

# What Makes Brain Drain More Likely?

## Measuring the Effects of Migration on the Schooling Investments of Heterogeneous Households <sup>☆</sup>

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### Abstract

This paper studies the effects of migration on the schooling investment of heterogeneous households. I use an IV-discrete choice model of schooling investment, which distinguishes between migration attempts and actual migrations to (partially) identify the net effect of migration on schooling investments. Looking at emigration from Senegal to Europe, I find a negative net effect of migration on the enrollment in upper secondary education for many sub-groups of households in Senegal. Interestingly, there is a gender difference in the causes of these negative signs: positively skill-biased migration leads to the negative net effect observed on women, whereas disincentives to invest in education drive the negative net effect observed on men. Furthermore, the analysis suggests that financially constrained households substitute an investment in migration to an investment in education.

*Keywords:* Migration, brain drain, brain gain, sharp bounds.

*JEL:* C71, I25, J61.

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## 1. Introduction

Despite all its negative connotations, the term “Brain Drain” has come to dominate the popular discourse about high-skilled migration. This dominance betrays a perception of high-skilled migration as a permanent loss of human capital experienced by the sending countries. To be sure, the disproportionately larger emigration of the high-skilled, when compared to the low-skilled migration, is a well established fact that should be primarily understood as a *selection effect*.<sup>1</sup> However and increasingly, economists warn that one should not be over-pessimistic about the effects of migration on the resulting human capital of the sending country, especially of a developing country. One reason is that migration prospects from some developing country  $A$  to some developed country  $B$  might create non-negligible incentives for further human capital accumulation in  $A$ . The resulting effect has been coined “brain gain” and can be understood as an *incentive effect*. Then, from the perspective of the source country  $A$ , what is important is the resulting *net effect*, rather than the sole *selection effect*. Indeed, if a sizable proportion of migration candidates stays in  $A$  after upgrading education, or part of the educated migrants returns,  $A$  might benefit from an increase in its overall human capital. One would then talk about a “positive net effect” or a “net brain gain” for source country  $A$ .<sup>2</sup>

As developed countries compete more fiercely to attract foreign talents, governments of developing countries ponder what should be the appropriate policy response to high-skilled migration. They expect from economists answers to at least three essential questions: what makes “brain drain” more likely? Does “brain gain” exist? what determines the sign and magnitude of the net effect?<sup>3</sup> Probably because of an understanding of the “brain drain” as a macroeconomic issue, the empirical microeconomic literature has so far concentrated on establishing the existence of the *incentive effect*<sup>4</sup>, leaving to the empirical macroeconomic literature the task to establish the

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<sup>1</sup>In one of the largest existing dataset on bilateral international migration, Docquier and Marfouk (2006) find that the emigration rate is five to ten times higher for individuals with more than twelve years of than for workers with less than twelve years of education.

<sup>2</sup>Beine, Docquier, and Rapoport (2001, 2008) also use the term beneficial brain drain.

<sup>3</sup>The first and second question have been asked by Gibson and McKenzie (2011a).

<sup>4</sup>Gibson and McKenzie (2011b) is an exception. They ask the first of the three questions, but look at the issue only indirectly by exploring the determinants of high-skilled migration from small

determinants of this net effect.<sup>5</sup>

This paper takes a new approach to the empirical study of the effects of migration on the source country's human capital by differentiating the *selection*, *incentive* and *net effects* at the household level. I study these effects for households in Dakar, the capital city of Senegal, a Sub-Saharan African country with a large "brain drain" rate. I argue that the differentiation at the household level is relevant in at least three respects: (1) it helps understanding the microeconomic mechanisms leading to the observed macroeconomic effects. The empirical analysis below clearly shows that well-off families invest more in secondary education when there exist emigration prospects, while other families might even disinvest in upper secondary education. This and further results point to credit constraints that force poor families to substitute a migration investment to a schooling investment. Thus, the observed "brain drain" is the result of a market imperfection and should be addressed with corrective policies. (2) Related to this point, the focus on household helps designing targeted interventions at well identified units. In the short and middle term, targeted interventions represent a more promising avenue to address concerns about the "brain drain" than vast governmental policies to upturn structural trends. In the context of Senegal, funding a skill-selective migration scheme for poor families could correct the market imperfection, and induce more investment in education. (3) Finally, the asymmetric distribution of incentives has in turn distributional effects. In a context where the sign of the net effect depends on the economic status of the household, one should question the implication of migration for social mobility in the next generation.

To measure the *incentive* and the *net effect*, one needs to compare the schooling investment in the observed (factual) state of the economy to the schooling investment in an hypothetical (counterfactual) situation where migration rules are stricter. As the main challenge is to retrieve the counterfactual schooling investment, a model describing investment in education in the presence (and absence) of an emigration option is

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Pacific countries.

<sup>5</sup>For example Beine, Docquier, and Rapoport (2001, 2008) shows that the brain drain is most severe in countries with small population or with high migration rates. The net brain gain exists mostly for countries combining initially low levels of human capital and low emigration rates. See also Kapur and McHale (2005) and Docquier and Rapoport (2012) who provide excellent discussions and surveys on the recent theoretical and macroeconomic literature on the brain gain hypothesis.

necessary. I introduce a simple discrete choice model in a human capital investment framework where a household take two decisions for a child: one about education and one about migration. These decisions are described as simultaneous, and both depend on observed as well as unobserved characteristics correlated across decisions. The “brain gain” hypothesis emphasizes that the realization of the migration project is subject to some randomness and that some candidates to migration are forced to stay in the home country. The model explicitly accounts for this discrepancy between the migration decision and the actual migration, and uses it as an additional source of identification. The proposed model improves on the previous literature in that it (i) accounts explicitly for the migration perspectives, and (ii) allows quantifying different net effects of the brain circulation for different household’s characteristics. Contrary to other studies though, e.g. Batista, Lacuesta, and Vicente (2012), the identification strategy imposes a focus on one precise counterfactual: the *closed economy*, where no migration prospect exists. Nevertheless, this is a counterfactual largely discussed in the literature, for example Mountford (1997), Stark, Helmenstein, and Prskawetz (1997), and Beine, Docquier, and Rapoport (2001, 2008).

Point identification of the *incentive* and the *net effect* in this framework is challenging as it requires large exogenous variations to isolate the counterfactual schooling investment. I argue that, given the data at hand, to entertain such assumptions on the exogenous variations would be untenable. Nevertheless, the model delivers simple tractable bounds on the counterfactual schooling investment. These bounds can be used to test for the existence of strictly positive incentive effects, even without instrument. When an instrument is available, the bounds require, neither the satisfaction of a “large support” condition, nor a specification of an equation of the migration decision. Moreover, the bounds are derived under mild *exogeneity* assumptions.

The empirical analysis of schooling investment in Senegal uses the MAFE (Migration from Africa to Europe Project) dataset, which contains detailed information on migrants and non-migrants from Senegal. Most importantly, the data provides information on attempts to migration, as well as detailed information on the respondent’s network, which I use to construct some exclusion restrictions. I find that the net effect is essentially negative in the population, meaning that the average schooling level in Senegal would have been higher in a closed economy. Only rich families seem to invest more in education because of emigration prospects. Poorest families

seem to disinvest the most in upper secondary education, suggesting that borrowing constraints are the causes of the disinvestment. Consistent with this explanation, in families where one member lives abroad and is likely to send remittances, the schooling investment is less elastic to emigration prospects than it is in similar families without a migrant member. Finally, there is almost no evidence of a net positive effect, even after accounting for return migration.

The rest of paper proceeds as follows: Section 2 links the present paper to the existing literature on the brain drain/brain gain topic. Section 3 motivates the measures for the net effect of the emigration prospects on human capital accumulation, and introduces the discrete choice model that describes schooling decisions in the presence of an emigration option. Subsequently, Section 4 discusses identification issues and derives the bounds on the net effect. Section 5 describes the background to education, migration and the brain drain in Senegal. Section 6 presents the MAFE dataset, along with some insightful descriptive statistics. Section 7 presents the estimation methodology. Then, Section 8 presents and discusses the estimation results, and, finally, Section 9 concludes. Technical proofs are relegated in the Appendix.

## 2. Related Literature

The “brain drain” argument as exposed, for example by Bhagwati and Hamada (1974), emphasizes the loss of human capital incurred by low-income countries due to positive skill-biased emigration. This loss impedes growth by depriving developing country from the output and positive externalities generated by high-skilled migrants. The so-called “brain drain” should be understood as a *selection effect*, in that high skill individuals select themselves more often into migration; thus they are overrepresented among migrants and underrepresented in the origin country. Against this background, the seminal contributions from Mountford (1997) and Stark, Helmenstein, and Prskawetz (1997), among others, pioneered a more optimistic view on the consequences of the high-skilled emigration, by pointing out the *incentive effect* of emigration prospects on human capital acquisition. This insight has been confirmed in several empirical studies, including Batista, Lacuesta, and Vicente (2012), Chand and Clemens (2008), Shrestha (2015), Theoharides (2015). Nevertheless, other studies also point out the possibility that in a context of low returns to education, emigration prospects produce negative incentives. Girsberger (2014) finds that labor migration from Burkina Faso

to Côte d'Ivoire lowers the educational attainment in rural regions of Burkina Faso. This labor migration is to work in Cocoa plantations, where no formal education is required. McKenzie and Rapoport (2011) show that household migration from US to Mexico can lower educational attainment of children, which the authors attribute to low returns to education for illegal migrants in the United States.

At the empirical level, studies on the net effect of emigration prospects on human capital formation at the individual level face the challenge to find plausible exogenous variations on the emigration prospects. Chand and Clemens (2008) use a quasi-experimental set-up after a military coup in Fiji, while Shrestha (2015) relies on a quasi-experimental setting about enrollment in the British Army in Nepal. Overall, the challenge remains the external validity of these specific experiments.

The framework of this paper is closest to the one of Batista, Lacuesta and Vicente (2014) (henceforth BLV) who study the case of Cape Verde using an instrumental variable strategy. They propose testing for the existence of the incentive effect by testing for a significant linear correlation between the own future probability of migration and the schooling decisions. Using simulation methods, they then estimate the country-wise net effect of the emigration prospects on the enrollment in upper secondary schools. This study improves on their work in several respects. The unique data used here allows observing migrants in their destination countries, while BLV have the concern that households who emigrate and leave no one in the origin country are not accounted for.<sup>6</sup> Moreover, the data contains information on migration attempts by the respondents, which is unobserved by BLV, but allows testing for a strictly positive incentive effect even without an instrument. The present study also presents methodological advances. While BLV measure an average effect of emigration prospects on schooling incentives, the methodology used here quantifies different effects for different individual's characteristics. Moreover, I substantially relax their stringent assumptions on the functional form of the model equations, the structure of the error terms and the properties of the instrumental variables. Indeed, the model proposed below uses very general functional forms. These functional forms would reduce to BLV's Simultaneous Equation Model only at the cost of high level assumptions about the linearity and additive separability in the pa-

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<sup>6</sup>This possible source of biases is studied by Steinmayr (2014).

rameters. Besides, I do not make any parametric assumption on the error terms. Moreover, the proposed methodology is immune to weak instrument biases, which sometimes seems to be problematic in BLV's framework and with our data. Finally, the validity of the instrument rests on a weaker exogeneity condition. This weaker set of assumptions can be entertained because the proposed methodology estimates precise features of the model rather than the full model. As noted by Heckman and Vytlacil (2001), weaker assumptions produce more reliable results, but at the same time, cannot generate the complete array of policy counterfactuals from estimates of the full model. While BLV estimate an average net effect for different levels of the emigration prospects, this study focuses on heterogeneous effects from one counterfactual scenario, the *closed economy*, a counterfactual largely discussed in the literature, for example Mountford (1997), Stark, Helmenstein, and Prskawetz (1997), and Beine, Docquier, and Rapoport (2001, 2008).

Finally, note that remittances and return migration are alternative channels through which the sending country can experience an increase in its human capital (Gibson and McKenzie, 2011a; Dinkelman and Mariotti, 2014; Theoharides, 2015). The present framework can isolate the contribution of return migrants to the observed human capital. The latter is considered in Section 8.2. Although the data do not permit to observe remittances at the time of schooling investment, I discuss the effect of having a family member living abroad in this period.

### 3. Measures of the Effects of Migration on Schooling Decision

The usual measure of the net effect of migration on schooling investment compares the level of schooling in the observed (factual) state of the economy to the level of schooling in an hypothetical (counterfactual) situation where migration rules are stricter, as described in Section 3.1. This paper focuses on a counterfactual situation where no migration is possible: the *closed economy*.<sup>7</sup> Since the factual household's schooling decision is observed, the main challenge is to retrieve the counterfactual schooling investment in the case of closed economy; hence, the need for the model in Section 3.2 that describes schooling investment decisions in the presence (and absence) of an emigration option.

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<sup>7</sup>Section ?? makes clear why identification is more difficult under other counterfactual scenarios.

### 3.1. Empirical Measures of the Selection, Incentive and Net Effect at the household level

Let a household (parents and child) be characterized by  $W$ , a set of observable characteristics,  $D$  the schooling attainment of the child, and  $Y$  the migration status of the child, with  $Y = 0$  when the child has not emigrated. The interest of this paper is in the difference between the expected schooling decision of stayers in the current state economy and the expected schooling decision in a closed economy, as measured by:

$$\Delta(W) := E(D|Y = 0, W) - E(D_{cf}|W) \quad (1)$$

where  $D_{cf}$  is the counterfactual schooling decision.  $\Delta(W)$  measures the gain or the loss in the expected schooling level of the subgroup of individuals with characteristics  $W$ , between the current open economy and a counterfactual closed economy. If  $\Delta(W) > 0$ , there is a positive net effect for the subgroup  $W$ . Conversely, if  $\Delta(W) < 0$ , there is a net negative effect.  $\Delta$  is the measure of the net effect in the theoretical models discussed by Mountford (1997), Stark, Helmenstein, and Prskawetz (1997), and Beine, Docquier, and Rapoport (2001, 2008), now defined at the household level.

Note the decomposition:

$$\Delta(W) = (E(D|Y = 0, W) - E(D|W)) + (E(D|W) - \mathbb{E}(D_{cf}|W)).$$

The net effect results from two effects: the first term is the *selection effect*  $\Delta_{sel}(W) := E(D|Y = 0, W) - E(D|W)$ , which stems from the difference in the skill composition of migrants and stayers. The second term is the *incentive effect*,  $\Delta_{inc}(W) := E(D|W) - \mathbb{E}(D_{cf}|W)$ , which stems from emigration prospects changing the choice of education compared to the counterfactual scenario without migration. The brain gain literature emphasizes the case where the incentive effect is positive, in which case we talk of the “brain gain” effect in group  $W = w$ . However, as discussed previously, there exists instances where emigration prospects give disincentives to obtain further education.

The proposed measures can be easily modified to account additionally for return migration. Denoting by  $\mathcal{R}$  the pool of never-migrants and returned migrants, I can define:

$$\Delta^r(W) \equiv E(D|i \in \mathcal{R}, W) - E(D_{cf}|W) \quad (2)$$

Note that if  $\Delta^r > 0$  while  $\Delta < 0$ , this points out to the importance of return migration in compensating for the *ex ante* loss in human capital.

Among the preceding quantities,  $\mathbb{E}(D_{cf}|W)$  is the key unobserved one, and the main interest of the following model of schooling investment.

### *3.2. A Model of Schooling Investment in the Presence of an Emigration Option*

#### *3.2.1. Sketch the model*

I consider a framework based on the human capital literature, where education is considered as an investment in future earnings and employment for rationale agents who seek to maximize their lifetime earnings Willis, Rosen, and Heckman (1979). One can see the education decision as one made by benevolent parents in order to maximize the net lifetime earnings of the child. With imperfect credit markets, some families will be able to invest in optimal education, while some other will invest until the liquidity constraint is binding. As in Rosenzweig (2008), the returns to education depends on the location where the individual works, either home or abroad.

Formally, I consider two periods, two education levels and two locations: an origin country and a possible destination country. In the first period, a household with a child makes two decisions: which schooling level the child should attain, and whether the child should attempt emigration to the destination country at some cost. Schooling investments are made in the first period. However, investments in migration attempts await the second period and their success is subject to some randomness. This randomness reflects both policy barriers from the sending and the receiving countries, as well as unexpected shocks preventing emigration of the candidate. In the second period, given the obtained education, emigration is attempted, if the household decided so in the first period. The uncertainty on migration is solved and only a proportion of candidates actually migrate. The child enjoys the returns to education according to his location in the second period.

In this environment, risk neutral households with a subjective assessment of the success probability choose in the first period their investment in education in order to maximize their expected net lifetime earnings. The simple but powerful insight of the model is that the expected schooling level in the closed economy is the expected schooling level when no household makes an attempt to emigrate. This result holds even if one considers binding budget constraints for the migration investment.

### 3.2.2. Further Notations

More formally, consider a household  $i$  that makes two decisions: one about education and one about migration. Denote by  $\mathcal{W}_i$  the information set of a household  $i$  when the household makes the schooling and migration decisions in the first period.  $\mathcal{W}_i$  regroups a set of observable characteristics of  $i$  (age, gender, family size, family physical capital, etc.), say  $W_i$ , and a vector of latent variables  $u_i$ , unobserved by the researcher.<sup>8</sup>

Recall that  $D_i$  denotes the schooling attainment decided for the child by the household. I will consider two levels, which will correspond in our baseline to obtaining at least some upper secondary education, or not. Denote by  $Y_i^*$ , a binary variable describing the household's decision to attempt migration, and equals 1 if  $i$ 's decides to migrate. Again,  $Y_i$  is the child's actual migration status observed in the second period.

The household has a subjective probability, that migration takes place given an attempt migration, say  $p_{di} \equiv P(Y_i = 1 | W_i, D_i = d, Y_i^* = 1)$ . This subjective probability depends on the educational attainment chosen by  $i$ . Based on the substantial evidence from the empirical literature, we expect migration to be positively skill biased, that is more educated are more mobile, so that  $p_{0i} < p_{1i}$ .

The counterfactual scenario of interest in this paper is the case of closed economy, that is there is zero emigration probability. Thus, the main interest is in the schooling choice when there is no emigration prospect,  $D_{cf}$ ; that is,  $i$  chooses  $D_{cf,i}$  when  $p_{di}$  is counterfactually set to equal 0, for all  $d$  and  $i$ .  $E(D_{cf,i} | W_i)$  is the conditional expectation of this quantity.

Finally, I borrow notations from the potential outcome literature, denoting by  $D_i(0)$  the child's schooling attainment when  $Y_i^*$  is counterfactually set to equal 0 and  $D_i(1)$ , the corresponding schooling attainment when  $Y_i^*$  is counterfactually set to equal 1. The simple insight of the model is that  $\mathbb{E}D_i(0) := E(D_i(0) | W_i) = E(D_{cf,i} | W_i)$ . Therefore, the appropriate object of interest is the schooling choice in the case where  $Y_i^*$  is counterfactually set to equal 0,  $D_i(0)$ .<sup>9</sup>

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<sup>8</sup>Section 4.4 gives a more precise description of information set.

<sup>9</sup>Note that, in general,  $\mathbb{E}D_i(1)$  is not the same as the expected schooling level when  $p_{di}$  is counterfactually set to equal 1. That is because, in the absence of migration barriers, individuals

In the rest of the paper, I drop the subscript  $i$  to lighten the notation.

### 3.2.3. The Schooling Decision

Consider the schooling decision given a decision on migration. It is assumed that the household chooses the schooling level that maximizes the child's expected return given the migration choice. Let  $\Pi_d^y(W, u)$  be the net return (gains net of the costs) to education  $d$  in location  $y$ ,  $y \in \{0, 1\}$ .

Following the literature on returns to education, for example Dahl (2002), I will assume for simplicity that the observed and unobserved returns to education are separable, that is:

$$\Pi_d^y(W, u) = \Pi_d^y(W) + u_d^y \quad (3)$$

$\Pi_d^y(W)$  is the average net expected return to education  $d$  for a household with characteristics  $W$ .  $u_d^y$  is a latent cost of education that I interpret as the unobserved ability of the child to complete education  $d$  or a private consumption value of education  $d$ .

Given a migration decision  $Y^*$ , the household chooses education  $D = 1$  over  $D = 0$ , if and only if the following expression is positive:

$$\begin{aligned} \Pi_1^0(W) &- \Pi_0^0(W) + u_1^0 - u_0^0 \\ &+ p_1 Y^* (\Pi_1^1(W) - \Pi_1^0(W)) - p_0 Y^* (\Pi_0^1(W) - \Pi_0^0(W)) \\ &+ p_1 Y^* (u_1^1 - u_1^0) - p_0 Y^* (u_0^1 - u_0^0) \end{aligned} \quad (4)$$

The first line of Equation 4 represents the private returns to education  $D = 1$ , in the absence of emigration prospects. The second and third lines represent the additional incentive created by the emigration prospects. The second line stems from the average returns given characteristics  $W$ , while the third line stems from the latent returns. Note that the unobserved part of the total returns differs when  $Y^* = 1$  or  $Y^* = 0$ , which is the reason why standard regression techniques will produce biased estimates.

The simple implication of Equation (4) is that the education decision in the case of closed economy is the same as the individual choice in the case where the migration decision,  $Y^*$ , is counterfactually set to be equal to 0. This is because the return to education is the same whether  $p_1 = p_0 = 0$  or  $Y^* = 0$ . Therefore  $E(D_{cf}|W) = \mathbb{E}D(0)$ .

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might not exert their migration option (Katz and Rapoport, 2005)

### 3.2.4. Binding budget constraint

Since imperfect credit markets are a common feature of developing economies, it is important to account for the possibility of a binding budget constraint. Two cases are possible: (1) the budget constraint is binding for education irrespective of the migration decision, or (2) the budget constraint is binding for education only when the family decides to attempt migration. Equation (4) already accounts for the first possibility. In the second case, the maximization problem of the household includes an additional term,  $\lambda(W, u)Y^* < 0$ , that reflects the constraint on the family. That is the family maximizes:

$$\begin{aligned} \Pi_1^0(W) &= \Pi_0^0(W) + u_1^0 - u_0^0 \\ &+ p_1 Y^* (\Pi_1^1(W) - \Pi_1^0(W)) - p_0 Y^* (\Pi_0^1(W) - \Pi_0^0(W)) \\ &+ p_1 Y^* (u_1^1 - u_1^0) - p_0 Y^* (u_0^1 - u_0^0) + \lambda(W, u) Y^* \end{aligned} \quad (5)$$

$\lambda(W, u)$  should increase with the wealth of the family, and be zero if the budget constraint is not binding. Conversely, if no borrowing opportunity exists,  $\lambda(W, u) = -\infty$ , and migration prospects do not provide additional incentives to obtain education 1. In the case of a constrained maximization,  $E(D_{cf}|W) = \mathbb{E}D(0)$  if no one attempts migration for  $p_1 = p_0 = 0$ . The latter will be true under three plausible conditions: (1) individuals maximize their expected returns to migration, (2) any migration attempt is costly, and (3) yields a positive return only in the case of a successful emigration ( $Y = 1$ ).

To sum up,  $\mathbb{E}D(0)$  is the proper object to compare with the level of education in the open economy. Section 4 discusses the identification of  $\mathbb{E}D(0)$ . In particular, while point identification of this quantity is challenging, one can easily derive tractable and informative bounds. Before turning to the identification of  $\mathbb{E}D(0)$ , it is instructive to pay more attention to the effects of emigration prospects on schooling returns.

### 3.3. The Effect of Emigration Prospect on Schooling Choice

At the heart of the brain gain literature is the assumption that, in the context of skilled migration from developing to developed countries, the prospect of future emigration gives positive incentives to acquire education. Two interrelated reasons are evoked in the literature: first, the migration probability of high skilled is larger

than the migration probability of low-skilled individuals, so that returns to education abroad matters more to high-skilled. Second, the absolute returns to education (mostly measured by earnings gap between high skilled and low-skilled) are substantially higher in developed countries than in developing countries (BLV).

There are two major exceptions to this hypothesis that are highly relevant in the case of migration from Senegal to Europe: first, the case of a binding budget constraint (Beine, Docquier, and Rapoport, 2008), second, the case of illegal migration or migration to low-skilled occupations (McKenzie and Rapoport, 2011). As described above, when the budget constraint is binding, migration prospects do not provide additional incentives to obtain further education. Moreover, the family might *substitute* the migration investment to the schooling investment: candidates to migration might drop out of school earlier in order to enter the labor market, and accumulate capital that they will invest in a migration investment. Hence, migration prospects might provide disincentives for poor families to invest in education.

Illegal migration or migration to low-skilled occupations might also provide disincentives for education for two reasons: first, the success of an illegal migration attempt (e.g. traveling through the sea) depends less on the individual schooling attainment than on borders surveillance. Thus, in the case of illegal migration  $p_0 = p_1 = \bar{p}$ . Second, job prospects for illegal migrants (e.g. picking tomatoes in rural region in Spain) are not likely to depend on education, so that  $\Pi_1^1(X) - \Pi_0^1(X)$  is close to zero. Hence, for someone who attempts illegal migration, the returns to education are approximately:

$$(1 - p_0) \times (\Pi_1^0(X) - \Pi_0^0(X)) + u_1^0 - u_0^0 + p_0((u_1^1 - u_0^1) - (u_1^0 - u_0^0)).$$

Since schooling is completed in the origin country, we might expect that the unobserved costs of education do not differ much by location, that is the last term in the above the equation is close to zero. Then, on average, the returns to education will be reduced by a factor  $p_0$ , compared to the returns in a closed economy.

To sum up, since absolute returns to education are larger in Europe than in Senegal, and following BLV's result in Cape Verde, a neighbor country of Senegal, we expect to find positive incentive effects. Possible exception are the subgroups where the budget constraint is binding, especially poor families, and the subgroups where illegal migration is highly prevalent. Whether the incentive effect can compensate for

the selection effect depends on intensity of the latter in each group.

## 4. Identification

This section discusses the identification of the net effect  $\Delta$ , in particular, the identification of the conditional expectation  $\mathbb{E}D(0)$ . First, Section 4.1 discusses the assumptions required for point identification of the counterfactual quantity, and show that informative bounds can be derived with less demanding assumptions. Then, Section 4.2 makes explicit the bounds on  $\mathbb{E}D(0)$ . Subsequently, the bounds on the measures of the net effect are presented in Section 4.3. These bounds exploit several exogenous variations that can be found using a proper decomposition of the household’s information set, as described in Section 4.4.

### 4.1. Point identification

The above model of schooling investment belongs to class of Generalized Roy models in the terminology of Heckman and Vytlacil (2007). It can also be called endogenous treatment model (migration is the treatment and schooling the outcome). Both observed and latent returns to education depend on the chosen location (or chosen treatment). The model is “incomplete” according to the terminology of Chesher and Rosen (2012), since it does not describe the selection into emigration. Typically, non-parametric point identification will be obtained at the cost of assuming the existence of exogenous variations, say  $Z$ , that affects the migration decision but not the schooling choice, and have a very large support (identification at infinity).

Even if the model was “completed” to describe the migration decision, non-parametric identification is still challenging for existing methods, for example the Local Instrumental Variable (LIV) as proposed by Heckman and Vytlacil (2001). The LIV would require (i) an approximation of the migration decision through a latent index equation, (ii) a monotonicity condition on the effect of the instrument(s) and (iii) a set of instruments with a sufficiently large support. As discussed in Appendix A, I view this set of assumptions as untenable in the present framework.

Therefore, I turn to the partial identification approach, which rests on a less disputable set of assumptions.

#### 4.2. Bounds on $\mathbb{E}D(0)$

The model delivers simple tractable bounds on the counterfactual educational attainment. When an instrument is available, sharper bounds can be derived, which require no support or monotonicity conditions on the instrument.

Suppose that  $W = (X, \tilde{Z})$ , with  $\tilde{Z}$  such that  $D(0)$  is stochastically independent from  $\tilde{Z}$  conditional on  $X$ . The first and most intuitive bounds on  $\mathbb{E}D(0)$  are the bounds derived by Manski (1993). It suffices to note that:

$$\mathbb{E}D(0) = P(D(0) = 1, Y^* = 0|X) + P(D(0) = 1, Y^* = 1|X)$$

The second term is unobserved, but bounded between 0 and  $P(Y^* = 1|X)$ , so that:

$$P(D(0) = 1, Y^* = 0|X) \leq \mathbb{E}D(0) \leq 1 - P(D(0) = 0, Y^* = 0|X).$$

The bounds can be tightened by noting that  $E(D(0)|X, \tilde{Z}) = E(D(0)|X)$ . Hence:

$$\sup_{\tilde{Z}} P(D(0) = 1, Y^* = 0|X, \tilde{Z}) \leq \mathbb{E}D(0) \leq \inf_{\tilde{Z}} \left( 1 - P(D(0) = 0, Y^* = 0|X, \tilde{Z}) \right).$$

The exogeneity condition on  $\tilde{Z}$  is a weaker condition than the one required by BLV that require the existence of some  $Z$ , such that the pair  $(D(0), D(1))$  is stochastically independent from  $Z$ , conditionally on  $X$ . This additional condition produces tighter bounds on the quantity  $\mathbb{E}D(0)$ , as given by the following proposition.

**Proposition 1.** *All the following probabilities are conditional on  $X$ . Assume that  $D(0)$  is stochastically independent from  $\tilde{Z}$ , conditionally on  $X$ , and the following expressions are well defined.*

$$\begin{aligned} \tilde{q}_{10} &:= \sup\{ \mathbb{P}(D = 1, Y^* = 0 | \tilde{Z} = \tilde{z}) : \tilde{z} \in \text{Supp}(\tilde{Z}) \} \\ \tilde{q}_{00} &:= \sup\{ \mathbb{P}(D = 0, Y^* = 0 | \tilde{Z} = \tilde{z}) : \tilde{z} \in \text{Supp}(\tilde{Z}) \} \end{aligned}$$

the following are sharp bounds for  $\mathbb{E}D(0)$ .

$$\tilde{q}_{10} \leq \mathbb{E}D(0) \leq 1 - \tilde{q}_{00}$$

If in addition  $Z$  is such that  $(D(0), D(1))$  is stochastically independent from  $Z$ , conditionally on  $X$ , and the following expressions are well defined:

$$\begin{aligned} q_1 &:= \inf\{ \mathbb{P}(D = 1 | Z = z) : z \in \text{Supp}(Z) \} \\ q_0 &:= \inf\{ \mathbb{P}(D = 0 | Z = z) : z \in \text{Supp}(Z) \} \\ q_{10-01} &:= \inf\{ \mathbb{P}(D = 1, Y^* = 0 | Z = z) + \mathbb{P}(D = 0, Y^* = 1 | Z = z) : z \in \text{Supp}(Z) \} \\ q_{00-11} &:= \inf\{ \mathbb{P}(D = 0, Y^* = 0 | Z = z) + \mathbb{P}(D = 1, Y^* = 1 | Z = z) : z \in \text{Supp}(Z) \}, \\ \bar{q}_{10} &:= \sup\{ \mathbb{P}(D = 1, Y^* = 0 | Z = z) : z \in \text{Supp}(Z) \} \\ \bar{q}_{00} &:= \sup\{ \mathbb{P}(D = 0, Y^* = 0 | Z = z) : z \in \text{Supp}(Z) \} \end{aligned}$$

the following are sharp bounds for  $\mathbb{E}D(0)$ .

$$\max(\tilde{q}_{10}, 1 - q_0 - q_{00-11}) \leq \mathbb{E}D(0) \leq \min(1 - \tilde{q}_{00}, q_1 + q_{10-01})$$

The tighter set of bounds follow by Corollary 2 of Mourifié, Henry, and Méango (2015).

#### 4.3. Bounds on the Net Effects

From bounds derived in the previous subsection, bounds for the measures  $\Delta(\cdot)$  and  $\Delta_{inc}(\cdot)$  follow trivially. Call  $LB_0(X)$  (resp.  $UB_0(X)$ ) the lower (resp. upper) bound derived in either Proposition 1, or 2, where the dependence on  $X$  is emphasized to remind the reader that the bounds vary with the individual characteristics. The following bounds measure the net effect of brain circulation on human capital accumulation in the source country :

$$E(D|Y = 0, X) - UB_0(X) \leq \Delta(X) \leq E(D|Y = 0, X) - LB_0(X)$$

and accordingly for the measures  $\Delta_{inc}$ ,  $\Delta^r$  and  $\Delta_{inc}^r$ . Note that the selection effect  $\Delta_{sel}$  and  $\Delta_{sel}^r$  are (point) identified.

An upper bound give the maximal magnitude of the corresponding net effect (or maximal gain) possible in the sub-population of interest, while a lower bound measures the minimal magnitude of the corresponding net effect (or maximal drain) possible. If for  $\Delta$  the lower (resp. upper) bound is positive (resp. negative), there is unambiguous evidence for a positive (resp. negative) net effect of migration on the human capital accumulation with respect to the sub-population with characteristics  $X = x$ . I will talk of a net brain gain (resp. net brain drain) in in the subgroup  $x$ . If the upper bound is positive, while the lower bound is negative, the measure is inconclusive about the direction of the effect. An optimistic interpretation will focus on the upper bound, a pessimistic one on the lower bound. The same type of interpretation pertains with respect to the measures  $\Delta_{inc}$ ,  $\Delta^r$  and  $\Delta_{inc}^r$ .

In Appendix B, I show that there exists additional non-redundant constraints on the net effect  $\Delta$  that are described by Equation (6).  $\Delta$  must satisfy:

$$\begin{aligned} \Delta &\leq P(D = 1, Y^* = 0) [1/P(Y = 0) - 1] + P(D = 1, Y^* = 1, Y = 0)/P(Y = 0) \\ \Delta &\geq P(D = 1, Y^* = 0) [1/P(Y = 0) - 1] + P(D = 1, Y^* = 1, Y = 0)/P(Y = 0) \\ &\quad - P(Y^* = 1) \end{aligned} \quad (6)$$

While the upper bound is almost surely larger than 0, the lower bound can take either a positive or a negative sign. Thus, one can test for the existence of a strictly positive net effect, even without an instrument.

#### 4.4. The Information Set

The bounds in Proposition 1 exploit exogenous variations that can be found using a proper decomposition of the household's information set, as described in the following.

Recall that  $\mathcal{W}$  is the information set of a household when this household makes the schooling and migration decisions in the first period.  $\mathcal{W}$  regroups a set of observable characteristics  $W$ , and a vector of latent variables  $u$ , unobserved by the researcher.  $W$  can be further decomposed in the following:

1.  $X$ , the characteristics of the family and of the candidate that influence the schooling choice both when no attempt is made,  $D(0)$ , and when an attempt is made,  $D(1)$ , as well as the migration probability. These are for example, the candidate's age, gender, the family physical capital, the size of the family, etc.
2.  $X_0$ , the characteristics that influence the returns to education at origin but not at destination. These are for example, the macro-economic conditions in the origin country.
3.  $X_1$ , the characteristics that influence the returns to education at destination but not at origin, for example, the labor market demand in the destination country. For example, Theoharides (2015) takes advantage of the fluctuations in the labor market demand in the destination countries, to identify the effect of international emigration on the human capital of children in Philippines.
4.  $Z$ , the characteristics that influence the migration decision but not the schooling decision irrespective of the decision to attempt migration.  $Z$  is a the type of exclusion restriction assumed by BLV.
5.  $Z_{(1)}$ , the characteristics that affect the emigration prospects but do not affect directly the choice of education when no attempt to migration is made. These are for example, characteristics of the household facilitating visa approval, as the existence of a sponsor.

From this decomposition of the information set, the net return to education can thus

be written:

$$\begin{aligned}
\Pi_1^0(X, X_0) &= \Pi_0^0(X, X_0) + u_1^0 - u_0^0 \\
&+ p_1(X, X_0, X_1, Z_{(1)})Y^* (\Pi_1^1(X, X_1) - \Pi_1^0(X, X_0)) \\
&- p_0(X, X_0, X_1, Z_{(1)})Y^* (\Pi_0^1(X, X_1) - \Pi_0^0(X, X_0)) \\
&+ p_1(X, X_0, X_1, Z_{(1)})Y^*(u_1^1 - u_1^0) - p_0(X, X_0, X_1, Z_{(1)})Y^*(u_0^1 - u_0^0)
\end{aligned} \tag{7}$$

where the notation  $p_d(X, X_0, X_1, Z_{(1)})$  emphasizes the role of these variables on the success probability. From Equation (7), it follows that:

$$E(D(0)|W) = E(D(0)|X, X_{(0)}) \tag{8}$$

Therefore,  $Z, X_{(1)}$  and  $Z_{(1)}$  can be used as exogenous variations to (partially) identify  $\mathbb{E}D(0)$ . Note that for convenience of notation, I will use a slight abuse of notation and refer to the vector  $X$  to denote the pair  $(X, X_{(0)})$ .

I now turn to the empirical analysis on Senegal.

## 5. Background: Education, Migration and the Brain Drain in Senegal

### 5.1. Education

Between 1960, year of the independence from France, and 1990, the enrollment rate in Senegal has steadily increased from 22 to 57% in primary school, and 2 to 16% in Secondary school. The Senegalese educational system is modeled on the French precedent. The typical curriculum consists of 6 years in primary school and 4 years in lower secondary school, 3 years in upper secondary. At the end of each level, State exams operate an increasingly selective screening of pupils, which outcome is often based on available governmental resources. The “brain drain” question is all the more relevant because the government devotes a large share of the total government expenditures to education (between 16 to 22% in the past decade, that is 4 to 6% of the GDP). Only recently, in 2004, have tuition fees for primary education been abrogated and compulsory education introduced for children aged between 6 to 16 years<sup>10</sup>. At the time of the survey (2008), the enrollment rate was estimated at 84%

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<sup>10</sup>Journal Officiel N 6202 du Samedi 22 Janvier 2005

in primary, 30% in Secondary, 8% in Tertiary. While the ratio male to female is the same in primary school, it falls to 7 girls for ten boys in secondary.

Despite the importance of the public resources allocated to education and the quantitative expansion in the enrollment rate, the performance of the educational system is still weak (Niang, *The primary school in Senegal: Education for all, quality for some*, 2014). Only one adult out of 2 is literate. As of 2013, Senegal ranks in the last decile of the UNDP education index (which consists almost exclusively of Sub-Saharan African countries, along with Afghanistan and Myanmar).<sup>11</sup>

## 5.2. Migration

Migration from Senegal has Africa and Europe as major destinations. Emigration to Europe has a long tradition, which finds its roots in colonial ties with France. Following the decolonization, a first wave of labor migration was sparked by an active recruitment in French automobile industry. However, new immigration regulations following the oil crisis in the mid 70's provoked an abrupt closure of this migration route Robin (1996), while introducing family reunification schemes. During the late 70's until the mid 80's, a new migration wave started as the result of poor economic performances and repeated environmental shocks (droughts). However, with France becoming increasingly less hospitable in comparison to other European countries, migrants from Senegal started to look for other destinations.<sup>12</sup> This coincided with increasing demands from the agriculture sectors in Spain and Italy Lacomba and Moncusi (2006). During the late 80's until the mid 90's, further economic difficulties in Senegal and in many Sub-Saharan countries, led to drastic cuts in public expenditures. Rising unemployment and poverty, accompanied by a reduction in the provision of public services acted as important push factors. Italy became all the more attractive as the demand grew for work in tourism and industry in northern Italy Obucina (2013). Finally, in 1994, the long-lasting economic crisis, culminated in a devaluation of 50%

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<sup>11</sup>The calculation of the UNDP education index accounts for the the mean years of schooling and the expected years of schooling.

<sup>12</sup>France introduced the requirement for a Visa for Senegalese workers, and launched initiatives to encourage voluntarily repatriation of Senegalese workers, offering them paid formation in Senegal. Source: Senegalese Embassy: <http://www.ambasseneparis.com/index.php/cooperation.html>, accessed on Dec, 4, 2015.

of the Franc CFA. However, this measure did not have the expected effects on the economy, and instead led to a deterioration of living conditions in the mid-term. The devaluation also had the effect of doubling overnight the cost of (legal) migration, as an importation good. This and increased immigration restrictions made illegal migration more attractive and sophisticated. Half of 30,000 migrants who arrived to Canary Island in 2006 were from Senegal Mbaye (2014). Meanwhile, the high demand in the construction sector in Spain at the turn of the century continued to fuel emigration flows (Baizán, Beauchemin, and González-Ferrer, 2013).

### 5.3. Fear of “Brain Drain” in Senegal

Raw measures of the brain drain suggest that Senegal, as many countries in Sub-Saharan Africa, is highly affected by the self-selection of high skilled in emigration. Although emigration is relatively low (as of 2005, a stock of 4.26% of the population, with close to 40% of migrants in Europe) in comparison with countries with small populations, the equally low level of high-skilled individuals and the strong discrepancy between skilled and unskilled migration are the main stated concerns Easterly and Nyarko (2008). According to Docquier and Marfouk (2006), in 2000, 17.7% of the population with a tertiary education as emigrated. Baizán, Beauchemin, and González-Ferrer (2013) reports that 31% of migrants have some secondary education, while only 16% in the remaining population. According to Beine, Docquier, and Rapoport (2008)’s measure, when one accounts for the net effect of emigration prospects, the computation of the net effect of emigration implies a loss of 0.2% of the tertiary educated.

## 6. Data

### 6.1. MAFE Dataset

The empirical analysis is based on the longitudinal biographical survey data collected in the framework of the MAFE (Migration between Africa and Europe) Project.<sup>13</sup> About 600 current Senegalese migrants in France, Italy and Spain and nearly 1100 residents of the region of Dakar were interviewed in 2008. As respondents

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<sup>13</sup>The MAFE project is coordinated by INED (C. Beauchemin) and is formed, additionally by the Universit catholique de Louvain (B. Schoumaker), Maastricht University (V. Mazzucato), the Université Cheikh Anta Diop (P. Sakho), the Universit de Kinshasa (J. Mangalu), the University of Ghana

are sampled non-randomly, sampling weights are provided to produce a representative sample.<sup>14</sup> The survey collects retrospective biographical information about the demographic and socio-economic characteristics, labor force participation and migration of the respondents and their household. There is additional information about migrant networks, documentation status, remittances and asset ownership. A major attractiveness of the MAFE Dataset for this study is that it records the actual migration history, as well as (unsuccessful) migration attempts, including year and destination of attempt, and reasons of failure.

In the following analysis, I restrict the sample to individuals who never migrated to Europe before the age of 21 to ensure that they obtained education in Senegal. I also exclude individuals aged 60 or more who are part of the first migration wave from Senegal and are underrepresented. This sample consists of 1342 individuals (626 men and 716 women).

## *6.2. Descriptive statistics*

The data reveals an important gender difference in migration behavior, with the female migrant population estimated between 19% to 29% of the migrant population. Figure 1 shows both the proportion of the population who attempted migration to Europe and the proportion of those who have been successful, by gender and education level. Education is categorized in four groups: at most some primary education (including those without education), some lower secondary education, some upper secondary education, and some tertiary education. More educated individuals are more likely to attempt migration, especially women, where the proportion of migration attempts nearly triples from primary to upper secondary education. The ratio of success also varies substantially by education level. Where one out of two low

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(P. Quartey), the Universitat Pompeu Fabra (P. Baizan), the Consejo Superior de Investigaciones Científicas (A. González-Ferrer), the Forum Internazionale ed Europeo di Ricerche sull'Immigrazione (E. Castagnone), and the University of Sussex (R. Black). The MAFE project received funding from the European Community's Seventh Framework Programme under grant agreement 217206. The MAFE-Senegal survey was conducted with the financial support of INED, the Agence Nationale de la Recherche (France), the Région Ile de France and the FSP programme 'International Migrations, territorial reorganizations and development of the countries of the South'. For more details, see: <http://www.mafeproject.com/>

<sup>14</sup>For more details on the MAFE project methodology, see Beauchemin (2012).

educated are successful in their attempt, at least two out of three high educated are successful in their attempt. Note that on average an individual makes 1.35 (s.e.=0.06) attempts to migrate, and the number of attempts increases with the education level: from 1.27 (0.08) to 1.61 (0.17). Reassuringly, the Docquier and Marfouk (2006)'s estimate for the migration rate of tertiary educated (17.7%) belongs to the confidence region as calculated on the sample.

Figure 3 compares the age at the first migration attempt for migrants and non-migrants. Migrants make their first attempt much earlier than non-migrants. The latter group consists of two main subgroups: those who attempt their first migration around the age of 25, and later movers, who attempt migration after the age of 30. This clearly suggests a selection that might depend on private information.

Figures 4 and 5 shows the distribution of the age at migration by gender and education group respectively. The peak of the migration is attained around age 25. Then migration rates decrease progressively to be almost nonexistent around age 40. Women migrate later than men, suggesting tied-moving. The age at migration is negatively correlated with the educational attainment, as the higher the education, the earlier the migration. This is partly because of student migrants, but also because the probability of success of a migration attempt decreases with the level of education.

Figures 6 shows the educational attainment by gender, migration status and cohort. The figures distinguish migrants to Europe from the rest of the population and differentiate between three cohorts: individuals aged 25 to 34, 35 to 44 and 45 to 59. Men are in general more educated than women. However, this gender gap seems to have narrowed over the years, as more women are likely to obtain intermediary or high education. This results from both the general expansion of education and the recent public initiatives to promote gender equality in education. With regard to the skill bias in migration, migrants to Europe are in general more educated than the rest of the population. In particular, a larger proportion of migrants have obtained at least some secondary education. But the distribution of educational attainment varies across cohort, with an increasing selection on women, and an increasing, then decreasing selection among men. This might be the result of the expansion in illegal emigration, which has been more attractive to uneducated males in the recent years.

Finally, Table 1 shows the estimated proportion of migrants without a visa or a resident permit at the time of their first stay abroad, by gender, cohort and for

Table 1: Proportion of individuals without a visa or resident permit at first migration

Education		Below 12 yrs	Above 12 yrs		
Gender	Cohort	Mean	S.d.	Mean	S.d.
Men	25-34	0.67	0.09	0.34	0.11
	35-44	0.45	0.07	0.20	0.07
	45-59	0.34	0.07	0.22	0.10
Women	25-34	0.16	0.08	0.10	0.07
	35-44	0.17	0.06	0.07	0.05
	45-59	0.22	0.11	0.21	0.17

education level below 12 years of schooling and above two years of schooling. While the proportion decreases or remain stable for women from the earliest cohort to the youngest, this proportion doubles for low educated men, attaining almost two third of the migrants.

## 7. Estimation strategy

In this section, I present the variables used as dependent, control, and instrumental variables, as well as the estimation methodology to compute the bounds advised in the Section 4.3.

### 7.1. Dependent Variables

The key variables are the schooling attainment, the migration attempt and the actual migration. In the baseline specification,  $D = 1$  if the respondent declares having at least attended upper secondary education;  $D = 0$  otherwise. The focus on upper secondary education is in line with the high migration incidence in the age where individual should have completed upper secondary education. It also make our results comparable to BLV and McKenzie and Rapoport (2011) who study the effect of migration prospects at the same level of education. In section 8.4, I also explore the effect of future emigration prospects on secondary and tertiary education.

The variable  $Y^*$  equals 1 if the respondent declares having attempted at least once migration to Europe. Note that the survey provides information about all migration attempts in all potential destinations as declared by the respondent.

Finally, since the dataset covers only the major destinations countries,  $Y$ , the actual migration is observed (equals 1 when migration, 0 otherwise) for migrants to these major destinations. To fit the definition of  $Y$ , ideally, we would like to sample migrants in all European destination countries. This is a limitation of the present data. The results presented here will hold, if migrants to other European destinations are not too different from those present in the sample.

### *7.2. Heterogeneous Household Characteristics*

The estimation strategy allows measuring heterogeneous net effects in the population. The empirical analysis addresses the heterogeneity with respect to gender, cohort, and family background. Estimation of the bounds is conducted for men and women separately. The measured effects are also differentiated for three cohorts: individuals aged 25 to 34, 35 to 44 and 45 to 59. The cohort 45 to 59 would correspond to the second wave of migration between the 70's and the mid 80's, characterized by the new labor migration to agriculture in Italy and Spain. The cohort 35 to 44 corresponds to the next wave of migration, between the mid 80's and the mid 90's, during the financial crisis and economic downturn in West Africa. This cohort should be the one where liquidity constraints are the strongest. Finally the cohort 25 to 34 corresponds to the last wave of migration, characterized mainly by the high attractiveness of illegal migration (see Section 5). With respect to family characteristics, the estimation procedure controls for the occupation of the father when the individual is 15.<sup>15</sup> I construct four categories: High-level occupation or employer, skilled employee, unskilled employee, and self-employed or unemployed. The effect of parental occupation on the measured effects is of particular interest, since it allows understanding whether poor or rich families are most likely to experience selection or incentives. In line with the literature on household schooling choice, I also control for the family size through a set of dichotomous variables that reflect the possibility of a quality-quantity trade-off .

To remain parsimonious, I assume that the effect of economic conditions in the origin country is absorbed by the cohort dummies. Later on, I also control for the religion (Mouride, Tidiane or others) and ethnicity (Pular, Wolof or others) that

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<sup>15</sup>Father's education is also available but highly correlated to occupation.

capture potential migration networks.

### *7.3. Instruments*

The first instrument follows from BLV's insight that the longest migration spell in the family at age 15 provides exogenous variation affecting the migration decision but not the educational attainment at home. As noted by BLV, maximum length of the family migration spell delivers information regarding the success of the closest migration experience to the individual. Longer migration spells in the family reflect more successful migration experiences that should translate into deeper access to migrant networks.<sup>16</sup>

A second source of exogenous variation comes from characteristics affecting the subjective probability of success but not the education decision. I use the number of individuals known by the respondents between 16 and 21 and that migrate in this period where upper secondary education should be completed. The rationale is that individuals who observe more migration in their network, will be more optimistic about their own chance of migration.

Because individuals with a stronger network would benefit from remittances and savings that can be invested in education, one should ideally control for remittances received by the family. As Beine, Docquier, and Rapoport (2008) argue, once one controls for remittances, there is no obvious reason why migration network would affect human capital formation. However, the MAFE dataset does not contain information on the size of remittances at the age of 15. Controlling for parents' occupation partially address this concern. Following BLV, I control additionally for at least one of the family member living abroad when the individual is aged 15 (around 20% of the sample). Note that this concern would not affect the second instrument.

Finally, to take advantage of exogenous variations that affect the returns to education abroad but not at home, I construct an index measure, which interacts, at a given age, the strength of an individual's network in one of the three destinations and the unemployment rate in this location. Ideally, one should use the unemployment rate gap by education level. However, this measure exists in an harmonized way for

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<sup>16</sup>The second instrument in BLV, regional proportion of migrants, cannot be fruitfully used in our context because the data are for individuals in the same geographical area.

France, Italy and Spain, only from 2000. For France, this measure exists from 1982 and is available from the INSEE.<sup>17</sup> I compute the correlation between the unemployment rate gap by education and the average unemployment in the population for individual aged 25 to 34. The correlation is 0.58 in the whole population, 0.77 for men and 0.21 for women. This entails that shocks to the labor market affect most importantly low skilled workers than their high skilled counterparts, especially for men. Therefore, I use the unemployment rate by gender as a proxy for the unemployment rate gap in the calculation of the index measure. The precise construction of the index is presented in Appendix C.

To heuristically assess the validity of the exclusion restrictions, I run an overidentification test for the aforementioned instruments from a 2SLS regression, separating men and women. Reassuringly, the null hypothesis of exogeneity cannot be rejected (p-value of 0.91 for men and 0.66 for women). However, the  $F$ -statistic is relatively low in both populations (7.5 for men and 9.42 for women), which is the sign of weak instruments.

In the baseline specification, I use the increase in the size of the network between age 16 to 21 and the index measure as exclusion restrictions. Additionally, I conduct the empirical analysis with each combination of instruments. The results remain qualitatively unchanged.

#### 7.4. Estimation methodology

The bounds proposed in Section 4.3 belong to the class of intersection bounds. Therefore, I use the methodology proposed by Chernozhukov, Lee, and Rosen (2013). They propose bias-corrected estimators of the upper and lower bounds, as well as confidence intervals.<sup>18</sup> Their approach employs a precision correction to the estimated

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<sup>17</sup>Available at [http://www.insee.fr/fr/themes/detail.asp?ref\\_id=ir-irsocmartra14&page=irweb/irsocmartra14/dd/irsocmartra14\\_paq3.htm](http://www.insee.fr/fr/themes/detail.asp?ref_id=ir-irsocmartra14&page=irweb/irsocmartra14/dd/irsocmartra14_paq3.htm), accessed on December, 10, 2015

<sup>18</sup>Chernozhukov, Lee, and Rosen (2013) note two reasons why estimation of and inference on intersection bounds is complicated: first, because the bound estimates are suprema and infima of parametric or nonparametric estimators, closed-form characterization of their asymptotic distributions is typically unavailable or difficult to establish. Second, since sample analogs of the bounds are the suprema and infima of estimated bounding functions, they have substantial finite sample bias, and estimated bounds tend to be much tighter than the population bounds.

bounding functions before applying the supremum and infimum operators. They achieve this by adjusting the estimated bounding functions for their precision by adding to each of them an appropriate critical value times their point-wise standard error.

A guide to the implementation of inference for intersection bounds using the Stata Package *clrbound* is provided by Chernozhukov, Kim, Lee, and Rosen (2013). In general, computations use the command *clr3bound*, which constructs confidence intervals of level  $1 - \alpha$  by inverting a statistical test of corresponding level. When, the computing time is too high, I use the faster command *clr2bound* that produce more conservative confidence regions. Because of the many control variables involved and the curse of dimensionality associated to it, estimation is conducted using the parametric estimator. This estimator produces a Linear Least-Square approximation of the bounds on each measure  $\Delta_j(X)$ .<sup>19</sup> Appendix D provides all the details of the estimation procedure.

The selection effect  $\Delta_{sel}$  is identified from the data. I approximate both  $E(D|Y = 0, X)$  and  $E(D|X)$  with a linear probability model, and compute the confidence interval on the difference using bootstrap (199 replications) .

## 8. Results [TBC]

### 8.1. Baseline

To separate the contribution of the analytical bounds from the contribution of the sampling uncertainty to the size of the bounds, I show both the median unbiased estimates (50% confidence interval) and the 90% Confidence Interval. Figure 7 summarizes the 50% Confidence Intervals and Figure 8 summarizes the 90% Confidence Intervals of estimated measures (from left to right  $\Delta_{sel}$ ,  $\Delta$  and  $\Delta_{inc}$ ) for different sub-groups in the population according to gender, the age cohort and the father's occupation when the respondent was 15 years old, fixing the family size at its median level (3 to 5 siblings). Father's occupation is a proxy of the family wealth. First, I

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<sup>19</sup>Chernozhukov, Kim, Lee, and Rosen (2013) warns that the bounds produced through the parametric procedure are tighter than their non-parametric alternative. However, given the size of the dataset at hand and the complexity of the problem, non-parametric estimation is unfeasible.

focus on households where no member was abroad when the respondent was 15 years old.

First, the *selection effect*,  $\Delta_{sel}$  is significantly negative or not significantly different from zero. The effect is stronger in earlier cohorts and in rich families. The latter confirms the fact that children from rich families are both more likely to be educated and more likely to migrate. Even in poor families, the high skilled are slightly more likely to migrate than low skilled, however, the proportion of migrants in this population is relatively small, so that the overall selection effect is small.

For women, the *incentive effect* is never significantly different from zero, even when the bounds are relatively tight. The confidence intervals are in general centered around zero. In sharp contrast, for men, Figures 7 and 8 display large and statistically significant negative incentive effects for men. This is true across all cohorts, and for all types of father's occupations, albeit a less negative effect for rich households. When one concentrates on the upper bound, the effect seems to be more negative in the youngest cohort than in the earlier cohorts. In this cohort, the incentive effect is strictly smaller than the selection effect.

Both for women and men, the *net effect* is mostly negative. However, for women, this negative effect is driven by the selection effect, whereas, for men, it is mostly driven by strong negative incentive effects. In the cohort 25-34, the net effect is strictly smaller than the selection effect, across all family types, except for the richest households.

Hence, Figures 7 and 8 reveal a striking gender difference in the effect of emigration prospects on the human capital accumulation. This difference is mostly the result of different incentive effects. The lowest upper bound from the subgroup of men between 25 and 35 whose parent is an unskilled employee implies a reduction of 16 percentage points in the enrollment in upper secondary education.

To check the robustness of the findings, I compute the bounds under further specifications. First, I compute the bounds, removing from the sample, individuals with no education. On one side, the decision to enroll in primary school intervenes early in life and might be very different from the one to obtain high school education. On the other side, families who do not invest at all in education usually do so because of a binding liquidity constraint (REF Survey 1-2-3). These families might well be

driving the observed results. Additionally, I compute the bounds with each different combination of instruments. Furthermore, I use the father's education rather than his occupation. The higher the education, the more likely he is to be in a high skilled occupation. Finally, the survey also collects information on the assets of the family. Unfortunately, this information is missing for migrants sampled on the street. I also conduct the analysis controlling for a dummy whether the respondent has some asset before the age of 21. In all these alternative specifications, the qualitative results remain very similar.

### *8.2. The contribution of returners*

The estimation of  $\Delta_{sel}^r$ ,  $\Delta^r$  and  $\Delta_{inc}^r$  helps understanding the contribution of returners to the human capital in the sending country. Students are overrepresented among returners. This fact leads Baizán, Beauchemin, and González-Ferrer (2013) to conclude that “brain drain appears to be a limited issue in the context of Senegalese migration”. Figure 9 depicts the change in the Brain Drain measures when one also accounts for the human capital brought back by the returners. There is hardly any change observed, suggesting that most returners would have acquired their education even if they would have stayed in the origin country. This qualifies the hypothesis that return migration might be a stronger channel for brain gain than the prospect of emigration.

### *8.3. Households with a Migrant Member*

Households with a migrant member are different in two respects; the absence of a parent might have a negative effect on educational attainment (earlier entrance on the labor market to substitute for loss in income, and lack of parental support) as noted by for example by Hanson and Woodruff (2003). Conversely, remittances can relax the liquidity constraint and allow more investment education. Dinkelman and Mariotti (2014) and Theoharides (2015) finds that the income effect overcomes the absent parent effect. Consistent with this findings, our sample shows that, in families with a member abroad, one out four children is enrolled in upper secondary school, against one out five in the remaining families.

Figure 10 depicts the change in the estimated measures for families where at least one member was abroad when the respondent was 15 years old. If anything, the

selection effect is more pronounced among women with a family member abroad than among their counterpart women without a family member abroad, but not significantly. In contrast, the incentive effects are larger in these type of households, both for men and women. In fact, for men, they are not anymore significantly different from zero, in most cases. For men in the richest families, as well as most female in the younger cohort, the 50% confidence regions are positive (not reported) and the 90% confidence region have a tilt toward positive values, suggesting a strictly positive incentives.

As a result, the net effect is not significantly different from zero for men, and still slightly negative for women. Thus, the investment in education of families with a migrant member is less elastic to migration prospects than the one of families where both parents are in Senegal. The income effect seems to offset the negative brain gain effect. For comparison with BLV, I also conducted the same analysis considering households with a migrant father or mother. The results do not change significantly.

#### *8.4. Alternative education levels*

In this section, I also investigate potential effects at alternative educational levels: lower secondary and tertiary education. Even though the father's occupation is only measured when the individual is 15 years old, there should be high correlation with the occupation at the point of enrollment in the lower secondary or tertiary level.

Start with the lower secondary school, fixing the family size at its median level and focusing first on families where none of the parent was abroad when the respondent was 15 years old. Figure 11 shows the same pattern as previously with respect to the selection effect, except more noisy measures for men. Measures of the incentive effect are also more noisy, but mainly not statistically different from zero, both for men and women, with the notable exception of households from the youngest cohort with a self-employed father or an unskilled father. In these groups, the incentive effects are negative, both for men and women. Hence, the net effect is again negative for women, mostly in the youngest cohort. For men, the effect is not significantly different from zero, however, the confidence regions for the cohort 25-34 have a tilt toward negative values.

The picture is very similar when one considers tertiary education (Figure 12). The selection effect is negative or not significantly different from zero, and more pro-

nounced for rich families. The incentive effects display large bounds mainly centered around zero. Finally, the net effects are negative for women, and for men, the confidence regions for the cohort 25-34 have a tilt toward negative values, although not significant.

Finally, note that families with a migrant member have again higher incentives effects. At the secondary level, for men and women, all confidence intervals show a tilt toward the positive values. At the tertiary level, the incentives for men from the richest households are significantly positive, balancing the selection effect.

### *8.5. Linear Approximation*

A parsimonious way to summarize the information conveyed by the bounds is to compute a linear approximation of the variation of the measured effects, as described in Appendix E. Table 2 summarizes the influence of the explanatory variables on the measured effects, according to the linear approximation. This approach being more flexible than the graphical approach, I control additionally for religious and ethnic characteristics, additional proxies for migrant networks.

The reference group is women from the earliest cohort, whose father had a higher-level occupation when they were aged 15, in small size families, from other ethnicity and religion than the main ethnic and religious groups in Senegal. In this group, the selection effect is strongly negative (see constant), with a decrease of upper secondary school attendance between 6 to 14 percentage points. Families with a migrant member are even more likely to experience the negative selection effect, of at least 1 additional percentage point. The selection seems not to differ with respect to gender, ethnic group or religion. However, less well-off families are not likely to experience the negative selection effect.

By contrast, there is more variation in the incentive effects depending on the individual characteristics. The reference group has positive (possibly strong incentives) to invest in education. Being a male candidate appears to deter substantially the incentive effect (a decrease between 15 to 19 percentage points), as well as belonging to less well-off families (a decrease between 4 to 23 percentage points), or religious and ethnic networks. The medium cohort, where the liquidity constraint was presumably binding for most households, seems to have the lowest incentives of the three cohorts. Conversely, households with a migrant have on average higher incentives (an increase

Table 2: Linear Approximation of the effect of individual characteristics on the variation of the 90% Confidence bounds

	$\Delta_{sel}$		$\Delta_{inc}$		$\Delta$	
	LB	UB	LB	UB	LB	UB
Gender						
Male	-0.053	0.052	-0.186	-0.157	-0.211	-0.083
Cohort (Ref. Age 45-59)						
Age 25-34	-0.001	0.058	-0.099	0.053	-0.113	0.125
Age 35-44	-0.027	0.037	-0.175	-0.018	-0.201	0.126
Father's occupation (Ref. Higher level Occupation)						
Skilled Employee	0.043	0.111	-0.235	-0.043	-0.197	0.017
Unskilled employee	0.038	0.094	-0.159	-0.073	-0.119	0.032
Self-employed	0.042	0.106	-0.132	-0.040	-0.106	0.019
Migrant Household						
Yes	-0.075	-0.015	0.059	0.079	-0.042	0.104
Family Size (Ref. 0-2 Children)						
3-5 Children	-0.082	0.026	-0.001	0.070	-0.076	0.116
6-8 Children	-0.029	0.026	0.027	0.122	-0.071	0.118
more than 8 Children	-0.042	0.024	0.029	0.074	-0.078	0.112
Ethnicity (Ref. Other)						
Wolof	-0.047	0.008	-0.051	0.017	-0.077	0.095
Pular	-0.047	0.014	-0.114	-0.056	-0.143	0.092
Religion (Ref. Other)						
Mouride	-0.015	0.046	-0.068	-0.029	-0.101	0.058
Tidiane	-0.004	0.052	-0.078	0.002	-0.126	0.066
Constant	-0.143	-0.061	0.002	0.192	-0.215	0.129

between 6 to 8 percentage points), so do larger families, compare to smaller families.

Given these variations in sometimes opposite direction, the resulting variations in the net effect depend mainly on the gender, and at a lesser extent on the father's occupation. Hence, decomposing the net effect in selection and incentive effects, and examining sub-groups of the population, reveal substantial variations that would pass unnoticed when focusing solely on the country-level brain drain measures.

## 9. Discussion: Why are Men not Investing in Education?

The results of the empirical analysis suggest that emigration provides significant disincentives for Senegalese men to invest in high school education. In this section, I assess the possible reasons why it would be the case.

The first fact that demands explanation is the significant gender difference in these incentives. The fact that emigration prospects produce no incentive for women can be explained by the role of women in Senegalese households. Female have a traditional role as wives and care takers at home, and a large differential social status with respect to men (Barou, 1991; Baizán, Beauchemin, and González-Ferrer, 2013). Figure 2 which compares the reason of a migration by gender confirms this insight. While men are more likely to migrate for work related reason or to improve their living conditions, the large majority of women seems to be tied-movers as they report migrating because of family reasons. Thus, it is not surprising that the incentive effect does not operate on most of them.

Why do emigration prospects cause disincentives to invest in education in Senegal? The literature evokes three potential reasons that I examine. The first potential reason is that households compare relative returns to education rather than absolute returns to education, as the Borjas-Roy model suggests (Borjas, 1987). In Equation (4), this would mean that  $\Pi$  has a log-linear approximation. Since, relative returns are higher in Sub-Saharan African countries than in OECD countries [REF], the additional returns to education from emigration prospects should be negative. The hypothesis of a log-linear utility function is however disputed in the context of migration from developing to developed countries. Grogger and Hanson (2011) note that “given the vast income differences that exist between countries [...] [the] linear utility appears to abuse reality less than the strong curvature of the log-linear util-

ity”. BLV also favor the idea that absolute returns to education matter more than relative returns, in the case of Cape Verde, the neighbor country of Senegal. Furthermore, since relative returns to education increase exponentially in education in Senegal (Kuepie, Nordman, and Roubaud, 2009), the disincentives should be higher at the tertiary level, which is not the case. Therefore, the higher relative returns to education cannot solely account for the negative incentives.

The second mechanism that could explain the negative incentives is the existence of liquidity constraints for households with an emigration option, as described in Section 3.3. Consistent with this mechanism, the results show that less well-off family have the strongest disincentives, while the richest households have sometimes strictly positive incentives. Moreover, households with a migrant, that presumably benefit from remittances, are more likely to have positive incentive effects. This explanation is also consistent with the finding that the incentive effects are the most negative for the medium cohort. Thus, liquidity-constrained households appear to substitute the investment in education for an investment in migration.

Third and final, the high prevalence of illegal migration or migration to low-skill jobs may explain the negative incentives. This is consistent with the observed negative effects of ethnic and religious networks that provide help to access low-skilled occupations abroad [REF NEEDED]. This would also be consistent with the higher incentives of households with a migrant, since these particular households would be more likely to attempt migration through legal ways. However, contrary to what we may have expected, the incentives do not seem to have significantly worsen in the last cohort, where illegal migration is the most prevalent. To further assess whether the observed negative incentives originate from low-skill job perspectives, I compare the factual average level of occupation of migrants to the average level of occupation in the counterfactual closed economy. To do so, I use the information in the survey about the occupation level at age 35, as measured by the ISCO-code or the ISEI-code of the occupation.<sup>20</sup> Obviously, this can only be computed for the two earliest cohorts. I define as high-skilled occupations, and denote by  $HSO = 1$ , occupations

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<sup>20</sup>I do not use the occupation level at age 25, which is not a good proxy for the long-run labor market outcomes. Indeed, Beauchemin et al. (201x) note that migrants have a significant occupational costs in the first years following migration. However, this costs reduces rapidly overtime.

with an ISCO-code below 5000, or occupations with an ISEI-code larger than 44. Each partition gives us a proportion of approximately 20% of the population being high-skilled, consistent with the proportion of men with upper secondary occupation. Then, for men, I test respectively at the 5% level:

$$H_0^a : E(HSO|Y = 1, X) - E(HSO(0)|X) \leq 0$$

$$H_0^b : E(HSO|Y = 1, X) - E(HSO(0)|X) \geq 0$$

where  $HSO(0)$  is the occupation level of occupation in the closed economy. Using the ISCO-code,  $H_0^a$  is never rejected, whereas  $H_0^b$  is rejected in 2 groups out of 8. Using the ISEI-code,  $H_0^a$  is rejected in 1 group out of 8, whereas  $H_0^b$  is rejected in 6 groups out of 8. Thus, it appears that emigration does not necessarily leads to lower types of occupations than the ones expected in Senegal.

Hence, illegal migration and migration to low-skill jobs might partly explain the negative incentive effects observed; however, financial constraints seem to be the main driver of the finding.

## 10. Summary

This paper measured heterogeneous effects of emigration prospects on the schooling investment of households in Senegal. I derived bounds on the magnitude of these effects from an IV discrete choice model that distinguishes migration decision and actual migration. Using the MAFE Survey on Senegal reveals strong gender difference in incentives: I find strong disincentives for men to invest in education. The most plausible explanation is that credit constraints leads to a substitution between migration and education investments. Thus, in the absence of migration opportunity, more men would have acquired secondary education.

Should the policy makers then increase the costs of migration? A marginal increase has unclear effect. While it will deter the migration incentives for some, it will worsen the liquidity constraint for others, possibly worsening the perverse effect of the market imperfection. Furthermore, the stories of thousands who risk their lives on their way to Europe should teach us that it is difficult to set migration costs high enough to deter all migration attempts. A better approach could be to focus on the credit market inefficiency, while promoting human capital accumulation. This could be done by

creating legal and selective ways for economic migration, that can be financed on a credit market.

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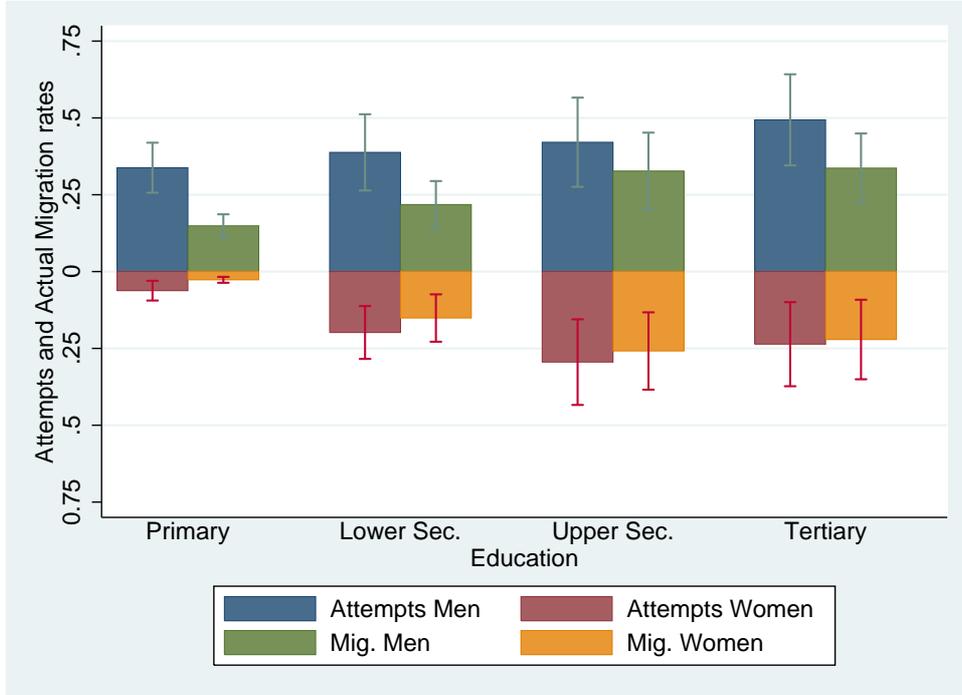
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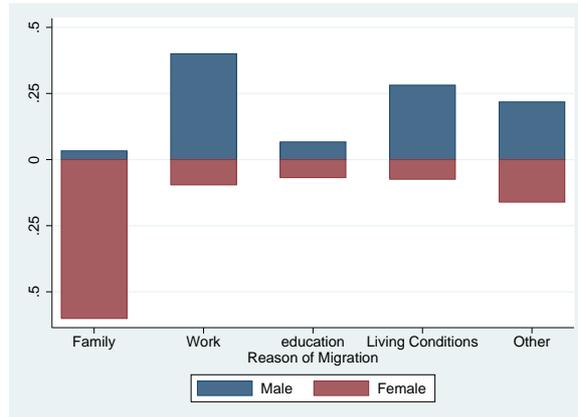
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Figure 1: Migration attempts and migration success



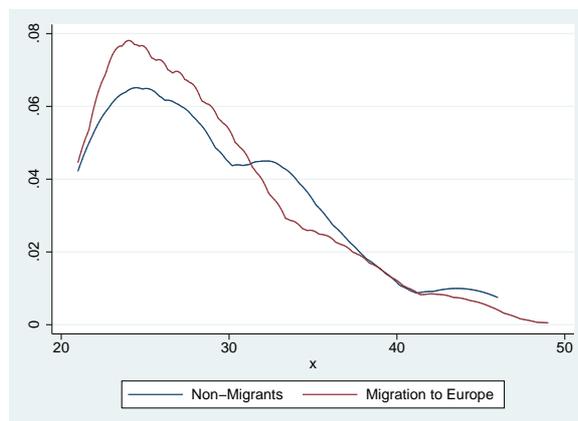
Note: Proportion of the population who attempted migration to Europe and the proportion of those who have been successful, by gender and education level. ‘Attempts Men/Women’: Estimated proportion in the population who attempted migration. ‘Mig Men/Women’: Estimated proportion in the population that migrated to Europe. Education: ‘Primary’: Primary or Less than Primary, ‘Lower Sec.’ some Lower Secondary, ‘Upper Sec.’: some Upper Secondary, and ‘Tertiary’: some Tertiary education. The bars represent the 95% Confidence Interval.

Figure 2: Reason of emigration



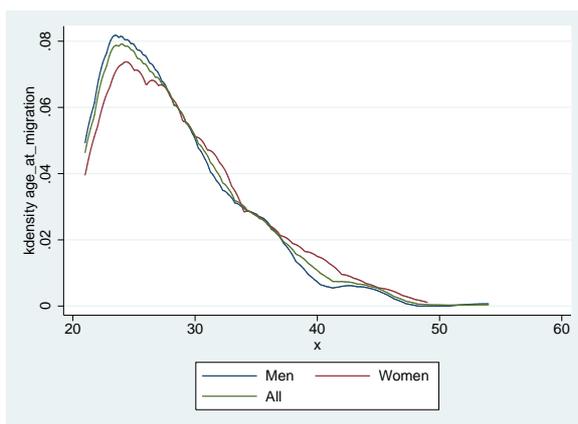
Note: Main stated reason of emigration by gender. 'Living condition' stands for 'Improving or find better living conditions'.

Figure 3: Age at first migration attempt, for migrants and non-migrants



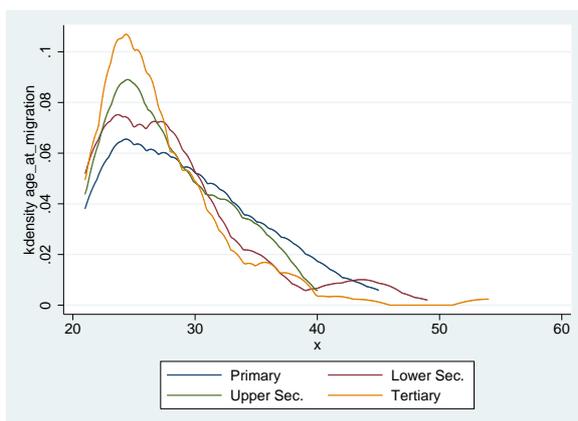
Note: Kernel distribution of the age at the first migration attempt, conditional on having attempted migration for the first time, after the age of 21, and on the migration status.

Figure 4: Age at migration, by gender



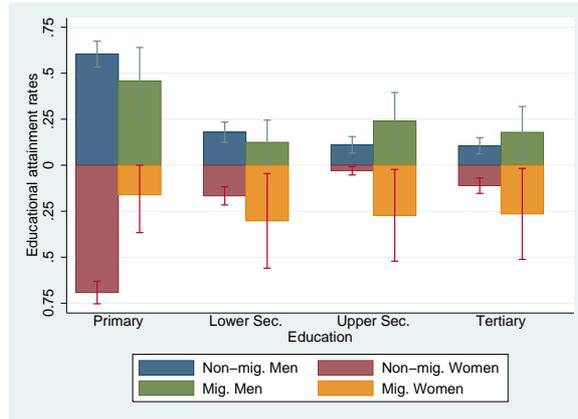
Note: Kernel distribution of the age at the first migration attempt, conditional on migration for the first time, after the age of 21, and on the gender.

Figure 5: Age at migration, by education

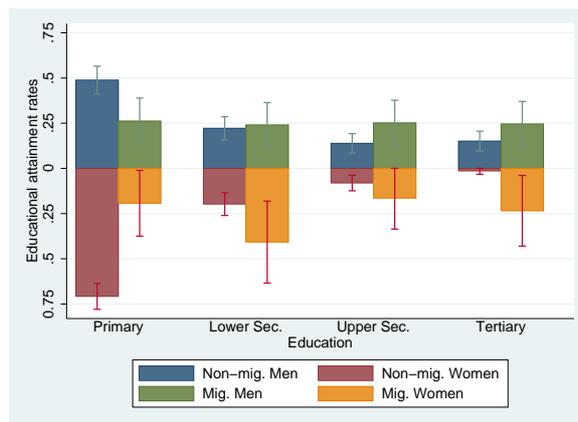


Note: Kernel distribution of the age at the first migration attempt, conditional on migration for the first time, after the age of 21, and on the educational attainment. Education: 'Primary': Primary or Less than Primary, 'Lower Sec.' some Lower Secondary, 'Upper Sec.': some Upper Secondary, and 'Tertiary': some Tertiary education.

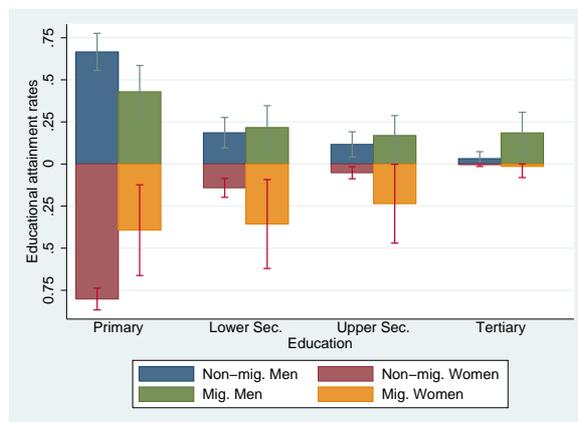
Figure 6: Education by gender, cohort and migration status



(a) Age cohort 25-34



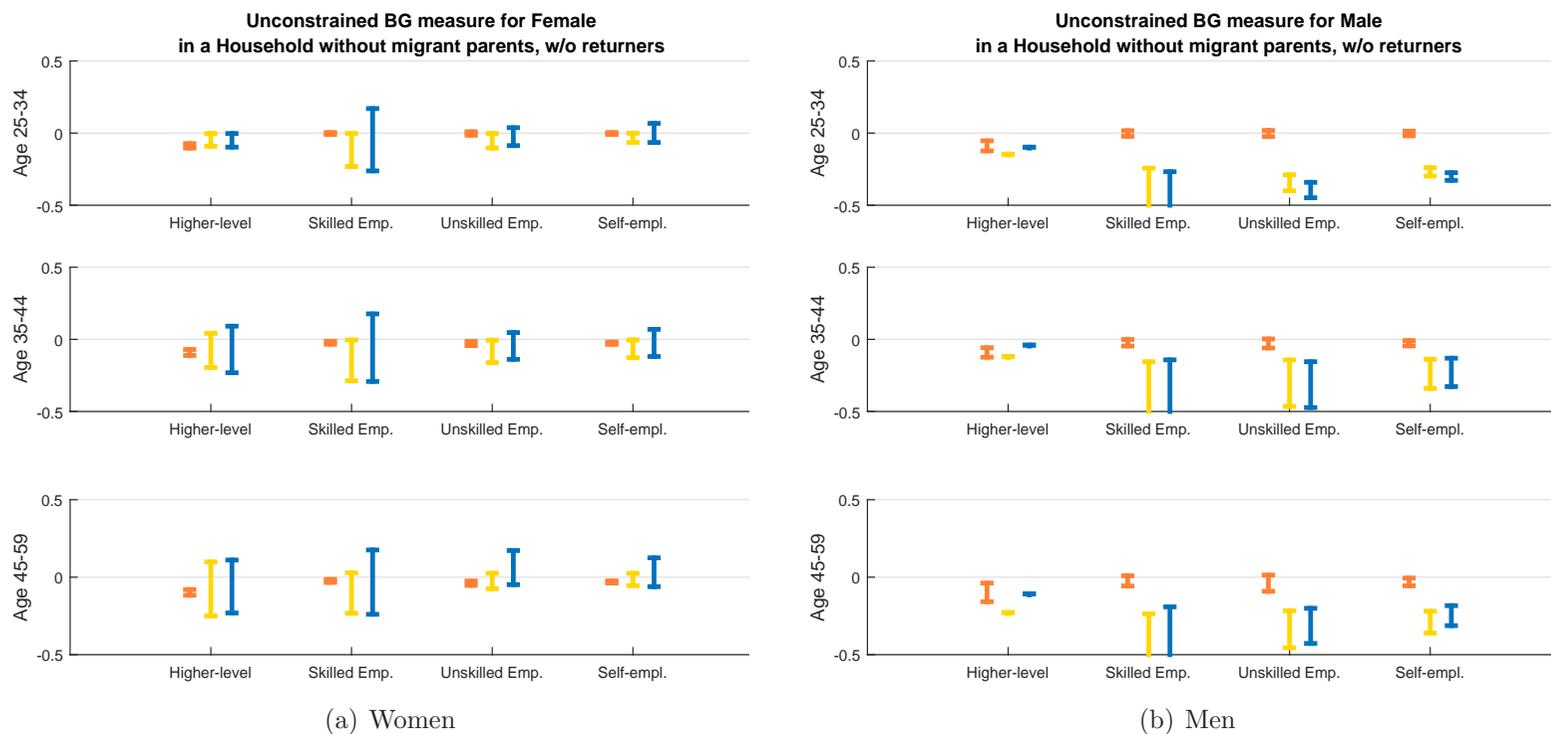
(b) Age cohort 35-44



(c) Age cohort 45-59

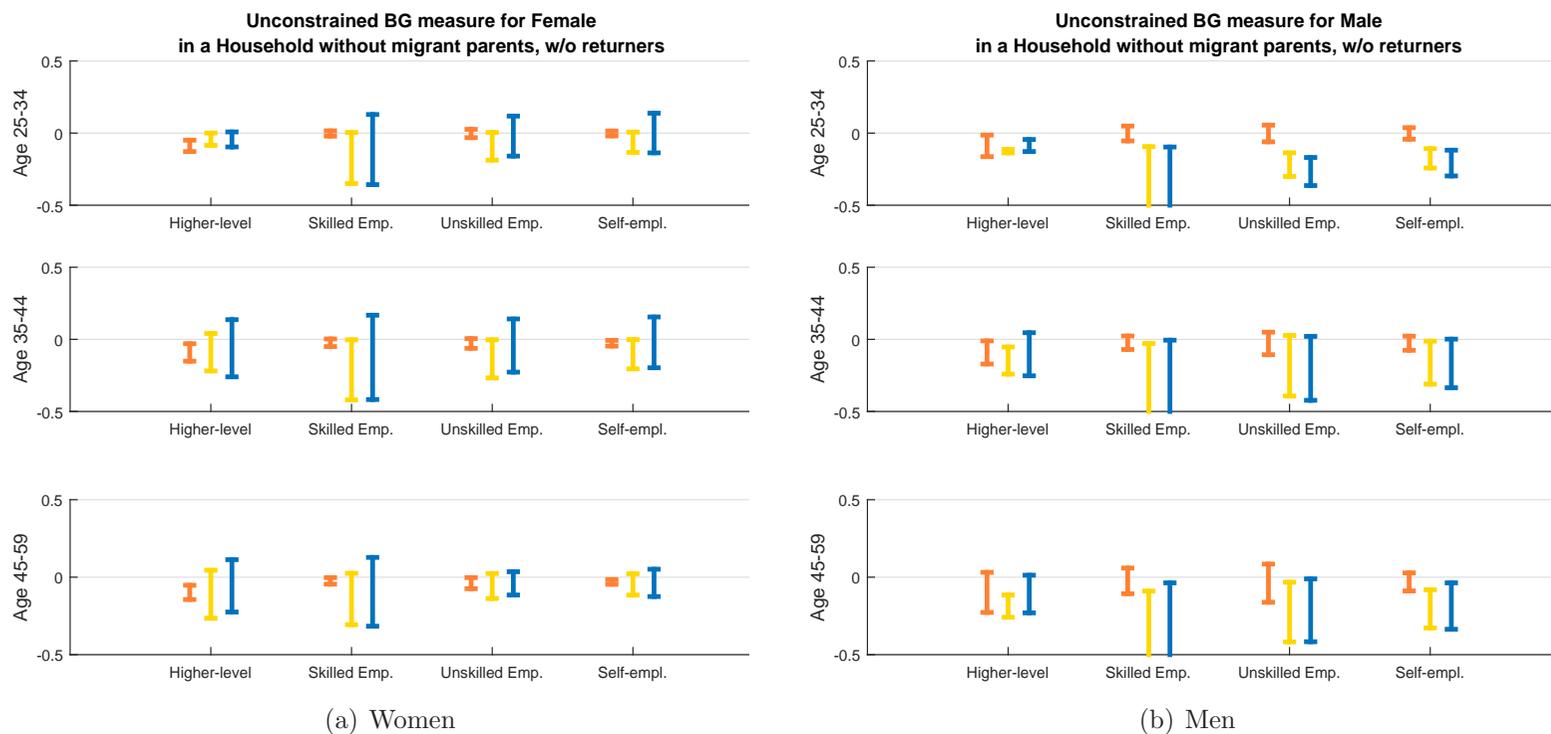
Note: Estimated distribution of education, conditional on migration status, age cohort and gender. Education: 'Primary': Primary or Less than Primary, 'Lower Sec.' some Lower Secondary, 'Upper Sec.': some Upper Secondary, and 'Tertiary': some Tertiary education. The bars represent the 95% Confidence Interval.

Figure 7: Bounds on the estimated effects  $\Delta_{sel}$ ,  $\Delta$ ,  $\Delta_{inc}$  - 50% CI

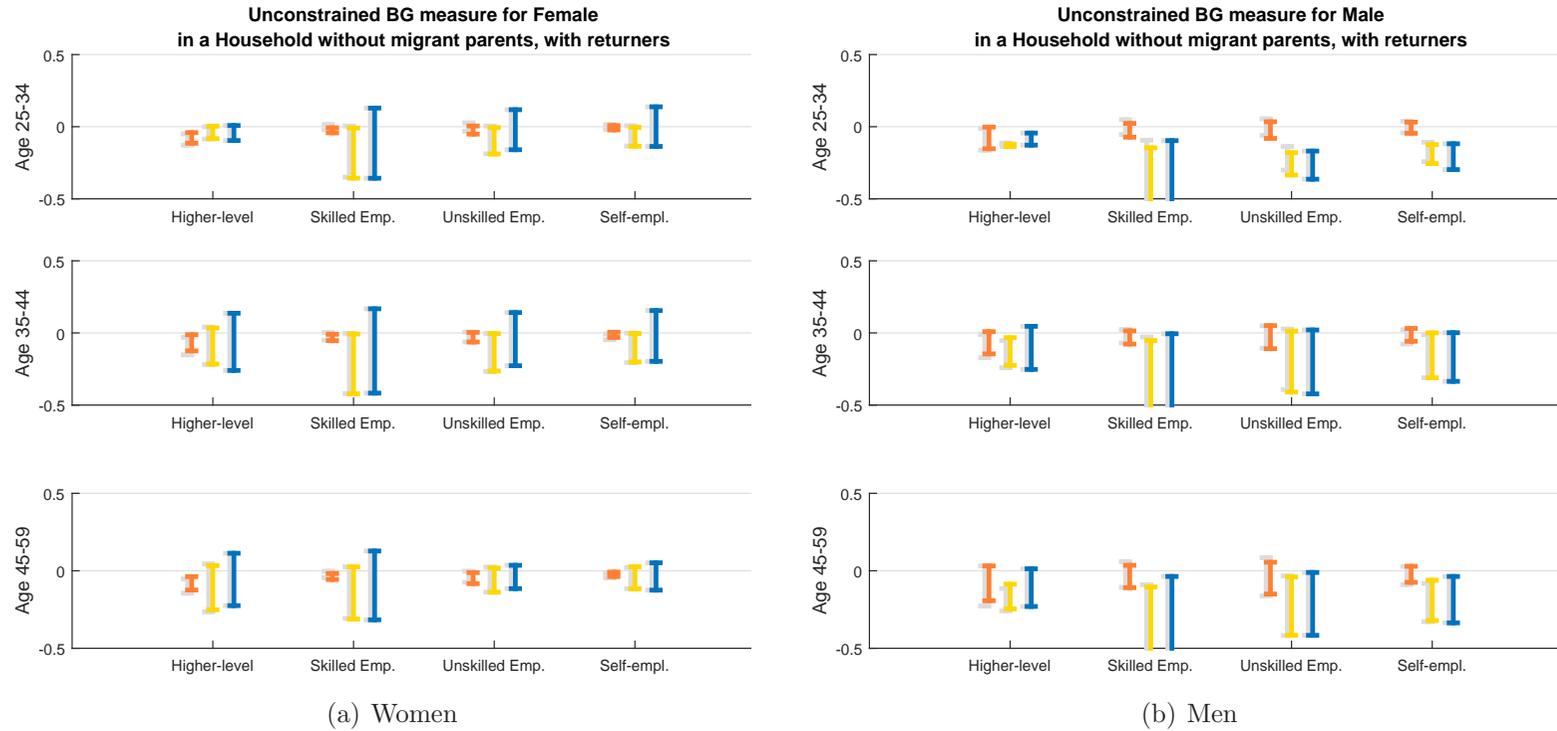


Note: 50% CI: from left to right:  $\Delta_{sel}$  (orange),  $\Delta$  (gold), and  $\Delta_{inc}$  (blue). No migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 34, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

Figure 8: Bounds on the estimated effects  $\Delta_{sel}$ ,  $\Delta$ ,  $\Delta_{inc}$  - 90% CI

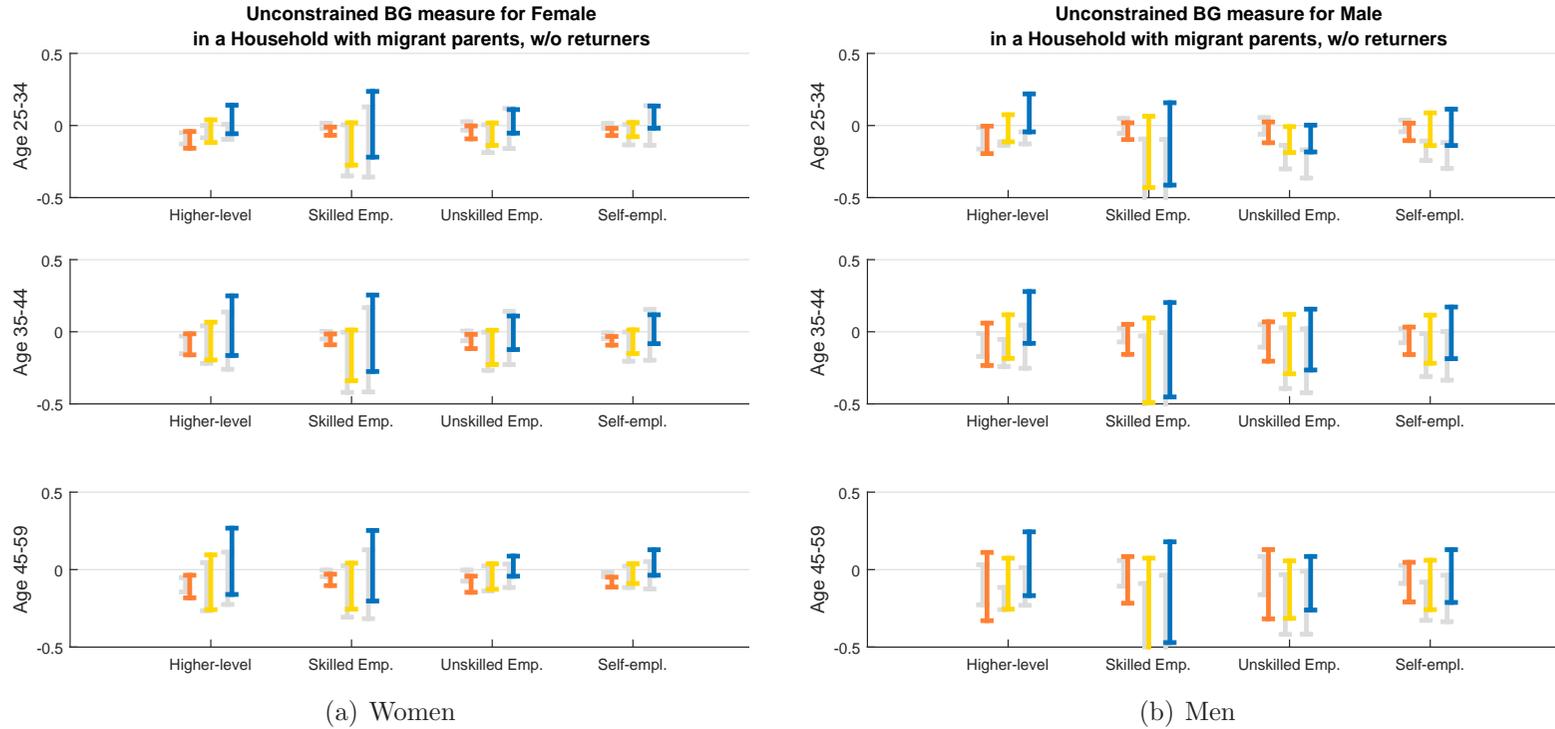


Note: 90% CI: from left to right:  $\Delta_{sel}$  (orange),  $\Delta$  (gold), and  $\Delta_{inc}$  (blue). No migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 24, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

Figure 9: Bounds on the estimated effects  $\Delta_{sel}^r, \Delta^r, \Delta_{inc}^r$  - 90% CI - Accounting for returners

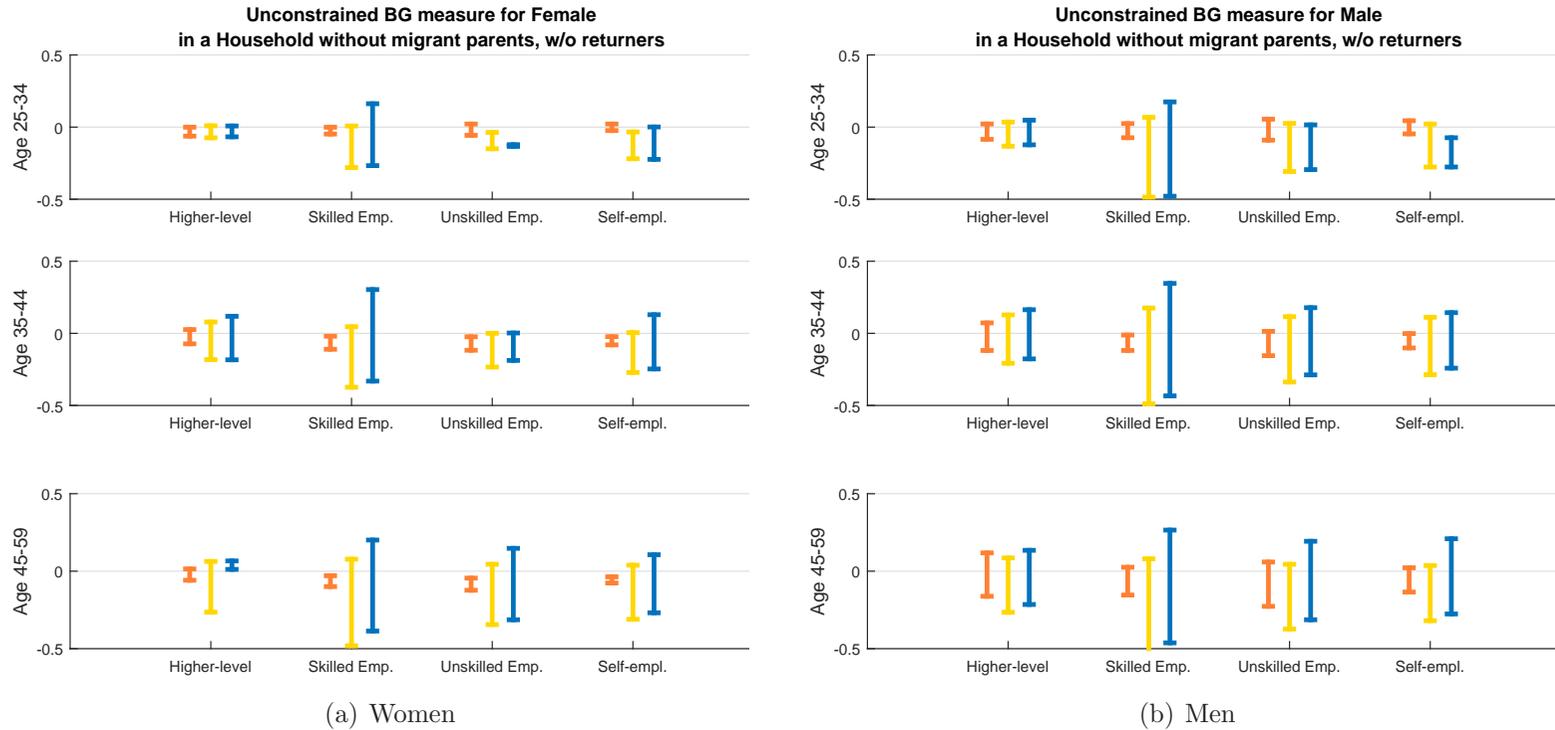
Note: 90% CI: from left to right:  $\Delta_{sel}^r$  (orange),  $\Delta^r$  (gold), and  $\Delta_{inc}^r$  (blue). The shadow bars represent the results of the baseline estimation. No migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 24, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

Figure 10: Bounds on the estimated effects  $\Delta_{sel}, \Delta, \Delta_{inc}$  - 90% CI - Households with a migrant



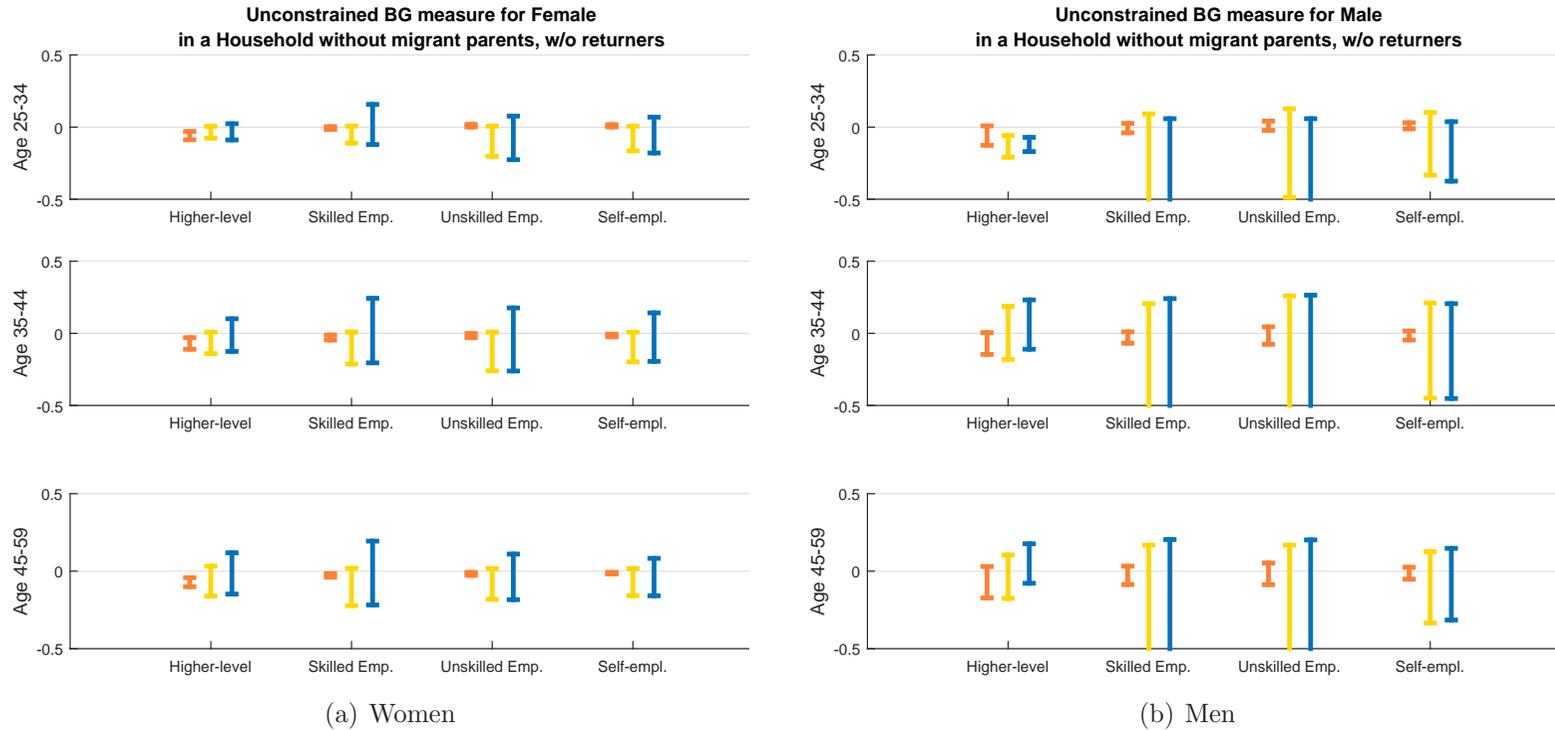
Note: 90% CI: from left to right:  $\Delta_{sel}$  (orange),  $\Delta$  (gold), and  $\Delta_{inc}$  (blue). The shadow bars represent the results of the baseline estimation. At least one migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 24, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

Figure 11: Bounds on the estimated effects  $\Delta_{sel}, \Delta, \Delta_{inc}$  - 90% CI - Lower Secondary Education



Note: 90% CI: from left to right:  $\Delta_{sel}$  (orange),  $\Delta$  (gold), and  $\Delta_{inc}$  (blue). No migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 34, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

Figure 12: Bounds on the estimated effects  $\Delta_{sel}$ ,  $\Delta$ ,  $\Delta_{inc}$  - 90% CI - Tertiary Education



Note: 90% CI: from left to right:  $\Delta_{sel}$  (orange),  $\Delta$  (gold), and  $\Delta_{inc}$  (blue). No migrant in the household. Conditional on gender, age cohort, parental occupation, family size. Father's occupation: 'High-level': Higher-level occupation or employer, 'skilled empl.': skilled employee, 'unskilled empl.': unskilled employee, and 'self-empl.': self-employed or unemployed. Upper panel: Aged 25 to 34, middle panel: aged 35 to 44, lower panel: aged 45 to 59.

## Appendix

### A. Point Identification with a LIV

The LIV requires (i) an approximation of the return to education through a latent index equation, (ii) a monotonicity condition on the effect of the instrument(s) and (iii) a set of instruments with a sufficiently large support. I view this set of assumptions as untenable in the present framework.

First, it is not clear whether the migration decision can be described by a latent index equation of the form:

$$Y^* = I(\mu(W, Z) > U) \quad (\text{A.1})$$

where  $U$  is uniformly distributed on the unit interval and stochastically independent of  $Z$  (an instrument) conditional on  $W$ . Indeed,  $Y^*$  depends on the choice of education through the success probability  $p_d$  and the net returns to emigration (gains minus costs). So that, if the true specification would be:

$$Y^* = I(\mu^*(D, W, Z) > U^*) \quad (\text{A.2})$$

the independence condition would require that  $U = U^* + \mu^*(D, W, Z) - \mu(W, Z)$  be independent of  $Z$ , a particular case.

Second, it is not clear whether the instrumental variables in the present context satisfy the monotonicity condition required by the latent index model. Following BLV, I use the length of the longest spell of migration among household members to instrument the migration decision. As explained below, a longer migration spell should influence positively the migration decision in general. According to the monotonicity assumption, the (weak) increase in the migration decision should then take place for all individuals. There is however reasons to think that longer migration spells would imply weaker ties for some families, decreasing instead the migration propensity for these particular families.

Finally, to attain point identification  $Z$  should drive the probability of attempting migration to zero. However, it is hard to believe that the instruments in the present context would induce such variations on the migration decision.

## B. Non-Redundant Restrictions on $\Delta$

Consider  $\Delta$ :

$$\begin{aligned}
\Delta &= E(D|Y=0) - \mathbb{E}D(0) \\
&= P(D=1, Y^*=0|Y=0) + P(D=1, Y^*=1|Y=0) - \mathbb{E}D(0) \\
&= P(D=1, Y^*=0, Y=0)/P(Y=0) + P(D=1, Y^*=1, Y=0)/P(Y=0) - \mathbb{E}D(0) \\
&= P(D=1, Y^*=0)/P(Y=0) + P(D=1, Y^*=1, Y=0)/P(Y=0) - \mathbb{E}D(0)
\end{aligned}$$

where the last line is the consequence of

$$Y^*=0 \Rightarrow Y=0. \quad (\text{B.1})$$

Since:

$$\begin{aligned}
\mathbb{E}D(0) &= P(D(0)=1, Y^*=0) + P(D(0)=1, Y^*=1) \\
&= P(D=1, Y^*=0) + P(D(0)=1, Y^*=1)
\end{aligned} \quad (\text{B.2})$$

It follows that:

$$\begin{aligned}
\Delta &= P(D=1, Y^*=0) [1/P(Y=0) - 1] + P(D=1, Y^*=1, Y=0)/P(Y=0) \\
&\quad - P(D(0)=1, Y^*=1)
\end{aligned}$$

As  $0 \leq P(D(0)=1, Y^*=1) \leq P(Y^*=1)$ ,  $\Delta$  must satisfy:

$$\begin{aligned}
\Delta &\leq P(D=1, Y^*=0) [1/P(Y=0) - 1] + P(D=1, Y^*=1, Y=0)/P(Y=0) \\
\Delta &\geq P(D=1, Y^*=0) [1/P(Y=0) - 1] + P(D=1, Y^*=1, Y=0)/P(Y=0) - P(Y^*=1)
\end{aligned} \quad (\text{B.3})$$

## C. Instrument: index measure interacting the network and the unemployment rate

To take advantage of exogenous variations that affect the returns to education abroad but not at home, I construct an index measure, which interacts, at a given age, the strength of a network in one of the three destinations and the unemployment rate in this location.

Let  $N_{c,t,i}$  be the size of  $i$ 's network in country  $c$  when he is aged  $t$ . Let  $U_{c,t,i}$  be the unemployment rate by gender for individual between 25 to 34, in country  $c$  when  $i$  is aged  $t$ . The index I construct takes the following form:

$$I_i = \frac{1}{6} \sum_{16 \leq t \leq 21} \frac{\sum_{c \in \{FR, IT, ES\}} U_{c,t,i} (N_{c,t,i} + 1)}{\sum_{c \in \{FR, IT, ES\}} (N_{c,t,i} + 1)}$$

When the data on unemployment rate are missing for a given country, I replace them by the OECD average. In particular, all three series start after 1972.

## D. Implementing the Command *clr3bound*

The command *clr3bound* is part of the Stata Package *clrbound* provided by Chernozhukov, Kim, Lee, and Rosen (2013). *clr3bound* constructs confidence intervals of level  $1 - \alpha$  by inverting a statistical test of corresponding level. It requires three inputs for each the lower and upper bound: the dependent variables, the control and instrument variables, and the range over which the optimization is to be performed.

### D.1. Dependent Variables

Take the Lower bound on  $\Delta(X)$ , that is  $E(D|Y = 0, X) - \overline{UB}_0(X)$ , where  $\overline{UB}_0(X) = 1 - \tilde{q}_{00}$ . First, to circumvent the curse of dimensionality, I approximate  $E(D|Y = 0, X)$  with  $\hat{E}(D|Y = 0, X) = \hat{P}(D, Y = 0|X)/\hat{P}(Y = 0|X)$  using Linear Probability Models for the numerator and the denominator.  $\hat{E}(D|Y = 0, X)$  is then used as a Plug-in estimator as advised by Mourifié, Henry, and Méango (2015).

As in ?, the dependent variable is defined as  $\hat{E}(D_i|Y_i = 0, X_i) - (1 - I(D_i = 0, Y_i^* = 0))$ , where  $I(D = 0, Y^* = 0) = 1$  if the  $i$ 's Education is  $D = 0$  and  $i$  never attempted migration.

The remaining bounds are constructed accordingly.

### D.2. Control and instrumental variables

I list in the command *clr3bound*, the control and instrumental variables in Section 7.2 and 7.3. Note that estimation is conducted separately for men and women. When a polynomial specification of the instrument is considered, further exponents of the instrumental variables are introduced up to degree 5. In the reported results, I use the degree 3.

### D.3. Range

The range matrix to be imputed in the command *clr3bound* is defined by producing combinations of the instrumental variables. In the baseline, I use the “Network innovation between 16 and 21” and the “Index measure”. I demean each of these variables. I use an eight points for the first instrument and a 25 grid points for the second instrument. When a polynomial specification of the instrument is considered, further exponents of the range are introduced up to degree 5. In the reported results, I use the degree 3.

## E. Linear Approximation

The information conveyed by the variation of bounds can be usefully summarized by using a linear approximation of the variation of the measured effects. Denote by  $\hat{L}B_{\Delta}(X)$  (respectively  $\hat{U}B_{\Delta}(X)$ ) the lower (resp. upper) bound estimated on the measure  $\Delta$ . And denote the estimated bounds on  $\Delta_{sel}$ , or  $\Delta_{inc}$  correspondingly. Assume that there exists some real vector  $\hat{\beta}_{\Delta}$  such that:

$$\hat{L}B_{\Delta}(X) \leq X\hat{\beta}_{\Delta} \leq \hat{U}B_{\Delta}(X) \quad (\text{E.1})$$

The range of each component of the vector  $\hat{\beta}_{\Delta}$  can be obtained by solving two linear programming problems: the first one minimizes the component of  $\hat{\beta}_{\Delta,j}$  under the inequality constraints (E.1) and the second one maximizes  $\hat{\beta}_{\Delta,j}$  under the same constraints.

The solutions of these optimization problems are presented in Table 2. Note that the results do not give the 90% confidence interval an hypothetical parameter  $\beta_{\Delta}$  such that  $\Delta(X) = X\beta_{\Delta}$ . This is because each confidence interval is computed separately. Ideally, one should construct first joint confidence region for all  $X$  and run the procedure. This is not feasible with the Stata package, because of computational restrictions.

## F. Refinements Using the Migration Status

Prior information on the sign of the returns to education can be used to refined the bounds. Moreover, these refined bounds allow to falsify assumptions on the returns to education. The data at hand allow to identify migrants without legal documents at their first migration. Therefore, I consider four possible assumptions on the returns to education, depending on the type of migration.

**Assumption 1.** *Assume that either:*

1. *For any household, the returns to education in case of illegal migration are lower than the returns to education in the origin country;*
2. *For any household, the returns to education in case of legal migration are higher than the returns to education in the origin country;*
3. *For any household, the returns to education in case of illegal migration are lower than the returns to education in the origin country, and the returns to education in case of legal migration are higher than the returns to education in the origin country;*

4. For any household, the returns to education in case of migration (legal or illegal) are higher than the returns to education in the origin country.

Assumption 1.1 states that for any randomly chosen household, illegal migration results in disincentives to invest in education, and follows from our previous discussion on illegal migration. Conversely, Assumption 1.2 states that legal migration provides incentive to invest in education. Assumption 1.3 claims both. Finally, Assumption 1.4 claims that incentives are always positive. From the discussion in Section 3.3, it should not hold in all subgroups. Assumption 1.4 should be seen as the most optimistic case for finding a net positive effect, that is because the incentive effect given by emigration prospects operates on all individuals in the population.

#### F.1. Bounds on $\mathbb{E}D(0)$

Refined bounds can be derived on the counterfactual quantity  $\mathbb{E}D(0)$ , under the different scenarios in Assumption 1. To state this bounds, it is necessary to introduce additional notations to distinguish legal and illegal migration spells. Still denoting by  $Y^*$  the migration decision,  $Y^*$  can take one of the three following values:  $Y^* = 0$ , if the household decides not to attempt migration,  $Y^* = 1l$  if the household decides to attempt legal migration, and  $Y^* = 1i$  if the household decides to attempt illegal migration. Then, the bounds on  $\mathbb{E}D(0)$  are given by the following proposition:

**Proposition 2.** Assume that  $D(0)$  is stochastically independent from  $\tilde{Z} := (Z, X_{(1)}, Z_{(1)})$ , conditionally on  $X$ , and the following expressions are well defined.

$$\begin{aligned}\tilde{q}_1 &:= \inf\{\mathbb{P}(D = 1|\tilde{Z} = z) : z \in \text{Supp}(\tilde{Z})\}, \\ \tilde{q}_{00-01l} &:= \inf\{\mathbb{P}(D = 0, Y^* = 0|\tilde{Z} = z) + \mathbb{P}(D = 0, Y^* = 1l|Z = z) : z \in \text{Supp}(Z)\}, \\ \tilde{q}_{10-11i} &:= \inf\{\mathbb{P}(D = 1, Y^* = 0|\tilde{Z} = z) + \mathbb{P}(D = 1, Y^* = 1i|Z = z) : z \in \text{Supp}(\tilde{Z})\}.\end{aligned}$$

Under Assumption 1.1:

$$\tilde{q}_{10-11i} \leq \mathbb{E}D(0) \leq 1 - \tilde{q}_{00} \quad (\text{F.1})$$

Under Assumption 1.2:

$$\tilde{q}_{10} \leq \mathbb{E}D(0) \leq 1 - \tilde{q}_{00-01l} \quad (\text{F.2})$$

Under Assumption 1.3:

$$\tilde{q}_{10-11i} \leq \mathbb{E}D(0) \leq 1 - \tilde{q}_{00-01l} \quad (\text{F.3})$$

Finally, Under Assumption 1.4:

$$\tilde{q}_{10} \leq \mathbb{E}D(0) \leq \tilde{q}_1 \quad (\text{F.4})$$

To understand the bounds above, it is useful to resort to an alternative interpretation. For example, Assumption 1.4 rules out the possibility that an individual who would have obtained education  $D = 1$  when  $Y^* = 0$ , would not obtain the same level of education when  $Y^* \in 1i, 1l$ . An individual with such behavior is known in the potential outcome literature has a “defier”.<sup>21</sup> Assumption 1.4 can therefore be interpreted as a “No-defier” assumption.

Each of these bounds has at least two use. First, they provide testable implications for the different scenarios in Assumption 1. Indeed if for example, under Assumption 1.4, the lower and the upper bound cross each other, the hypothesis of positive incentives for all households is rejected by the data. Second, even if the bounds do not cross, they provide an interpretation in terms of the proportion of defiers needed to revert the estimated net effect. For example, assume that under the No-defier Assumption, the lower bound on  $\Delta(x) = b$ , where  $0 < b < 1$ . If defiers are rule out, then we should unambiguously conclude to a net brain gain in the sub-group  $x$ . If one does not rule out the existence of defiers,  $b$  represents the proportion of defiers that is needed in the sub-population of individuals with characteristics  $x$  to refute the hypothesis of a net positive effect in the sub-population of interest. The higher  $b$ , the more credible is the conclusion of a net brain gain.

## *F.2. Results under Assumption 1*

Assumption 1.4 is readily rejected, since the unrestricted bounds derived in Section 8 show that some sub-groups have on average negative incentive effects. The inference procedure also rejects Assumption 1.1 and, hence Assumption 1.3, for men in the youngest cohort and men from the richest families. In other words, despite their status as illegal migrants, some individuals in these sub-groups receive additional incentives to invest in education from emigration prospects. The proportion of these individuals is the largest among the richest household: at least 11% of the Senegalese in the youngest cohort and richest families have positive returns to illegal migration. Interestingly, Assumption 1.4 is rejected when one considers Tertiary education, but not Assumption 1.3.

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<sup>21</sup>The other possible categories comprise (i) the never-taker who never obtain education  $D = 1$  irrespective of their migration decision, (ii) the always-taker who always obtain education  $D = 1$  irrespective of their migration decision, and (iii) the compliers who obtain education  $D = 1$  if and only if they decide to migrate.

This set of results is consistent with upper secondary education giving language skills that can be useful in the destination country, so the positive returns to education even with low-skill jobs prospects. However, skills obtained in tertiary education might be useful only when migrating legally. Figure ?? shows the bounds on the effects under Assumption 1.3: the incentives are negative or very limited.