



(**b**) International

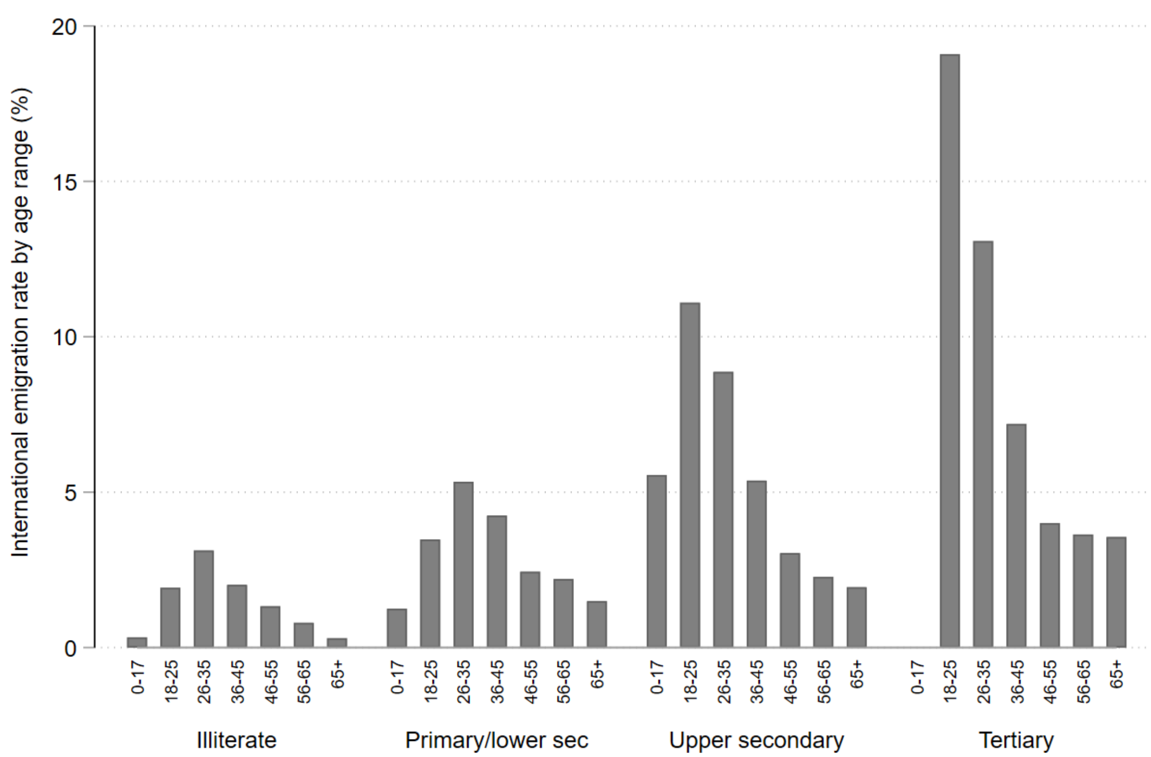


Figure A.3: Senegalese migrants: destinations

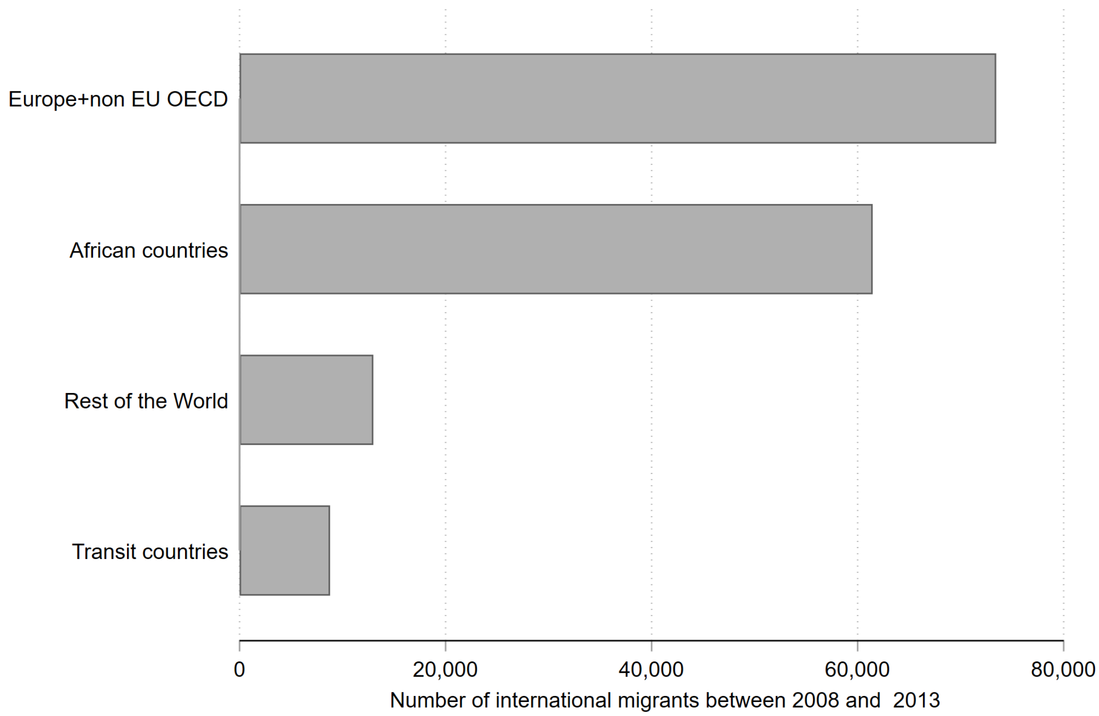


Figure A.4: Senegalese migrants: breakdown by gender by destination

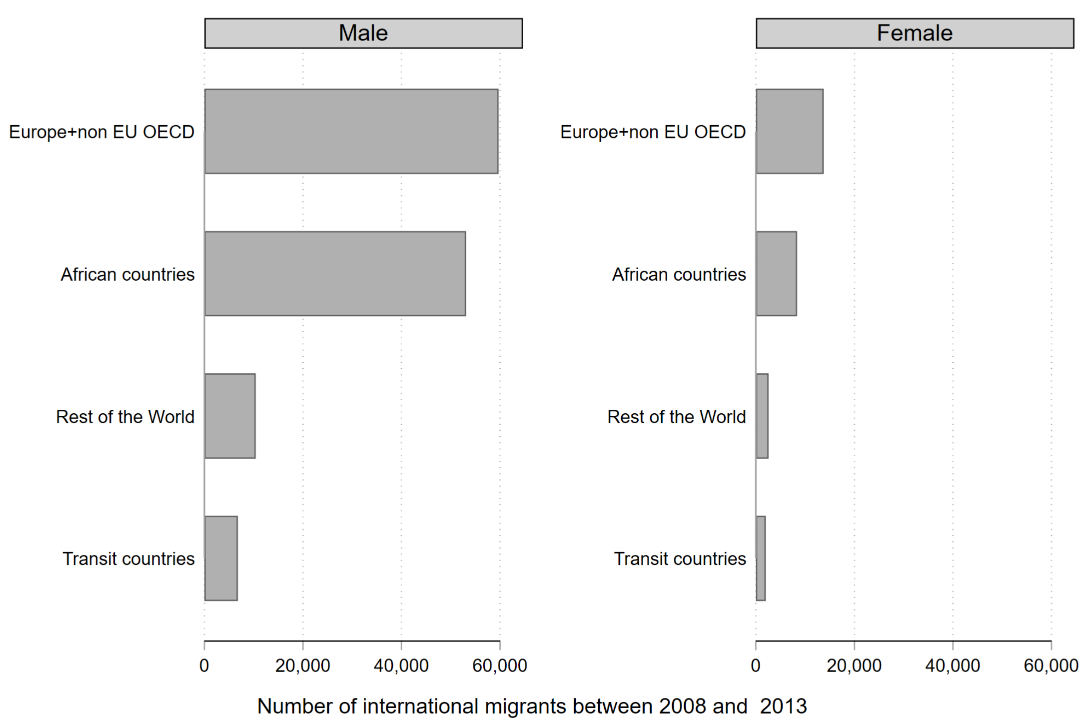


Figure A.5: Senegalese migrants: breakdown by age and destination

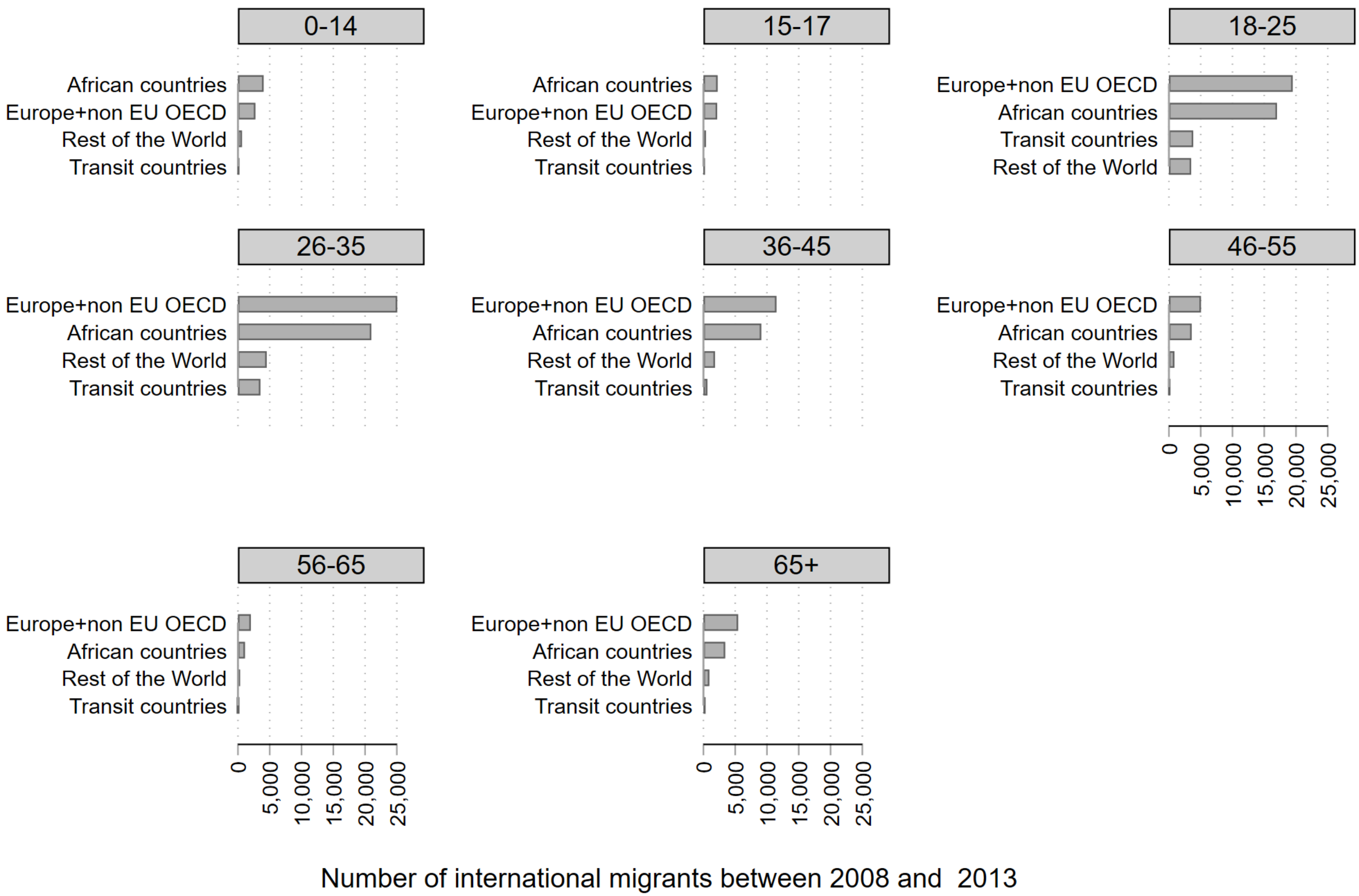


Figure A.6: Synthetic disbursement profile

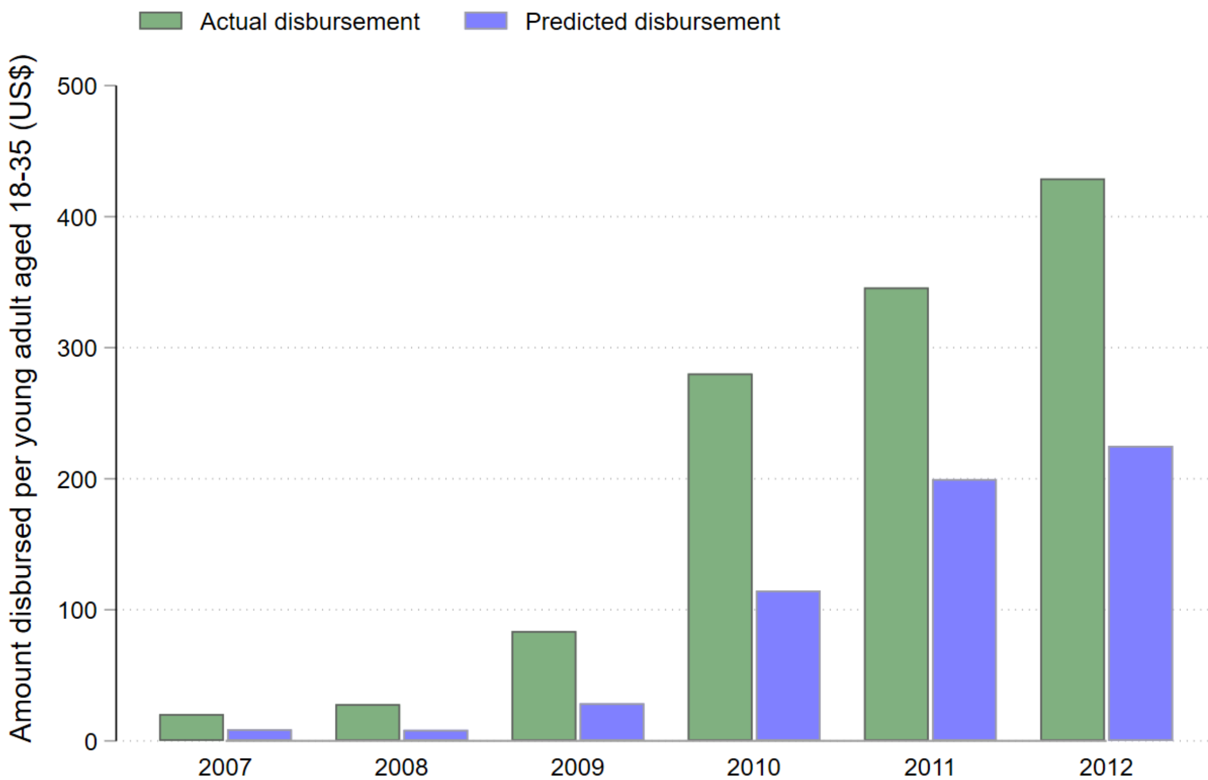
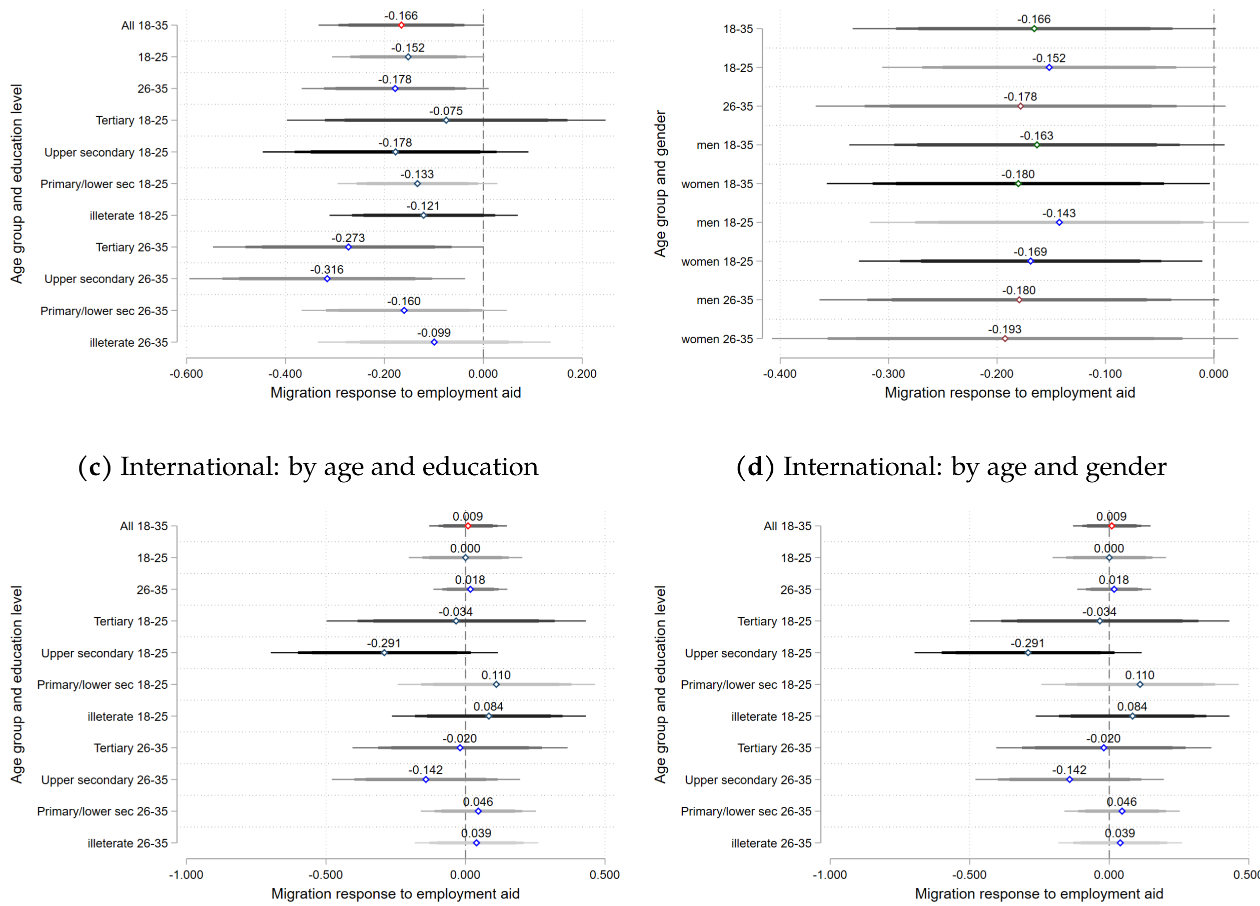


Figure A.7: Migration response to employment aid by age, education and gender



(**a**) Internal: by age and education

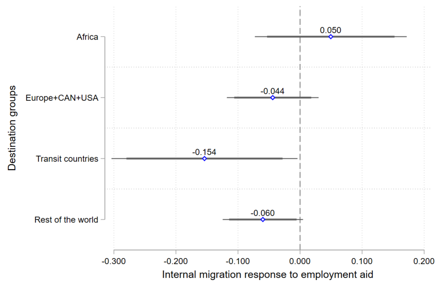
(**b**) Internal: by age and gender

(**c**) International: by age and education

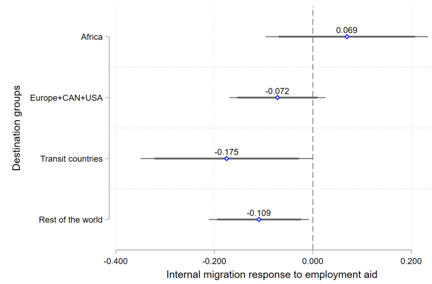
(**d**) International: by age and gender

Figure A.8: International migration response to employment aid by age, gender and destination

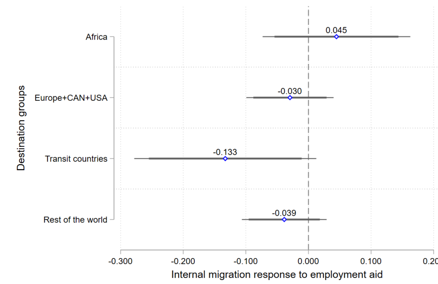
(**a**) All (18-35)



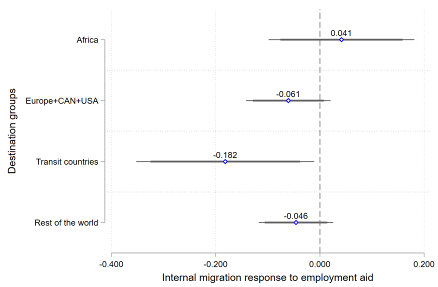
(**b**) 18-25



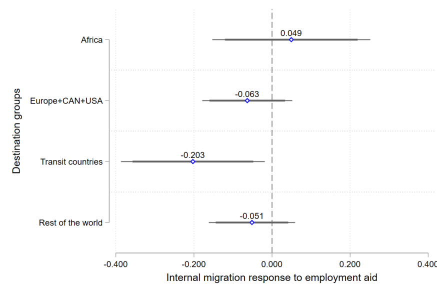
(**c**) 26-35



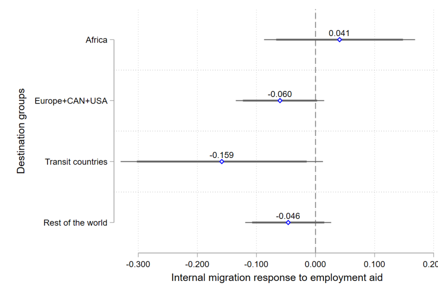
(**d**) All men (18-35)



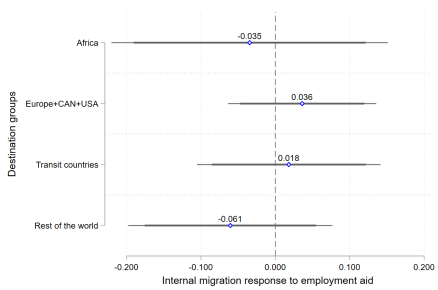
(**e**) Men 18-25



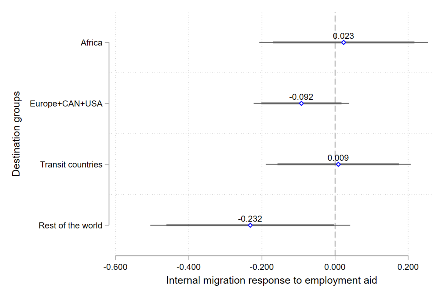
(**f**) Men 26-35



(**g**) All women



(**h**) Women 18-25



(**i**) Women 26-35

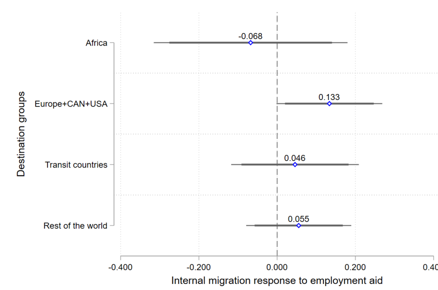
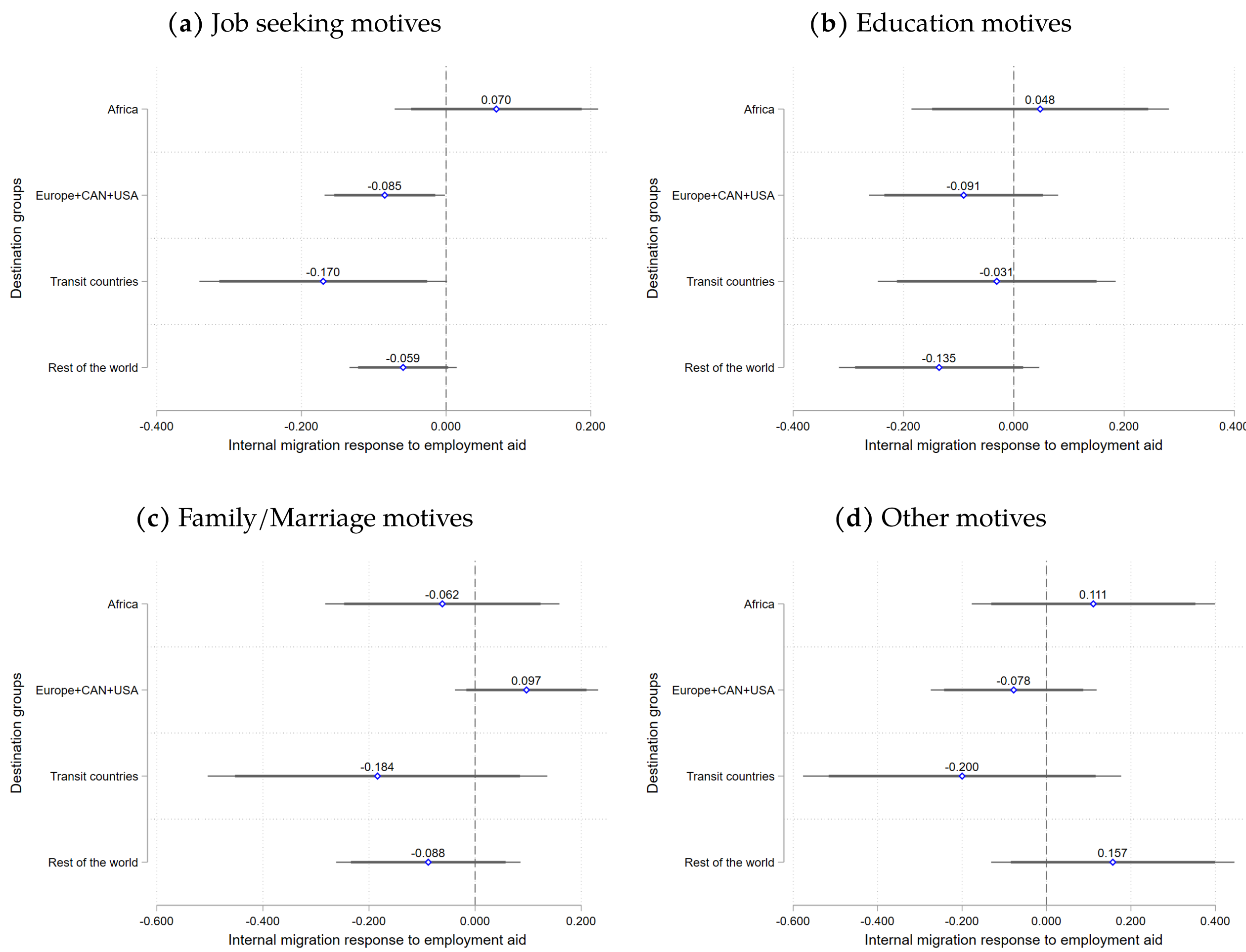


Figure A.9: International migration response to employment aid by motive and destination



Conclusion

This thesis discusses the complex relationship between selective migration, human capital, and economic development, revealing both the opportunities and challenges that migration presents at various geographical scales. Through a combination of theoretical modeling and empirical analysis, it offers fresh insights into how internal and international migration influence the spatial distribution of workers, productivity and welfare across countries, and within countries using Senegal as a case study. Migration, both internal and international, emerges as an important factor that shapes economic outcomes for both origin and destination locations. The thesis acknowledges that migration has complex, often contradictory effects: on the one hand, it provides opportunities for skill accumulation and ("brain gain") and productivity, while on the other hand, it can deplete some poor locations of valuable human capital ("brain drain") required for their development and generates negative productivity externalities on workers left behind.

The first key contribution of this research is the development of a generalized framework that quantifies these effects in a simple and comprehensive way. The second central contribution of this thesis is to extend the assessment of the distributional effects of migration to internal migration, which is not only an additional component of mobility, but also the dominant one. This allows me to show that the brain gain effect at cross-country level to be stronger in the least developed countries operates differently within countries were those gains are concentrated in rich and well connected regions and strengthened by internal migration. The third major contribution of this thesis is to rationalize the heterogeneity of migration patterns at sub-national level and connect it with the spatial distribution of economic activity using a Spatial General Equilibrium Model. The model accounts for various migration flows—both internal (e.g., rural-urban) and international—and integrates the feedback effects that arise from migration, such as changes in local productivity, human capital formation, and remittance flows. Through this model, the dissertation offers a deeper understanding of how migration reshapes the spatial distribution of economic activity and welfare, providing a robust framework for policy analysis. The fourth contribution of the thesis is its exploration of how economic shocks, such as exposure to development aid, influence migration decisions. Using the case of Senegal, the thesis shows that local development aid projects by improving employment opportunities reduce internal migration and international migration to transit countries. This finding highlights the need for a better understanding of how local economic conditions shape migration flows.

Overall, this thesis demonstrates that, not only the understanding of the distributional effects of selective migration requires a generalized approach that simultaneously accounts for most of its well established feedback effects, but also requires the simultaneous consideration of internal and international migration. The thesis has also demonstrated that these distributional effects of migration need to be assessed at various geographical level as the mechanisms at play operate in very heterogeneous ways at different geographical scales, featuring the local migration pattern (size, skill composition, origin and destination dyads involved). Through a combination of structural modeling and empirical evidence, it offers valuable insights for policy makers. The thesis provides a solid foundation for future work on migration and its role in shaping global and local development trajectories.