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Heaven's Swing Door: Endogenous skills, migration networks and the effectiveness of quality-selective immigration policies

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Abstract: A growing number of OECD countries are leaning toward adopting quality-selective immigration policies. The underlying assumption behind such policies is that more skill-selection should raise immigrants' average quality (or education level). This view tends to neglect two important dynamic effects: the role of migration networks, which could reduce immigrants' quality, and the responsiveness of education decisions to the prospects of migration. Our model shows that migration networks and immigrants' quality can be positively associated under a set of sufficient conditions regarding the degree of selectivity of immigration policies, the initial pattern of migrants' self-selection on education, and the way time-equivalent migration costs by education level relate to networks. The results imply that the relationship between networks and immigrants' quality should vary with the degree of selectivity of immigration policies at destination. Empirical evidence presented as background motivation for this paper suggests that this is indeed the case.

Résumé: Un nombre croissant de pays de l'OCDE adoptent des politiques d'immigration sélectives. Le raisonnement qui sous-tend ces politiques est qu'une sélection accrue devrait permettre d'augmenter la « qualité » (le niveau d'éducation) des immigrants. Ce point de vue tend à négliger deux effets dynamiques importants : le rôle des réseaux migratoires, qui concourent à la réduction de la qualité des migrants, et la réactivité des décisions d'investissement en éducation aux perspectives de migration. Notre modèle montre que les réseaux de migrants et la qualité de l'immigration peuvent être positivement associés sous un ensemble de conditions suffisantes portant sur le degré de sélectivité des politiques d'immigration, le pattern initial d'auto-sélection des migrants, et la façon dont les réseaux affectent les coûts de migration (en équivalent-temps) par niveau d'éducation. Nos résultats impliquent que la relation entre réseaux migratoires et qualité des immigrants doit varier avec le degré de sélectivité des politiques migratoires à destination. Les analyses empiriques que nous présentons comme motivation en arrière-plan de cet article suggèrent que c'est effectivement le cas.

Heaven's Swing Door: Endogenous skills, migration networks and the effectiveness of quality-selective immigration policies*

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Abstract

A growing number of OECD countries are leaning toward adopting quality-selective immigration policies. The underlying assumption behind such policies is that more skill-selection should raise immigrants' average quality (or education level). This view tends to neglect two important dynamic effects: the role of migration networks, which could reduce immigrants' quality, and the responsiveness of education decisions to the prospects of migration. Our model shows that migration networks and immigrants' quality can be positively associated under a set of sufficient conditions regarding the degree of selectivity of immigration policies, the initial pattern of migrants' self-selection on education, and the way time-equivalent migration costs by education level relate to networks. The results imply that the relationship between networks and immigrants' quality should vary with the degree of selectivity of immigration policies at destination. Empirical evidence presented as background motivation for this paper suggests that this is indeed the case.

Keywords: migration, self-selection, brain drain, immigration policy, discrete choice models.

JEL classification codes: F22, O15, J61.

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1 Introduction

A growing number of Western countries are leaning toward adopting more restrictive and increasingly "quality selective" immigration policies (i.e., biased towards the highly educated and skilled). This tendency is apparent from the gradual introduction of points-based immigration systems, first in Canada in 1967,[1] followed by Australia in 1989, New Zealand in 1991 and more recently the United Kingdom in 2008. Elsewhere, immigration policies have also evolved towards becoming more restrictive quantitatively and more selective qualitatively, be it through the introduction of specific visa categories for highly-skilled professionals (e.g., the H1-B visa category in the US, or the European "Blue Card" project currently in its infancy) or through introducing biased selection criteria making low-skill immigration more difficult while at the same time encouraging permanent high-skill immigration (e.g., France's short-lived "chosen immigration" reform of 2007).[2]

The underlying assumption behind quality-selective immigration policies is that more selection will raise immigrants' average education level. This makes perfect sense from a static standpoint. One has to keep in mind, however, that observed immigration flows are the result of a combination of self-selection (i.e., size and skill composition of a given pool of candidate immigrants) and out-selection (i.e., external selection among existing candidates) mechanisms. While immigration policy is seemingly all about out-selection, in reality it also affects the decisions to acquire human capital ahead of immigration and to migrate in the first place. In addition, once migration networks are formed, they tend to reduce the moving costs for prospective migrants (Massey *et al.*, 1994; Carrington *et al.*, 1996; Munshi, 2003; Kanbur and Rapoport, 2005) and to benefit low-skill workers the most, resulting in more negative self-selection in the presence of larger networks. McKenzie and Rapoport (2010)

[1] Education alone can provide an applicant with up to 25 out of the 67 points that are currently necessary for admission into Canada (Bertoli *et al.*, 2012), and its pivotal role in shaping the chances of admission is magnified by its positive correlation with labor market experience (21 points) and language proficiency (24 points).

[2] The decline in the level of education of the immigrants (Borjas, 1999), with its possible contribution to rising inequality and increased pressure on underprivileged segments of the native population (Borjas *et al.*, 2010), has prompted proposals to increase the degree of selectivity of immigration policies (see, for instance, the specific proposals advanced by Borjas, 1999); the immigration reform bill that was introduced in the US Senate in April 2013 contains a provision for the admission of 120,000 immigrants per fiscal year through a merit-based system.

show this using Mexican data. They find the probability of (first time) migration increases with education up to relatively high education levels in communities with small networks (high migration costs), which is consistent with positive self-selection, and, conversely, that migration propensities decreases with education in Mexican communities with large networks (small migration costs), which is consistent with negative self-selection. A similar result is obtained by Bertoli (2011) from the analysis of Ecuadorian migration, while Beine *et al.* (2011a) provide evidence that larger networks translate into more negative self-selection patterns using bilateral data from 195 sending to 30 OECD destination countries.[3,4]

The migration cost-reducing effects of networks is best illustrated by the "swing door" metaphor in our title: while the first migrants to push the door will encounter the most resistance, their followers will be able to enjoy the lower resistance of a swing door in movement. This paper asks whether quality-selective immigration policies can be effective in preserving or improving the quality of immigration not just temporarily but also in the longer run, once the dynamic effects outlined above are accounted for. To answer this question we draw on two recent strands of migration research−the literature on networks and self-selection (Borjas, 1987; Chiquiar and Hanson, 2005; McKenzie and Rapoport, 2010; Belot and Hatton, 2012; Fernández-Huertas Moraga, 2013), and the new brain drain literature (Mountford, 1997; Stark *et al.*, 1997; Beine *et al.*, 2001, 2008; Docquier and Rapoport, 2012)−to propose a unified theoretical framework where immigration policies, migration networks and endogenous education decisions jointly determine the eventual pattern of migrants' selection. The model consists of a discrete-choice, random utility-maximization model where heterogeneous individuals in terms of ability make their education decisions while considering the costs (which depend on networks) and expected benefits (which depend on foreign wages and on the probability of admission at destination) of emigration.

A central result of this paper is to show that quality-selective immigration policies can be dynamically effective (i.e., quality-enhancing in the long run). More precisely, we show

[3] See also Beine *et al.* (2011b) for an analysis across US metropolitan areas and Beine and Salomone (2013) who allow for the effect of networks to vary with gender.

[4] The structure of fixed effects in Beine *et al.* (2011a) and Beine and Salomone (2013) controls for the dependency of migrants' quality on immigration policies, but both papers maintain the assumption that the effect of migration networks on quality is independent from immigration policies; see also Antecol *et al.* (2003) and Jasso and Rosenzweig (2009) for analyses of the relationship between immigration policies and the level of education of the immigrants where the latter is assumed to be independent from the size of migration networks at destination.

that migration networks and immigrants' quality can be positively associated under a set of sufficient conditions regarding (*i*) the degree of selectivity of immigration policies, (*ii*) the initial pattern of migrants' self-selection on education and (*iii*) the way time-equivalent migration costs by education level relate to networks. Interestingly, the possibility of a positive relationship between network size and immigrants' quality is fully driven by the endogenous response of education decisions at origin and is independent of the static gains from increased selectivity.

In any event, these results imply that the relationship between network size and immigrants' quality should differ according to the type of immigration policy (selective versus non-selective) at destination. This is consistent with the empirical evidence presented as background motivation in Section 2 below. Section 3 and 4, on the other hand, are purely theoretical: Section 3 presents the general theoretical framework and Section 4, which derives the main predictions, focuses on the interplay between networks, immigrants' quality and the degree of selectivity of immigration policies. Section 5 concludes.

2 Empirical background

In this section we present a number of stylized facts on the dynamic relationship between migration networks and the skill composition of immigration. We draw on data on immigration stocks disaggregated by country of origin and level of education recently collected by Brücker *et al.* (2013) for 20 OECD receiving countries.[5] We use these data as background empirical motivation for our model rather than for testing it empirically as such an ambitious objective would require having data on gross migration flows (rather than stocks) and would also require obtaining comparative data on immigration policies for all main destinations.[6] However, there is at present no comparative database on immigration policies; Mayda (2010) and Ortega and Peri (2013) represent only partial exceptions in this respect, as they focus only on the openness of immigration policies, while our theoretical model suggests that it is their degree of selectivity that can shape the relationship between networks and migrants'

[5] The dataset by Brücker *et al.* (2013) provides seven observations between 1980 and 2010 on the size of bilateral migrant stocks, broken down by gender and level of education, for up to 195 origin countries, and it builds upon the methodology proposed by Docquier *et al.* (2009) and Defoort (2008).

[6] Variations in stocks represent a very noisy measure of gross flows, as they also reflect attrition due to return migration, migration to third countries, and mortality (Docquier and Rapoport, 2012).

quality.

We specify a pseudo-gravity model of international migration from an underlying random utility model that describes the location-decision problem faced by prospective migrants (Grogger and Hanson, 2011; Beine *et al.*, 2011a; Ortega and Peri, 2013; Bertoli and Fernández-Huertas Moraga, 2013) to estimate the following selection equation:[7]

$$g_{jkt} \equiv \ln\left(\frac{m^h_{jkt}}{m^l_{jkt}}\right) = \alpha_k \ln(n_{jkt-5}) + d_{jk} + d_{jt} + d_{kt} + \epsilon_{jkt} \tag{1}$$

where m^h_{jkt} and m^l_{jkt} represent the stock of high- and low-educated migrants[8] originating from country j and residing in destination k at time t,[9] n_{jkt-5} represents the size of migration networks at time $t-5$,[10] and d_{jk}, d_{jt} and d_{kt} represent origin-destination, origin-time and destination-time dummies respectively. The inclusion of origin-destination dummies d_{jk} allows to purge the relationship between migrants' quality and the size of migration networks from the confounding influence of dyadic time-invariant factors such as distance, historical relationships, or linguistic and cultural proximity, that could introduce a spurious relationship between networks and quality. Similarly, the dummies d_{jt} and d_{kt} allow to control for any time-varying factors that are specific either to the origin country j or to the destination country k. We allow for the coefficient of the size of migration networks, α_k, to vary across destinations k. In the absence of systematic data on immigration policies adopted at destination, this approach represents a parsimonious (albeit crude) way to capture differences in the relationship of interest across countries that have different legal frameworks that regulate incoming migration flows, as in Docquier *et al.* (2012).

Table 1 reports the estimates of the selection equation on an unbalanced panel of 16,521 non-missing observations.[11] Specification (1) retains the assumption that the effect of networks does not vary across destinations: the estimates suggest that a 10 percent increase in

[7]This equation can be derived from an underlying RUM model where the stochastic component follows an identically and independently distributed Extreme Value Type-1 distribution (McFadden, 1974) or a nested logit model *á la* Ortega and Peri (2013), where there is a positive correlation in the realization of the stochastic component of utility across destinations.

[8]Highly-educated migrants are defined as having college education.

[9]We use migration stocks rather than flows as in Grogger and Hanson (2011) and Beine *et al.* (2011a).

[10]Notice that we follow Beine *et al.* (2011a) and Bertoli and Fernández-Huertas Moraga and (2012) by adding one to the size of migration networks before taking the natural logarithm, to avoid generating missing values.

[11]The dataset by Brücker *et al.* (2013) has a total size of 23,280 observations.

Table 1: Migrants' quality and migration networks

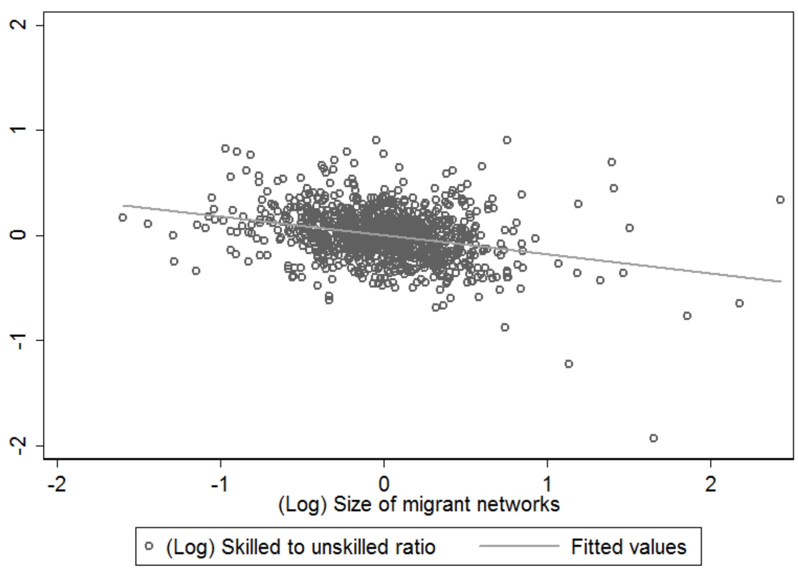
	Dependent variable: $\ln(m^h_{jkt}/m^l_{jkt})$			
	(1)		(2)	
Networks	-0.097***	(0.006)		
Networks interacted with destination dummies				
Australia			0.014	(0.031)
Austria			-0.116***	(0.031)
Canada			0.003	(0.023)
Switzerland			-0.128***	(0.032)
Chile			-0.195***	(0.017)
Germany			-0.105***	(0.034)
Denmark			-0.106***	(0.028)
Spain			0.025*	(0.015)
Finland			-0.026	(0.032)
France			-0.066**	(0.027)
United Kingdom			-0.072**	(0.032)
Greece			-0.098***	(0.025)
Ireland			-0.097***	(0.030)
Luxembourg			-0.065*	(0.037)
Netherlands			-0.085**	(0.036)
Norway			0.033	(0.027)
New Zealand			-0.180***	(0.026)
Portugal			-0.200***	(0.020)
Sweden			-0.178***	(0.027)
United States			-0.180***	(0.023)
Observations	16,521		16,521	
Adjusted R^2	0.888		0.890	
F-test	-		11.96***	
Origin-destination dummies	Yes		Yes	
Origin-time dummies	Yes		Yes	
Destination-time dummies	Yes		Yes	

Notes: Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; standard errors in parentheses; F-test on the null hypothesis that the estimated coefficients α_k do not vary across destinations.

Source: Authors' elaboration on Brücker *et al.* (2013).

the scale of bilateral migration networks reduces the ratio between high- and low-educated migrants by 0.97 percent, an effect that is significant at the 1 percent confidence level and is in line with the evidence provided by Beine *et al.* (2011a) using cross-sectional data.[12] Specification (2) relaxes this assumption, whose validity is rejected by the data: a F-test on the null hypothesis that $\alpha_k = \alpha$ for all k rejects it, suggesting that the relationship between migrants' quality and migration networks varies across destinations.

Figure 1: Migrants' quality and migration networks, US (1985-2010)



(coefficient: -0.180, t-stat: -10.27)

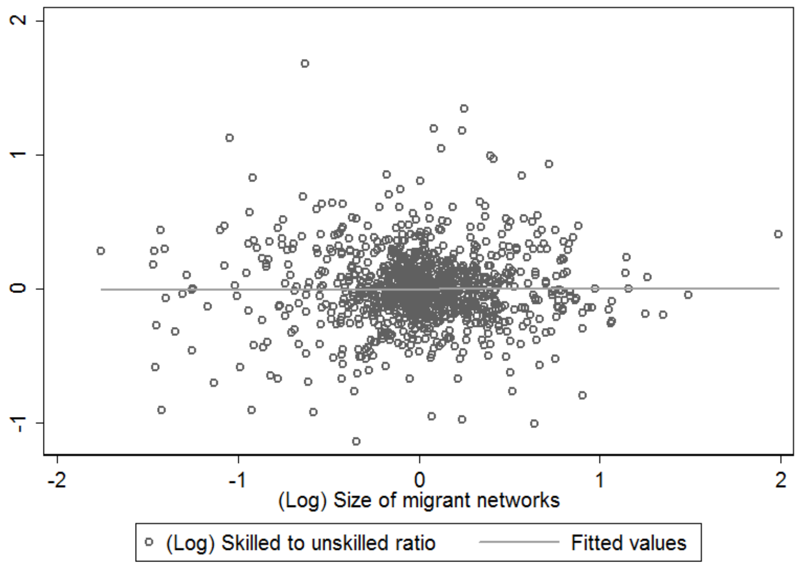
Notes: partial regression plot of the residuals of a regression of each of the two variables on origin×year, destination×year and origin×destination dummies; skilled migrants are defined as the migrants with tertiary education; migration networks are defined as the total stock of migrants in the year $t-5$; the figure is based on 1,095 observations with positive stocks for both skilled and unskilled migrants.

Source: Authors' elaboration on Brücker *et al.* (2013).

The second data column of Table 1 reveals that the negative elasticity of migrants'

[12]Notice that the corresponding effect estimated in the baseline specification of the selection equation by Beine *et al.* (2011a) stands at -1.71 percent; the longitudinal dimension of the data by Brücker *et al.* (2013) allows us to include dyadic fixed effects d_{jk} in (1), and this might contribute to explain the smaller size of our estimated elasticity of migrants' quality with respect to networks.

Figure 2: Migrants' quality and migration networks, Canada (1985-2010)



(coefficient: 0.003, t-stat: 0.14)

Notes: see the notes to Figure 1; the figure is based on 1,018 observations with positive stocks for both skilled and unskilled migrants.

Source: Authors' elaboration on Brücker *et al.* (2013).

quality with respect to networks identified by Beine *et al.* (2011a) is notably robust when we allow for heterogeneity across destinations, but it also suggests that the adoption of selective immigration policies could actually be influencing the relationship between networks and quality. Specification (2) reveals that the estimated coefficient $\widehat{\alpha}_k$ is negative for 16 out of 18 non-selective destinations in our sample,[13,14] while the estimated coefficient is not significantly different from zero for Australia and Canada, two destinations that adopted selective immigration policies since 1989 and 1967, respectively. We also allowed α_k for

[13] The only exceptions are represented by Norway and Spain.

[14] Notice that we regard New Zealand, whose estimated coefficient of networks is negative and significant, as a non-selective destination, as "the New Zealand system has evolved into a model where entry is granted on the basis of very short-term labour market considerations" (Bertoli *et al.*, 2012, p. 28), and as the points associated to individual characteristics, such as education, is less pronounced than either in Australia or in Canada.

Australia to vary before and after the introduction of the point-based system: the estimated coefficient is negative before 1989, and positive and significant at the 5 percent confidence level after the adoption of selective immigration policies.[15]

Figure 1, which plots the variation in the data that identifies $\widehat{\alpha}_k$ for the US, reveals that a 10 percent increase in the size of the bilateral migration networks is associated with a significant 1.8 percent decline in the quality of immigrants, as measured by the ratio of skilled to unskilled immigrants, in the US. For Canada, which has been adopting selective immigration policies since 1967, the partial-regression plot in Figure 2 does not reveal a negative relationship between the two variables, as the slope of the fitted line stands at 0.003 and it is not significantly different from zero. Similar differences emerge if we compare another destination with selective immigration policies such as Australia with other non-selective destinations, such as France or Germany, as evidenced by our estimates in Table 1. This suggests that an increase in the size of migration networks leads to a worsening in migrants' quality in nearly all non-selective destinations, while quality does not systematically vary with the scale of migration networks in the few clearly selective countries in our sample. The theoretical model proposed below tries to make sense of these stylized facts and identifies (sufficient) conditions for selective immigration policies to preserve or improve the quality of immigration even if networks grow large over time.

3 The model

The model extends Beine *et al.* (2001) by (*i*) allowing moving costs to depend on the size of migration networks as in McKenzie and Rapoport (2010) and Beine *et al.* (2011a), (*ii*) including a stochastic term in location-specific utility, and (*iii*) non-normalizing the probability to migrate of low-skilled individuals to zero. We also introduce a key modification in the underlying hypotheses of the model as we assume that the heterogeneity across individuals results from different time-equivalent costs of education, as in Beine *et al.* (2008), rather than from differences in innate learning abilities.[16]

[15] Results are available upon request.

[16] Both assumptions give rise to differences across individuals in the net returns to education, but the one that we retain here is more convenient from an analytical perspective, as it implies that educated migrants are not heterogeneous with respect to their productivity.

3.1 Setup

We model the choices taken by a mass of two-period lived individuals; in the first period, agents can either devote all of their time to domestic employment, or devote a share $a \in [0,1]$ of their time to education.[17] The agents who do not invest in education keep their initial level of human capital unchanged also in the second period of their lives, i.e. $h_1^i = h_2^i = 1$, while the individuals who invest in education have a human capital h_2^i equal to $(1+\phi_h)$, with $\phi_h > 0$ representing the education premium at origin, in the second period of their lives.[18] Let $I(i)$ be an indicator function that takes a value of one if individual i invested in education in the first period, and zero otherwise.

We focus on a small open economy. We assume that wages are an exponential function of h; utility u^i is additively separable and logarithmic in the income received in the two periods; furthermore, utility in the second period also contains an individual- and location-specific stochastic component ϵ_j^i, with $j = h, d$. The stochastic component of utility can reflect a preference shock or a shock to the cost of moving, as in Kennan and Walker (2011), or a random term in wages.[19] Notice that, as migration occurs only in the second period, the inclusion of a stochastic component of utility in the first period would have no influence on the analysis.

Normalizing the first-period utility of an individual who does not invest in education to one, the utility associated to domestic employment in both periods is equal to:[20]

$$u_h^i[I(i)] \equiv 1 + \ln[1 - I(i)a^i] + V_h[I(i)] + \epsilon_h^i \tag{2}$$

where $V_h[I(i)] = 1 + I(i)\phi_h$ represents the deterministic component of utility at origin in period 2.[21]

In the second period of their lives, individuals self-select into migration. If individual

[17] Higher-ability individuals devote a lower share a of their first period time to education.

[18] We do not explicitly consider inter- or intra-generational education externalities, as we are not concerned about the social returns to education in the source country.

[19] See also Borjas (1987), Grogger and Hanson (2011), Beine *et al.* (2011a), Bertoli *et al.* (2013), Bertoli and Fernández-Huertas Moraga (2013) and Ortega and Peri (2013) for random utility models applied to migration decisions.

[20] The inclusion of a discount rate r has no influence on the model.

[21] Notice that this does *not* depend on a^i, and this is why we omit the individual superscript.

i self-selects into migration, s/he faces a probability $p_{I(i)}$, which is set by the country of destination, to be admitted at destination. The probability can vary depending on whether individual i is educated, and we assume that $p_1 = p_0 + \pi$, with $p_0 \in (0, 1]$ and $\pi \in [0, 1 - p_0]$. The probability p_0 can be interpreted as reflecting the options to migrate through non-selective channels (e.g., family reunification provisions, or undocumented migration). Notice that we have assumed that p_0 is bounded away from zero, as the country of destination is unable to completely close its borders, so that the baseline probability to migrate p_0 cannot be indefinitely compressed. The destination country retains control over π, which represents the additional chances to be admitted at destination that immigration policies can give to educated applicants.

The utility associated to domestic employment in the first period and to foreign employment in the second period is equal to:

$$u_d^i[I(i)] \equiv 1 + \ln[1 - I(i)a_i] + V_d[I(i), n] + \epsilon_d^i \tag{3}$$

The deterministic component of utility at destination, $V_d[I(i), n]$, depends on the wages that a migrant earns and destination and on migration costs, which are, in turn, a function of the size of migration networks n.[22] We assume that migrants enjoy a non-negative return to education at destination (i.e., $V_d[1, n] \geq V_d[0, n]$), but we *do not* introduce assumptions on the sign of the difference between the return to education at home and at destination, which might depend on n. Even if the *gross* education premium for natives is lower at destination than at origin, this does not pin down the sign of the difference in the *net* return to education for immigrants, as (i) immigrants might enjoy a different gross education premium than natives (Borjas, 1987), and (ii) time-equivalent migration costs can decrease with education (Chiswick, 1999; Chiquiar and Hanson, 2005; McKenzie and Rapoport, 2010). Furthermore, we also assume that an expansion in the size of migration networks can produce a larger impact on the utility of uneducated than of educated migrants:

$$\frac{\partial V_d[0, n]}{\partial n} \geq \frac{\partial V_d[1, n]}{\partial n} \tag{4}$$

A specification of the deterministic component of utility at destination that satisfies these

[22]The size of migration networks n can be thought of as a function of the scale of past bilateral migration flows; more broadly, n could also reflect the factors, such as the thickness of information flows between the destination and the origin country, that influence the size of migration costs.

conditions can be obtained by adjusting the one proposed by McKenzie and Rapoport (2010), who consider a continuous education variable s, to the case of a dichotomous education variable, with $V_d[I(i), n] = 1 + \phi_d I(i) - e^{\mu_\pi - \gamma_1 I(i) - \gamma_2 n}$, with $\gamma_1, \gamma_2 \geq 0$.

3.2 Self-selection into migration

An individual i will self-select into migration if and only if:

$$V_d[I(i), n] + \epsilon_d^i > V_h[I(i)] + \epsilon_h^i \tag{5}$$

The probability of self-selection into migration q_j, with $j = 0, 1$, can be derived by specifying the distributional assumptions on the stochastic component of utility and the information upon which the self-selection decision is based. If we assume that ϵ follows an identically and independently distributed Extreme Value Type-1 distribution and that the realizations of both ϵ_h^i are ϵ_d^i are observed,[23] then following McFadden (1974) we can express the probability of self-selection into migration as a function of the deterministic component of utility in the two countries:[24]

$$q_{I(i)} = \frac{e^{V_d[I(i),n]}}{e^{V_h[I(i)]} + e^{V_d[I(i),n]}} \tag{6}$$

We assume that education decisions are taken before observing the realizations of the stochastic component of utility, so that each individual anticipates that he will self-select into migration in period 2 with a different probability $q_{I(i)} \in (0, 1)$ depending on his own education decisions in the first period of his life. We say that a pattern of positive migrants' self-selection in education occurs if $q_1 > q_0$.

[23]As in Borjas (1987). Alternatively, we could assume that the stochastic components of utility are only *locally* observable, as in Bertoli (2010), and hence the individual i decides whether to migrate before having observed the realization of ϵ_d^i; this different information structure would generate the same self-selection probability $q_{I(i)}$ if we assumed that ϵ follows an identically and independently distributed logistic distribution.

[24]Notice that the self-selection probabilities in (6) are not influenced by the anticipation of the probability of not being admitted at destination; this would no longer be the case, as in Bianchi (2013), if we introduced a fee of applying for migration.

3.3 Expected utility

Expected utility depends both on the probability of self-selection $q_{I(i)}$ and on the probability $p_{I(i)}$ to be admitted at destination. More specifically, expected utility is the (weighted) sum of three components: (i) the utility *at origin* conditional upon *not* self-selecting into migration, (ii) the utility *at destination* conditional upon self-selecting into migration, and (iii) the utility *at origin* conditional upon self-selecting into migration, with the weights being represented by the probability of each one of these three cases.

Formally, we have that:

$$\begin{aligned} E\big[u^i[I(i)]\big] = (1-q_{I(i)})E\big[u_h^i[I(i)]|u_d^i[I(i)] \leq u_h^i[I(i)]\big] + \\ p_{I(i)}q_{I(i)}E\big[u_d^i[I(i)]|u_d^i[I(i)] > u_h^i[I(i)]\big] + \\ (1-p_{I(i)})q_{I(i)}E\big[u_h^i[I(i)]|u_d^i[I(i)] > u_h^i[I(i)]\big] \end{aligned} \tag{7}$$

Here, we can exploit a key result from the literature on discrete choice models to simplify (7): when the stochastic component of utility is i.i.d. EVT-1, then the expected utility from choosing *any* of the possible alternatives *conditional* upon the fact that the chosen alternative is a utility-maximizing one, does *not* vary across alternatives (de Palma and Kilani, 2007).[25] Specifically, this implies that the first two expected conditional utilities on the right hand side of (7) coincide.

Furthermore, it is a well-established result that the expected utility from an unconstrained choice situation is equal to the Euler's constant γ plus the logarithm of the sum of the exponentiated values of the deterministic component of utility in the various alternatives (Small and Rosen, 1981). In our case, this implies that:[26]

$$\begin{aligned} E\big[u_d^i[I(i)]|u_d^i[I(i)] > u_h^i[I(i)]\big] = E\big[u_h^i[I(i)]|u_d^i[I(i)] \leq u_h^i[I(i)]\big] = \\ 1 + \ln[1 - I(i)a_i] + \ln\left(e^{V_h[I(i)]} + e^{V_d[I(i),n]}\right) + \gamma \end{aligned}$$

[25]Theorem 2.4 in Cardell (1997) already established the invariance of the distribution of conditional utility when the choice set includes two alternatives, as in our model.

[26]We can notice that the opportunity to migrate raises expected utility even if domestic and foreign wages coincide : it represents, as in Katz and Rapoport (2005), a put option that can be used as a protection against a poor realization of the stochastic component of utility in the origin country; specifically, we have that $E(u_2^i) = 1 + I(i)\phi_h + \gamma + \ln(2)$.

These two results entail that we know the value of the first two terms on the right hand side of (7); if the decision to migrate is not subject to the restrictions imposed by immigration policies,[27] then the expected utility of migrants coincides with the expected utility of stayers, even if the two countries are characterized by different wages. The size of the wage differential influences the probability of self-selecting into migration, but the utility-maximizing location decisions imply that stayers and migrants enjoy the same expected level of utility.[28]

The third term corresponds to the expected utility of the individuals who could not opt for their utility-maximizing location, as they self-selected into migration but did not get admitted at destination. We can notice that the (unconditional) utility from staying at home in the second period can be expressed as:

$$\begin{aligned} E\big[u^i_{h2}[I(i)]\big] = 1 + I(i)\phi_h + \gamma = \\ q_{I(i)} E\big[u^i_{h2}[I(i)] | u^i_{d2}[I(i)] > u^i_{h2}[I(i)]\big] + \\ (1 - q_{I(i)}) E\big[u^i_{h2}[I(i)] | u^i_{d2}[I(i)] \leq u^i_{h2}[I(i)]\big] \end{aligned}$$

This implies that:

$$\begin{aligned} E\left[u^i_{h2}[I(i)] | u^i_{d2}[I(i)] \leq u^i_{h2}[I(i)]\right] = \\ [1 + I(i)\phi_h + \gamma] - \frac{1 - q_{I(i)}}{q_{I(i)}} \left[\ln\left(e^{V_h[I(i)]} + e^{V_d[I(i),n]}\right) + \gamma\right] \end{aligned}$$

This eventually allows us to rewrite expected utility as:[29]

$$\begin{aligned} E\big[u^i[I(i)]\big] = 1 + \ln[1 - I(i)a^i] + \\ p_{I(i)} \ln\left(e^{V_h[I(i)]} + e^{V_d[I(i),n]}\right) + (1 - p_{I(i)}) V_h[I(i)] + \gamma \end{aligned} \tag{8}$$

The expected utility of the individual i is a linear combination of the expected utility from domestic employment plus the expected utility from the choice situation, with the weight

[27] This is the case considered by Delogu *et al.* (2013), who also rely on the theoretical result by de Palma and Kilani (2007) to derive the expression for expected utility to model optimal education decisions when individuals self-select into migration across different destinations.

[28] The result is actually stronger than this, as the *actual* distribution of utility will also be the same for migrants and stayers (de Palma and Kilani, 2007).

[29] Notice that the probability of self-selection into migration $q_{I(i)}$ does not enter explicitly into the expression of expected utility in (8) once we simplify the initial expression (7).

of the latter term being given by the probability to be admitted at destination conditional upon self-selecting into migration.

In the presence of the out-selection mechanisms represented by p_0 and π, the average utilities of stayers and migrants do *not* coincide, as stayers also include would-be migrants who self-selected into migration but were not admitted at destination; the welfare costs of immigration policies for a potential migrant i are represented by $(1 - p_{I(i)})$ times the differential between the utility from the unconstrained choice situation and the (unconditional) utility from staying at home. Formally, we have that:

$$\frac{\partial E\big[u^i[I(i)]\big]}{\partial p_{I(i)}} = \ln\left(e^{V_h[I(i)]} + e^{V_d[I(i),n]}\right) - V_h[I(i)] > 0$$

If we take the partial derivative of (8) with respect to the size of migration networks, we obtain:

$$\frac{\partial E\big[u^i[I(i)]\big]}{\partial n} = p_{I(i)} q_{I(i)} \frac{\partial V_d[I(i),n]}{\partial n} > 0$$

The size of the effect depends on (*i*) the *un*conditional probability of migration $p_{I(i)}q_{I(i)}$, and on (*ii*) the derivative of the deterministic component of utility at destination with respect to networks. Notice that the assumption we introduced on the size of this derivative for educated and for uneducated migrants in (4) does *not* suffice to say whether a marginal increase in networks increases expected utility more for uneducated or for educated individuals, as this latter group might enjoy a higher unconditional probability of migration.

3.4 Optimal education decisions

An individual i will invest in education if and only if:

$$E[u^i(1)] > E[u^i(0)]$$

which, using (8), can be rewritten as:[30]

$$\ln(1-a^i) + p_1 \ln\left(e^{V_h(1)} + e^{V_d(1,n)}\right) + (1-p_1)V_h(1) >$$
$$p_0 \ln\left(e + e^{V_d(0,n)}\right) + (1-p_0)$$

[30]Recall that $V_h(0)$ is normalized to unity.

This inequality implicitly defines a threshold level of innate learning ability $a(n, \mathbf{p}|\boldsymbol{\theta})$, where $\mathbf{p} = (p_0, \pi)'$ and $\boldsymbol{\theta}$ is a vector that contains all the other parameters of our model, which separates the individuals with $a^i \in \big[0, a(n, \mathbf{p}|\boldsymbol{\theta})\big)$ who find optimal to invest in education from the individuals with $a^i \in \big[a(n, \mathbf{p}|\boldsymbol{\theta}), 1\big]$ whose utility-maximizing choice is to not invest in education.[31] We have that:

$$a(n, \mathbf{p}|\boldsymbol{\theta}) \equiv 1 - e^{E[u_2(0)] - E[u_2(1)]} \tag{9}$$

where $E[u_2(0)]$ and $E[u_2(1)]$ represent respectively the expected utility in the second period for an uneducated and an educated agent, which, in turn, depend on n and $\mathbf{p}$. The expression for the threshold value of ability in (9) can also be rewritten as follows:[32]

$$a(n, \mathbf{p}|\boldsymbol{\theta}) = 1 - e^{-\phi_h} \frac{(1 - q_1)^{p_0 + \pi}}{(1 - q_0)^{p_0}} \tag{10}$$

This expression evidences the direct relationship between the share of the population at origin that invests in education and (i) the prevailing pattern of migrants' self-selection in education, and (ii) the immigration policies adopted by the country of destination.

3.4.1 The relationship between the immigration policies p and $a(n, \mathbf{p}|\boldsymbol{\theta})$

An increase in π always increases the share of the population at origin that invests in education, as it raises the expected return from schooling as we saw above. From (10), we have that:[33]

$$\frac{\partial a(n, \mathbf{p}|\boldsymbol{\theta})}{\partial \pi} = [a(n, \mathbf{p}|\boldsymbol{\theta}) - 1] \ln(1 - q_1) > 0 \tag{11}$$

The responsiveness of optimal education choices at origin with respect to a variation in π depends on q_1, the probability of self-selection for educated individuals: if migration costs are very high, then $\ln(1 - q_1)$ is close to zero, and education decisions at origin are insensitive to changes in the differential between p_1 and p_0. On the other hand, we have that

[31] We are abstracting here from the possibility that private education costs might be endogenous with respect to the prospect to migrate (Docquier *et al.*, 2008; Bertoli and Brücker, 2011).

[32] See the Appendix A for the derivation.

[33] Notice that (11) also implies that variations in π produce progressively smaller increases in the share of the population at origin that invests in education, i.e., $\partial^2 a(n, \mathbf{p}|\boldsymbol{\theta})/\partial \pi^2 < 0$.

an increase in p_0 exerts an ambiguous influence on the threshold value of ability. Taking the partial derivative of (9) with respect to p_0, we get:

$$\frac{\partial a(n,\mathbf{p}|\boldsymbol{\theta})}{\partial p_0} = \left(\frac{\partial E[u_2(1)]}{\partial p_0} - \frac{\partial E[u_2(0)]}{\partial p_0}\right)[1 - a(n,\mathbf{p}|\boldsymbol{\theta})] \lesseqgtr 0$$

The sign of the inequality above depends on whether the expected second period wages for educated agents respond more to a variation in p_0 than the wages for uneducated agents. Specifically, we have that $\partial a(n,\mathbf{p}|\boldsymbol{\theta})/\partial p_0 > 0$ if and only if migrants are positively self-selected on education, i.e. $q_1 > q_0$.[34] A positive self-selection arises if the utility gain from migration is increasing with education, so that a greater openness of immigration policies increases the expected return to the investment in education.

3.4.2 The relationship between migration networks n and $a(n,\mathbf{p}|\boldsymbol{\theta})$

How does a variation in the size of migration networks n influence the threshold level of ability $a(n,\mathbf{p}|\boldsymbol{\theta})$? This depends on whether the expected utility for educated or for uneducated individuals responds more to a marginal variation in n. We have that:

$$\frac{\partial a(n,\mathbf{p}|\boldsymbol{\theta})}{\partial n} = \left((p_0+\pi)q_1\frac{\partial V_d(1,n)}{\partial n} - p_0 q_0\frac{\partial V_d(0,n)}{\partial n}\right)[1 - a(n,\mathbf{p}|\boldsymbol{\theta})] \tag{12}$$

When migration costs are very high, so that the two probabilities of self-selection into migration q_1 and q_0 are close to zero, then (12) reveals that optimal education choices at origin are (nearly) insensitive to a variation in the size of migration networks n at destination. This expression also reveals that the impact of a marginal variation in the size of migration networks n on the threshold level of ability crucially depends on immigration policies and on the prevailing pattern of migrants' self-selection in education. For instance, it is straightforward to verify that $\partial a(n,\mathbf{p}|\boldsymbol{\theta})/\partial n < 0$, so that fewer individuals invest in education following an expansion of migration networks n, if immigration policies are non-selective, i.e. $\pi = 0$, and migrants are negatively self-selected on education, i.e. $q_1 < q_0$.[35] More generally, we have that $\partial a(n,\mathbf{p}|\boldsymbol{\theta})/\partial n \geq 0$ if and only if π is not lower than a threshold $\pi_m(n,p_0|\boldsymbol{\theta})$, which is defined as follows:

[34] This result follows directly from the derivation of the alternative expression for $a(n,\mathbf{p}|\boldsymbol{\theta})$ in (10) with respect to p_0.

[35] This case resembles the one considered in McKenzie and Rapoport (2011), where a higher probability to migrate, here induced by an expansion in n, reduces educational attainment at origin.

$$\pi_m(n, p_0|\boldsymbol{\theta}) = p_0 \left[\frac{q_0}{q_1} k(n|\boldsymbol{\theta}) - 1\right]$$

where $k(n|\boldsymbol{\theta}) \geq 1$ is defined as the ratio between the partial derivative of $V_d(0, n)$ with respect to n and the corresponding partial derivative of $V_d(1, n)$.[36,37] Notice that $\pi_m(n, p_0|\boldsymbol{\theta})$ needs not to belong to the interval $[0, 1-p_0]$ of admissible values for the policy parameter π; if $\pi_m(n, p_0|\boldsymbol{\theta}) < 0$, then any value of π gives rise to a positive relationship between $a(n, \mathbf{p}|\boldsymbol{\theta})$ and migration networks n, while $\pi_m(n, p_0|\boldsymbol{\theta}) > 1 - p_0$ determines $\partial a(n, \mathbf{p}|\boldsymbol{\theta})/\partial n < 0$ for any feasible value of π. Conversely, if $\pi_m(n, p_0|\boldsymbol{\theta}) \in [0, 1 - p_0]$, then an expansion in the size of migration networks improves the incentives to invest in education provided that immigration policies offer a sufficient reward to educated would-be migrants in terms of better chances to be admitted at destination.

If $\pi_m(n, p_0|\boldsymbol{\theta}) \in [0, 1-p_0]$, then the range of values of π that are able to induce a positive relationship between $a(n, \mathbf{p}|\boldsymbol{\theta})$ and n is larger when p_0−the degree of openness of immigration policies (which is only partly controlled by the destination country)−is lower. Furthermore, this range also depends on the distribution of wages at origin and at destination across the two levels of education, which determine the values of q_0 and q_1, and on the responsiveness of migration costs to variations in the size of migration networks n. Specifically, $\pi_m(n, p_0|\boldsymbol{\theta})$ is lower when the degree of migrants' positive self-selection on education is stronger. When migrants are exposed to a brain waste (Mattoo *et al.*, 2008) at destination, this raises the value of $\pi_m(n, p_0|\boldsymbol{\theta})$, and it increases the likelihood that an expansion of migration networks reduces $a(n, \mathbf{p}|\boldsymbol{\theta})$. Finally, $\pi_m(n, p_0|\boldsymbol{\theta})$ is higher the greater the differential in the influence of migration networks on utility for the two levels of education, as this can determine a reduction in the expected returns to education following an expansion of n.

From (11) or (12), we can observe that the cross-derivative of $a(n, \mathbf{p}|\boldsymbol{\theta})$ with respect to π and n is given by:

[36]Notice that we are slightly abusing notation here, as the vector $\boldsymbol{\theta}$ also includes the parameters that shape time-equivalent migration costs, and hence $k(n|\boldsymbol{\theta})$; if we adopt the functional specification for time-equivalent migration costs from McKenzie and Rapoport (2011), then $k(n, \boldsymbol{\theta})$ does not vary with n and it is equal to e^{γ_1}.

[37]Even assuming that $k(n|\boldsymbol{\theta}) = 1$ suffices to establish that the extent of migrants' positive self-selection in education is reduced by an expansion in the size of migration networks n, as in McKenzie and Rapoport (2010), as shown in Proposition 1 below.

$$\frac{\partial^2 a(n,\mathbf{p}|\boldsymbol{\theta})}{\partial n \partial \pi} = [1-a(n,\mathbf{p}|\boldsymbol{\theta})]\left[(1+\ln(1-q_1)(p_0+\pi))\, q_1 \frac{\partial V_d(1,n)}{\partial n} - \ln(1-q_1)p_0 q_0 \frac{\partial V_d(0,n)}{\partial n}\right] \tag{13}$$

We have that (13) is certainly positive when $\pi \leq \pi_m(n, p_0|\boldsymbol{\theta})$; in this case, the stronger the effect of an increase in selectivity on the share of the population at origin that invests in education, the higher is n. The sign of the cross-derivative becomes ambiguous if $\pi > \pi_m(n, p_0|\boldsymbol{\theta})$, but it is sufficient to assume that $q_1 \leq 1 - e^{-1} \approx 0.63$ to conclude that (13) is positive for any value of π.[38] Hence, a larger size of migration networks magnifies the responsiveness of education decisions at origin to the provision of better chances to be admitted at destination to educated applicants.

4 The scale of migration and migrants' quality

If we normalize the size of population at origin to one, we can define the scale of migration $f(n,\mathbf{p}|\boldsymbol{\theta})$ simply as:

$$f(n,\mathbf{p}|\boldsymbol{\theta}) = (p_0+\pi)q_1 F[a(n,\mathbf{p}|\boldsymbol{\theta})] + p_0 q_0\big(1 - F[a(n,\mathbf{p}|\boldsymbol{\theta})]\big)$$

where $F(a)$ represents the cumulative density function of innate learning ability. We can define migrants' quality as an increasing function of the ratio between the number of educated and of uneducated migrants; following the relevant empirical literature and the suggestive evidence that we provided in Section 2, we define migrants' quality $g(n,\mathbf{p}|\boldsymbol{\theta})$ as the logarithm of this ratio:

$$g(n,\mathbf{p}|\boldsymbol{\theta}) = \ln\left(\frac{(p_0+\pi)q_1 F[a(n,\mathbf{p}|\boldsymbol{\theta})]}{p_0 q_0\big(1 - F[a(n,\mathbf{p}|\boldsymbol{\theta})]\big)}\right) \tag{14}$$

It is straightforward to observe that $g(n,\mathbf{p}|\boldsymbol{\theta})$ is an increasing function of π, as we know from (11) that $a(n,\mathbf{p}|\boldsymbol{\theta})$ increases with π. Our key interest is to understand whether this positive static effect of selective immigration policies can be preserved over time.

[38] This condition ensures that $1 + \ln(1-q_1)(p_0+\pi) \geq 0$ even when $p_0 + \pi = 1$.

4.1 Networks and migrants' quality

How does a variation in the size of migration networks n influence the composition of the migrants by level of education? Deriving (14) with respect to n, we have that:

$$\frac{\partial g(n,\mathbf{p}|\boldsymbol{\theta})}{n} = \frac{\partial[\ln(q_1)-\ln(q_0)]}{\partial n} + \frac{f[a(n,\mathbf{p}|\boldsymbol{\theta})]}{F[a(n,\mathbf{p}|\boldsymbol{\theta})]\big(1-F[a(n,\mathbf{p}|\boldsymbol{\theta})]\big)}\frac{\partial a(n,\mathbf{p}|\boldsymbol{\theta})}{\partial n} \quad (15)$$

where $f(a)$ represents the density function of learning ability a. The first term on the right hand side of (15) describes the impact of a marginal variation in n on migrants' quality that goes though migrants' self-selection, while the second term captures the effect that goes through a variation in education decisions at origin. We have the following Proposition:

Proposition 1 *If migrants' are positively self-selected on education, then an increase in the size of migration networks reduces migrants' quality if education decisions at origin are exogenous.*

Proof. From (6), we have that:

$$\partial[\ln(q_1)-\ln(q_0)]/\partial n = (1-q_1)\frac{\partial E[u_{d2}(1)]}{\partial n} - (1-q_0)\frac{\partial E[u_{d2}(0)]}{\partial n}$$

Given (4), then:

$$\partial[\ln(q_1)-\ln(q_0)]/\partial n \leq (q_0-q_1)\frac{\partial E[u_{d2}(0)]}{\partial n} < 0$$

if $q_1 > q_0$. ■

Proposition 1 gives us a sufficient condition to sign (15) if we assume (following the entire literature on immigrants' self-selection) that the distribution of education is exogenous. In such a case, if migrants are positively self-selected on education to begin with,[39] then an

[39]Notice that the aggregate migration data by Docquier *et al.* (2009) reveal that international migrants are (almost) invariably positively selected in education, i.e. $p_1q_1 > p_0q_0$; as most destination countries covered in their dataset do *not* adopt selective immigration policies, i.e. $p_1 \approx p_0$, then this suggests that migrants are positively self-selected on education; this pattern might also be the result of the presence of liquidity constraints that prevent low-educated individuals from migrating (Belot and Hatton, 2012).

expansion of migration networks n reduces the extent of positive self-selection on education.[40]

An immediate corollary of Proposition 1 is that, when migrants are positively self-selected on education, an expansion in migration networks can lead to an improvement in migrants' quality only if the increase in n induces an increase in $a(n, \mathbf{p}|\boldsymbol{\theta})$ that more than offsets the negative impact on quality due to the change in the pattern of migrants' self-selection. This, in turn, certainly requires *sufficiently* selective immigration policies, as established by the following Proposition:

Proposition 2 *If $\pi \leq \pi_m(n, p_0|\boldsymbol{\theta})$ and migrants are positively self-selected on education, then an increase in the size of migration networks unambiguously reduces migrants' quality.*

Proof. (Omitted).[41] ■

Endogenizing education decisions at origin is, *per se*, not sufficient to alter the prediction of a negative relationship between networks size and migrants' quality contained in Proposition 1. Proposition 2 generalizes the theoretical prediction by McKenzie and Rapoport (2010) and Beine *et al.* (2011a) to a context where education is endogenous and responds to changes in the economic incentives to migrate determined by variations in the size of migration networks.

4.2 Can selective immigration policies preserve migrants' quality?

Let us assume that innate learning ability a is uniformly distributed over the unit interval, so that $F(a) = a$;[42] in this case, we can simplify (15), and we have that a marginal increase in the size of migration networks n improves migrants' quality $g(n, \mathbf{p}|\boldsymbol{\theta})$ if and only if:

[40] The same result holds in McKenzie and Rapoport (2010), but there is a key difference between the two models: McKenzie and Rapoport (2010) do not consider a stochastic component of utility, so that the probability of self-selection into migration q is either 0 or 1 and an expansion of migration networks n as no impact on the choices of all individuals for whom q was already equal to 1; in our model, $q \in (0, 1)$, so that a marginal increase in n influences the location decisions of *all* individuals.

[41] The proof simply follows from the fact that n reduces $g(n, \mathbf{p}|\boldsymbol{\theta})$ through both the self-selection and the endogenous education channel.

[42] The assumption of a uniform distribution is analytically convenient, but the results would be qualitatively unchanged under different distributional assumptions.

$$\frac{\partial[\ln(q_1)-\ln(q_0)]}{\partial n}a(n,\mathbf{p}|\boldsymbol{\theta})[1-a(n,\mathbf{p}|\boldsymbol{\theta})]+\frac{\partial a(n,\mathbf{p}|\boldsymbol{\theta})}{\partial n}\geq 0$$

Using the partial derivative of the threshold level of innate learning ability with respect to n in (12) and the proof of Proposition 1, we can rewrite this condition as follows:

$$\frac{a(n,\mathbf{p}|\boldsymbol{\theta})+[p_0+\pi-a(n,\mathbf{p}|\boldsymbol{\theta})]q_1}{a(n,\mathbf{p}|\boldsymbol{\theta})+[p_0-a(n,\mathbf{p}|\boldsymbol{\theta})]q_0}\geq k(n,\boldsymbol{\theta}) \tag{16}$$

The right hand side of (16) depends on the ratio between the sensitivity of the second-period expected utility at destination with respect to networks for an uneducated and for an educated agent respectively that we denoted by $k(n,\boldsymbol{\theta})$. Moving terms around in (16), we have that $\partial g(n,\mathbf{p}|\boldsymbol{\theta})/\partial n\geq 0$ if and only if $z(\pi|n,p_0,\boldsymbol{\theta})\geq 0$, where:

$$z(\pi|n,p_0,\boldsymbol{\theta})\equiv\pi-\frac{\big[k(n,\boldsymbol{\theta})-1\big]a(n,\mathbf{p}|\boldsymbol{\theta})+[q_1-k(n,\boldsymbol{\theta})q_0]\big[a(n,\mathbf{p}|\boldsymbol{\theta})-p_0\big]}{q_1} \tag{17}$$

We can now derive two of the main predictions of our theoretical model: (i) non-selective immigration policies, i.e. $\pi=0$, determine a negative relationship between migrants' quality and networks size under a mild restriction on $\boldsymbol{\theta}$, and (ii) sufficiently selective immigration policies give rise to a positive relationship between migrants' quality and the size of networks. The following Proposition establishes the result described at point (i) above:

Proposition 3 *If the share of individuals who invest in education is not lower than* p_0 *and migrants are not negatively self-selected on education, then migrants' quality does not increase with the size of migration networks* n *when the destination country adopts non-selective immigration policies.*

Proof. From (17), we have that $\pi=0$ implies that:

$$z(0|n,p_0,\boldsymbol{\theta})=-\frac{\big[k(n,\boldsymbol{\theta})-1\big]a(n,p_0,0|\boldsymbol{\theta})+[q_1-k(n,\boldsymbol{\theta})q_0]\big[a(n,p_0,0|\boldsymbol{\theta})-p_0\big]}{q_1}$$

$z(0|n,p_0,\boldsymbol{\theta})$ is non-positive if and only if:

$$\big[k(n,\boldsymbol{\theta})-1\big]a(n,p_0,0|\boldsymbol{\theta})+[q_1-k(n,\boldsymbol{\theta})q_0]\left[a(n,p_0,0|\boldsymbol{\theta})-p_0\right]\geq 0$$

We can notice that the left hand side of this inequality is non-decreasing in $a(n, p_0, 0|\boldsymbol{\theta})$ when $q_1 \geq q_0$. We also know from (10) that $a(n, p_0, 0|\boldsymbol{\theta})$ is a non-decreasing function of q_1. This implies that, when $a(n, p_0, 0|\boldsymbol{\theta}) \geq p_0$, the left hand side of this inequality is a non-negative function of q_1. Hence, it suffices to establish that the inequality holds when $q_1 = q_0$. When $q_1 = q_0$, we can rewrite it as follows:

$$[k(n, \boldsymbol{\theta}) - 1]\,[a(n, p_0, 0|\boldsymbol{\theta})(1 - q_0) + p_0 q_0] \geq 0$$

which clearly holds as $k(n, \boldsymbol{\theta}) \geq 1$ and $q_0 < 1$. ■

Proposition 3 demonstrates that non-selective immigration policies always give rise to a negative relationship between quality and networks.[43] This result extends the theoretical prediction by McKenzie and Rapoport (2010) to a setting where education at origin is endogenous.[44] This, in turn, implies that selective immigration policies are a necessary condition for preserving migrants' quality when networks expand, and Proposition 4 determines the condition under which selective immigration policies are also sufficient:

Proposition 4 *If migrants are not negatively self-selected on education and an increase in the size of migration networks induces an identical variation in time-equivalent migration costs for educated and uneducated agents, then a marginal increase in the size of migration networks improves migrants' quality when educated individuals can freely migrate. Formally,* $q_1 \geq q_0$ *and* $k(n, \boldsymbol{\theta}) = 1$ *imply that* $\partial g(n, \mathbf{p}|\boldsymbol{\theta})/n > 0$ *when* $\pi = 1 - p_0$.

Proof. If $k(n, \boldsymbol{\theta}) = 1$, then the expression for $z(\pi|n, p_0, \boldsymbol{\theta})$ in (17) simplifies to:

$$z(\pi|n, p_0, \boldsymbol{\theta}) = \pi - \left[a(n, \mathbf{p}|\boldsymbol{\theta}) - p_0\right] \frac{q_1 - q_0}{q_1}$$

From (10), the threshold value of ability $a(n, \mathbf{p}|\boldsymbol{\theta})$ is equal to:

$$a(n, \mathbf{p}|\boldsymbol{\theta}) = 1 - e^{-\phi_h} \frac{(1 - q_1)^{p_0 + \pi}}{(1 - q_0)^{p_0}}$$

[43] Notice that $a(n, \mathbf{p}|\boldsymbol{\theta}) < p_0$ is a sufficient but not a necessary condition to establish that migrants' quality is non-increasing in the size of migration networks when immigration policies are non-selective.

[44] Notice that the hypotheses of Proposition 3 are consistent with the case where an expansion of networks n improves the incentives to invest in education, i.e. $\partial a(n, \mathbf{p}|\boldsymbol{\theta})/\partial n > 0$; Proposition 3 ensures that the negative influence of the self-selection channel upon migrants' quality dominates the (potentially positive) effect of the endogenous education channel when $\pi = 0$.

This allows us to rewrite $z(\pi|n, p_0, \boldsymbol{\theta})$ as follows:

$$z(\pi|n, p_0, \boldsymbol{\theta}) = \pi - \left[1 - e^{-\phi_h}\frac{(1-q_1)^{p_0+\pi}}{(1-q_0)^{p_0}} - p_0\right]\frac{q_1 - q_0}{q_1}$$

When $\pi = 1 - p_0$, we have that:

$$z(1-p_0|n, p_0, \boldsymbol{\theta}) = (1-p_0)\frac{q_0}{q_1} + e^{-\phi_h}\frac{1-q_1}{(1-q_0)^{p_0}}\frac{q_1-q_0}{q_1}$$

The hypothesis that $q_1 \geq q_0$ suffices to conclude that $z(1-p_0|n, p_0, \boldsymbol{\theta}) > 0$, and hence $\partial g(n, p_0, 1-p_0|\boldsymbol{\theta})/\partial n > 0$. ■

Proposition 4 assumes that a marginal variation in the size of migration networks induces an identical change in the deterministic component of utility at destination for educated and for non-educated migrants.[45] The assumption that time-equivalent migration costs do not vary with education as in Borjas (1987) is a sufficient but *not* a necessary assumption to satisfy the hypotheses of Proposition 4,[46] and it demonstrates that this assumption suffices to conclude that migrants' quality is an increasing function of the size of migrant networks when $\pi = 1 - p_0$, i.e. there are no restrictions on the migration of educated agents, and migrants are not negatively self-selected on education.[47]

We can easily demonstrate that, under the hypotheses of Propositions 3 and 4, $z(\pi|n, p_0, \boldsymbol{\theta})$ is a convex function of π.[48] This, in turn, suffices to conclude that $z(\pi|n, p_0, \boldsymbol{\theta})$ has only

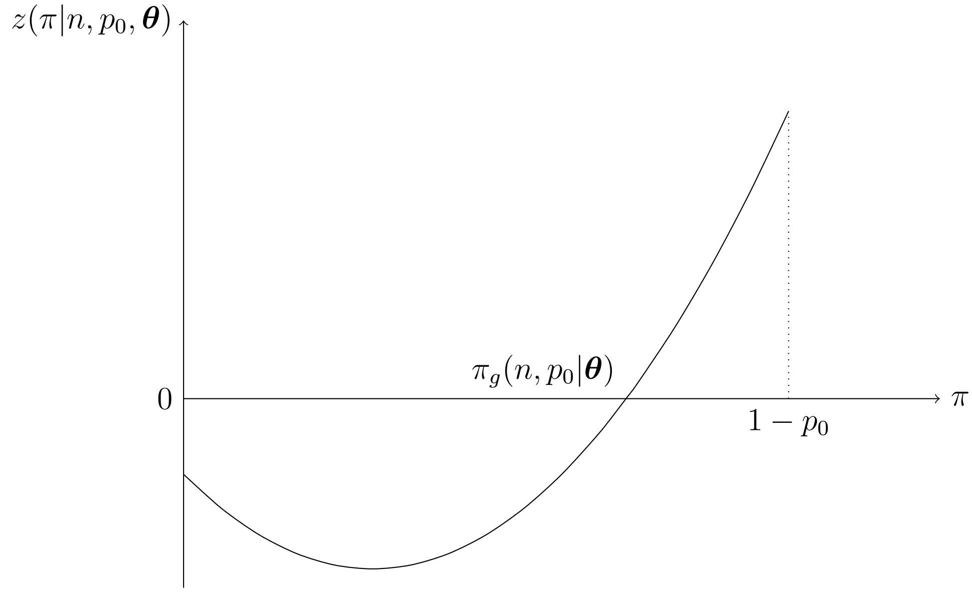
[45]Notice that $\pi_m(n, p_0|\boldsymbol{\theta}) < 0$ when $k(n, \boldsymbol{\theta}) = 1$ and migrants are positively self-selected on education, so that $\partial a(n, \mathbf{p}|\boldsymbol{\theta})/\partial n > 0$ for any value of π.

[46]Recall that Proposition 1 guarantees that the hypotheses of Proposition 4 still imply that the elasticity of the share of uneducated would-be migrants is *larger* than the corresponding elasticity for educated individuals, so that assuming that $k(n) = 1$ entails that an increase in n reduces the degree of migrants' positive selection in education, as in McKenzie and Rapoport (2010), once we do not consider its impact education choices at origin.

[47]Notice that Proposition 4 also applies to the limiting case when $p_0 = 1$, and hence $\pi = 0$; in such a case, there is no contradiction with Proposition 3, which shows that migrants' quality is decreasing with n when $\pi = 0$, as the hypothesis that $a(n, \mathbf{p}|\boldsymbol{\theta}) \geq p_0 = 1$ is clearly violated, so that Proposition 3 does not apply. More specifically $a(n, \mathbf{p}|\boldsymbol{\theta}) \leq p_0$ becomes a necessary condition to derive the result of Proposition 3 when $k(n, \boldsymbol{\theta}) = 1$, as we assume in Proposition 4.

[48]The sign of the first partial derivative of $z(\pi|n, p_0, \boldsymbol{\theta})$ with respect to π is ambiguous under the same set of hypotheses, and numerical simulations show that $\partial z(\pi|n, p_0, \boldsymbol{\theta})/\partial \pi$ can take either sign; see Appendix B for an analytical derivation of the first and second derivative.

Figure 3: The shape of the function $z(\pi|n, p_0, \boldsymbol{\theta})$



one root for $\pi \in [0, 1-p_0]$, which we can denote with $\pi_g(n, p_0|\boldsymbol{\theta})$. Hence, only selective immigration policies with $\pi \in [\pi_g(n, p_0|\boldsymbol{\theta}), 1-p_0]$ prevent migrants' quality from falling when n increases. Figure 3 provides a graphical representation of the function $z(\pi|n, p_0, \boldsymbol{\theta})$, which is drawn under the hypothesis of Propositions 3 and 4. How does a change in the size of migration networks n shift the position of the function $z(\pi|n, p_0, \boldsymbol{\theta})$ in Figure 3, thus influencing the range of values of π that are able to preserve migrants' quality when networks expand? If we derive $z(\pi|n, p_0, \boldsymbol{\theta})$ when $k(n, \boldsymbol{\theta}) = 1$ with respect to n and we evaluate it at $\pi = \pi_g(n, p_0|\boldsymbol{\theta})$, we get:

$$\begin{aligned} \frac{\partial z(\pi|n, p_0, \boldsymbol{\theta})}{\partial n}\Big|_{\pi=\pi_g(n,p_0|\boldsymbol{\theta})} = & -\frac{q_1-q_0}{q_0}\frac{\partial a(n, \mathbf{p}|\boldsymbol{\theta})}{\partial n}\Big|_{\pi=\pi_g(n,p_0|\boldsymbol{\theta})} + \\ & - [a(n, \mathbf{p}|\boldsymbol{\theta}) - p_0]\,\frac{\partial \frac{q_1-q_0}{q_0}}{\partial n} \end{aligned} \tag{18}$$

Proposition 2 guarantees that the first derivative on the right hand side of (18) is positive at $\pi = \pi_g(n, p_0|\boldsymbol{\theta})$, while the second derivative is always negative as established by Proposition 1. Hence, when migrants are positively self-selected on education and $a(n, \mathbf{p}|\boldsymbol{\theta}) \geq p_0$, the sign of the derivative of $z(\pi|n, p_0, \boldsymbol{\theta})$ with respect to n is ambiguous. Why do we have this ambiguity? As discussed above in Section 3.4.2, a larger size of migration networks n can increase the sensitivity of optimal education decisions at origin with respect to a variation in π, thus possibly increasing the range of values of π that are able to preserve migrants' quality when networks expand. Without introducing assumptions on higher-order derivatives of the deterministic component of utility at destination with respect to the size of migration networks, we cannot determine whether a larger networks size shifts $\pi_g(n, p_0|\boldsymbol{\theta})$ to the left or to the right (as these assumptions shape the responsiveness of q_1 and q_0 to n).

Proposition 4 assumes that migrants are not negatively self-selected on education and that an increase in the size of migration networks induces an identical variation in time-equivalent migration costs for educated and uneducated agents. Both assumptions are sufficient to establish the central theoretical prediction of our model, but neither of them is necessary.[49] Specifically, we have that migrants' quality is an increasing function of the size of migration networks even when time-equivalent migration costs for uneducated migrants are more sensitive to the size of migration networks, or migrants are negatively self-selected on education, provided that $k(n, \boldsymbol{\theta})$ is sufficiently close to one and $q_0 - q_1 > 0$ is sufficiently small. Clearly, a differential sensitivity of the expected utility of educated and uneducated agents with respect to the expansion of migration networks, or a pattern of negative self-selection on education, narrow down the range of admissible values of π that are able to preserve migrants' quality in the face of growing migration networks.

The evidence presented in Section 2 on the absence of a negative relationship between migrants' quality and the size of migration networks in countries that adopt selective immigration policies suggests that Proposition 4 is based on hypotheses that are plausible from an empirical perspective. For example, if we were to use Figure 3 to interpret the results against the empirical background of Section 2, then we could say that non-selective destinations such as the US or France have immigration policies that are characterized by a differential in the probability of admission for educated and uneducated applicants that falls short of $\pi_g(n, p_0|\boldsymbol{\theta})$, so that an expansion of networks invariably reduces the quality of the immigrants that they receive. Australia and Canada, on the other hand, provide a reward to education π in terms of higher chances of admission such that $z(\pi|n, p_0, \boldsymbol{\theta})$ is, on average, equal to zero, so that there is no systematic relationship between the size of migration networks and the quality of the migrants.

[49] Appendix C provides a numerical simulation of the function $z(\pi|n, p_0, \boldsymbol{\theta})$ that violates the hypotheses of Proposition 4 but that still has a root for $\pi \in [0, 1 - p_0]$, so that sufficiently selective immigration policies can preserve migrants' quality when networks expand.

5 Concluding remarks

The model in this paper proposes a possible rationale to explain why quality-selective immigration policies can be dynamically effective and neutralize the otherwise adverse effect of migration networks on migrants' self-selection. The central prediction of our model is that migration networks and immigrants' quality can be positively associated under a set of sufficient conditions regarding the degree of selectivity of immigration policies, the prevailing pattern of migrants' self-selection on education, and the way time-equivalent migration costs by education level relate to networks. Bringing the model to the data is currently out of reach due to binding data constraints; in particular, the stringency and selectivity dimensions of immigration policies are very imperfectly captured in existing datasets. However, our main testable implication is that the relationship between network size and immigrants' quality should vary with the type of immigration policy (selective versus non-selective) at destination. Empirical evidence presented as background motivation shows that this is indeed the case, suggesting that quality-selective immigration policies can have lasting effects on the education structure and skill composition of immigration.

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Appendix

A The threshold value of ability $a(n, \mathbf{p}|\boldsymbol{\theta})$

We have that:

$$a(n, \mathbf{p}|\boldsymbol{\theta}) \equiv 1 - e^{E[u_2(0)] - E[u_2(1)]}$$

where, from (8), the expected second-period utility is given by:

$$E[u_2 (I(i))] = p_{I(i)} \ln \left(e^{V_h[I(i)]} + e^{V_d[I(i), n]} \right) + (1 - p_{I(i)}) V_h[I(i)]$$

with $I(i) = 0, 1$. Moving terms around, and exploiting the expression for the probability of self-selection into migration in (6), we have that:

$$E[u_2 (I(i))] = u_{h2} [I(i)] - \ln \left(1 - q_{I(i)}\right)^{p_{I(i)}}$$

This allows to rewrite the expression for the threshold value of ability $a(n, \mathbf{p}|\boldsymbol{\theta})$ as follows:

$$a(n, \mathbf{p}|\boldsymbol{\theta}) = 1 - e^{-\phi_h} \frac{(1 - q_1)^{p_0 + \pi}}{(1 - q_0)^{p_0}}$$

B Characterization of the function $z(\pi|n, p_0, \boldsymbol{\theta})$

From (17) with $k(n, \boldsymbol{\theta}) = 1$, we have that:

$$\frac{\partial z(\pi|n, p_0, \boldsymbol{\theta})}{\partial \pi} = 1 + \frac{\partial a(n, \mathbf{p}|\boldsymbol{\theta})}{\partial \pi} \frac{q_0 - q_1}{q_1}$$

Using (11) for $\partial a(n, \mathbf{p}|\boldsymbol{\theta})/\partial \pi$ and the fact that:

$$\ln \left(e^{[1+\phi_h]} + e^{w(n)[1+\phi_d(n)]} \right) - [1 + \phi_h] = - \ln(1 - q_1)$$

the partial derivative of $z(\pi|n, p_0, \boldsymbol{\theta})$ with respect to π can be rewritten as follows:

$$\frac{\partial z(\pi|n, p_0, \boldsymbol{\theta})}{\partial \pi} = 1 + e^{-\phi_h} \ln(1 - q_1) \frac{q_1 - q_0}{q_1} \frac{(1 - q_1)^{p_0 + \pi}}{(1 - q_0)^{p_0}} \tag{19}$$

As $\ln(1 - q_1) < 0$, then (20) has an ambiguous sign when $q_1 > q_0$. We also have that:

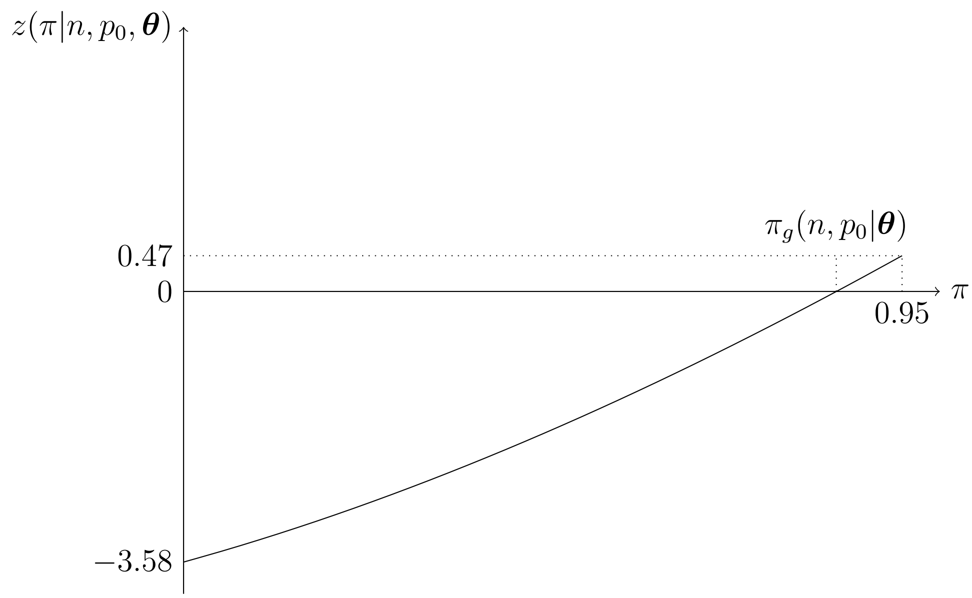
$$\frac{\partial^2 z(\pi|n, p_0, \boldsymbol{\theta})}{\partial \pi^2} = e^{-\phi_h} \left[\ln(1-q_1)\right]^2 \frac{q_1 - q_0}{q_1} \frac{(1-q_1)^{p_0+\pi}}{(1-q_0)^{p_0}} \tag{20}$$

so that $\partial^2 z(\pi|n, p_0, \boldsymbol{\theta})/\partial \pi^2 \gtreqless 0$ when $q_1 \gtreqless q_0$.

C A departure from the hypotheses of Proposition 4

Proposition 4 assumes that $q_1 \geq q_0$ and $k(n, \boldsymbol{\theta}) = 2$. Figure 4 displays a possible shape of the function $z(\pi|n, p_0, \boldsymbol{\theta})$ that violates the hypotheses of Proposition 4, as it is drawn under the assumption that an increase in migration networks n induces a reduction in time-equivalent migration costs for uneducated individuals that is twice as large as the corresponding reduction for educated individuals, i.e., $k(n, \boldsymbol{\theta}) = 2$.[50] We have that $\pi_g(n, p_0|\boldsymbol{\theta}) \approx 0.863 < 1 - p_0$, so that there are feasible values of π that give rise to a positive relationship between networks and quality even if we depart from the hypotheses of Proposition 4.

Figure 4: A possible shape of $z(\pi|n, p_0, \boldsymbol{\theta})$ with $k(n, \boldsymbol{\theta}) = 2$



[50]We retain here the same functional specification for migration costs as in McKenzie and Rapoport (2010), with the following values for the elements of the vector of parameters $\boldsymbol{\theta}$: $\phi_h = 0.1$, $\phi_d = 0.2$, $\gamma_1 = \ln(2)$, $\gamma_2 = 3$, $\mu_\pi = 3$; we also assume that $n = 1$, and $p_0 = 0.05$.