Migration networks as a response to financial constraints: Onset, and endogenous dynamics

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Migration networks as a response to financial constraints: Onset, and endogenous dynamics☆

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ABSTRACT

A migration network is modeled as a mutually beneficial cooperative agreement between financially-constrained individuals who seek to finance and expedite their migration. The cooperation agreement creates a network: "established" migrants contract to support the subsequent migration of others in exchange for receiving support themselves. When the model is expanded to study cooperation between more than two migrants, it emerges that there is a finite optimal size of the migration network. Consequently, would-be migrants in the sending country will form a multitude of networks, rather than a single grand network.

1. Introduction

Migration in general, and migration in developing countries in particular, is rarely an isolated event, and is nearly always a sequence of moves – a process in which earlier migrants shape the migration infrastructure of today's would-be migrants. The intertemporal linkages can and often do assume the form of a migration network. In this paper we develop the idea that the phased nature of migration is caused by the endogenous dynamics of the operation of migration networks, and that a migration network evolves as a response to financial constraints. Specifically, we model a migration network as an arrangement between financially-constrained individuals who, in a manner akin to

the functioning of a Rotating Savings and Credit Association (ROSCA), seek to finance and expedite their migration. Thus, we combine two strands of the literature, allowing us to view a migration network as an informal financial cooperation scheme that spans time and space.

Research on networks as facilitators of migration has shown that network-type links account for a single migration turning into a migration process, as would-be migrants tread the path chartered by others. Myrdal (1957) drew attention to the power and role of *cumulative causation* – the self-perpetuating interplay between networks that encourages additional migration, which, in turn, reinforces the network itself, causing it to grow and become more efficient in helping other would-be migrants. Taylor (1986) shows that networks play a crucial role in the evolution of migration, especially in the dynamics of international migration, where migration risks are highest, labor market information is most costly and scarce, and the penalty for making bad forecasts is most severe. Networks influence both the direction and the magnitude of migration over time. The network effect is strongest when a member of a single village household establishes himself at a

particular destination, and less strong when those concerned come from other village households. Massey (1990) notes that the social capital of migrant networks lowers the costs and risks associated with migration, thereby raising the net benefit from migration. A large body of empirical work shows that the cross-border links that migration networks provide have a significant positive impact on the intensity (rate) of migration (Davis and Winters, 2001; Dolfin and Genicot, 2010). Orrenius and Zavodny (2005) find that the likelihood of a young Mexican male migrating to the U.S. is positively correlated with his father having migrated and with the number of siblings who have migrated. Hanson and McIntosh (2010) document how, to some extent, networks act as substitutes for a wage differential in moving the migration flow between Mexico and the U.S. in the period 1960 to 2000. Beaman (2012) looks at how within-network competition for job information could weaken the effectiveness of a network as a device that overcomes labor market imperfection, and assesses the relationship between the size of the network and its effectiveness. Although the empirical context of her work (refugees in the U.S.) is distinct from ours, the perspectives of her research, namely the inner composition of the network and its optimal size, are akin to ours. Massey (1990) defines migration networks as "sets of interpersonal ties that link migrants, former migrants, and nonmigrants in origin and destination areas by the bonds of kinship, friendship, and shared community origin." We model the intensity of interpersonal bonds (affinity) and we identify the precise role that such bonds play in the design of a network.

Often, the support provided by the "network" is critical to subsequent migration; without that support, follow-up migration will not take place. What is the underlying rationale for providing support? Even though it is not hard to see why would-be migrants *accept* assistance from established migrants, what prompts the latter to *provide* assistance? And could it be that the first act in establishing a "network" actually takes place at origin rather than at destination?

Given the role that networks play, it is somewhat surprising that there has been no formal economic theory of migration networks. In this paper we take a step towards correcting this lacuna. We ask: why are migration networks formed? In what circumstances are networks more likely to emerge or evolve? Under what conditions will individuals join networks? What benefit does belonging to a network confer compared with "going it alone?" What determines the (optimal) size of a network? What constrains this size?

We model migration network as a form of cooperation between financially-constrained would-be migrants aimed at shortening the time required to accumulate the resources needed to pay for the cost of migration and initial settlement in the country of destination.[1] Seen this way, a migration network is a mutually beneficial cooperative arrangement between financially-constrained, utility-maximizing individuals, an implementation of an exchange arrangement that binds individuals across the sending and receiving countries and over time. This perspective complements the view of migration networks as conveyors of information, especially about job opportunities, and as suppliers of a variety of types of support with which established migrants furnish would-be and newly-arriving migrants.[2] Moreover, in the received literature, the emergence and formation of migration networks are typically not explained; rather, their role is highlighted. For example, Hanson and McIntosh (2010) refer to networks as "preexisting" or "historical," and Carrington et al. (1996) relate to migrant networks as "self-perpetuating." Our charge in this paper is to explain the very formation, design, and rationale of a "network plan" even before the very first migrant has embarked on his voyage.

Just as a ROSCA is a means to overcome the lack of access to credit that is needed to facilitate and expedite the purchase of a costly good in one's locale, migration network is an informal group-saving scheme aimed at facilitating and expediting access to a rewarding yet costly employment opportunity in a location farther afield. However, migration networks have an important feature distinct from the mechanisms of ROSCA as presented, for example, by Besley et al. (1993), and Anderson et al. (2009). Namely, the enforcement of future payments from a member of ROSCA who has won "the pot" early on depends on the threat of social and material sanctions that other members are capable to impose. In sustaining a ROSCA, a crucial factor is the physical and regular proximity of the members, a feature that is absent in the context of migration. Put differently, whereas the study of ROSCA is of a mechanism for arranging finances across time, the study of migration network as a "dynamic" ROSCA is of a device for financing gainful activity both across time and across space. Space matters because transactions are not seen by all members at subsequent "meetings" (in each "meeting," the number of members who are away increases by one), and "collecting" from members who are far away is qualitatively distinct from collecting from members nearby; direct and immediate enforcement devices available in the latter case are not available in the former, for example. Put somewhat crudely, in the spectrum spanned by the polar cases of spot exchanges and sequential exchanges, the standard ROSCAs are placed significantly to the left of migration networks as dynamic ROSCAs.

We present a setting in which in terms of utility-measured gains and opportunity costs, a cooperation agreement will be preferred to "going it alone." We show that the agreement creates a network in which "established" migrants contract to support the subsequent migration of others in exchange for being supported themselves, and that the optimal size of the network (the number of the cooperating migrants) is finite.

Perceiving migration networks as mechanisms geared at financing and expediting migration is not the only way of thinking about networks as a means of supporting and facilitating follow-up migration. In earlier writings, we alluded to other variables and mechanisms that explain why "established" migrants provide support for the follow-up migration of others. These variables and mechanisms include: altruism (Stark, 1999); the building up of a community of migrants to constitute a reference group that will constrain the relative deprivation that would otherwise be felt through unavoidable comparisons with the "natives" (Fan and Stark, 2007); wage gains (Stark and Wang, 2002); and the formation of a political constituency (Stark, 1993). We also considered the support given to others as a means of building up the individual's reputation in the home community so as to cushion his return (Lucas and Stark, 1985), although here we develop an argument premised on permanent migration. The present perspective of networks adds to the received literature in a number of concrete ways: it identifies a new rationale, both from the perspective of established migrants and from the perspective of would-be migrants, for the prevalence of a network; it considers membership in a network as a choice variable in an explicit optimization process; it yields a precise prediction as to the timing and sequencing of migratory moves by members of the network; it determines the optimal size (membership) of the network; it establishes a link between the magnitude of remittances and the cost of migration, and explicates the varying intensity of remittances over time; and it explains a large number of stylized facts that were hitherto subject to a plethora of theories.

Before proceeding, we summarize the migration characteristics and stylized facts that we seek to explain:[3]

– Migration is phased; migrants arrive at destination sequentially, not simultaneously.
– Would-be migrants receive assistance from past migrants; past migrants provide assistance to would-be migrants.

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[1] There is a perception in the migration literature that the cost of migration to the *n*-th individual, including the cost of getting established at destination, is not independent of the presence at destination of past *n* − 1 migrants. The standard argument in the received literature (cf., for example, Carrington et al., 1996) is that the cost decreases in *n* − 1. But this is not what interests us. We study the case in which the overall cost is *given*, and we show how cost sharing is arranged such that established migrants bear part of the cost.

[2] See, for example, Banerjee (1983), Massey et al. (1987), and Munshi (2003).

[3] Several of the listed stylized facts are elicited from Stark (1993), Rosenzweig and Stark (1997), and Stark (2009).

– There are different levels of likelihood that migration will be mediated by networks, depending, inter alia, on the cost of migration, and on the difference in earnings between destination and origin.
– Networks constitute an endogenously-generated voluntary arrangement, not an exogenous pre-existing structure.
– Networks are more likely to consist of individuals who are close to each other in the community of origin (family members, friends) than of individuals who are little related to each other at origin.
– Tightly-linked communities in the home country are more likely to form larger networks than communities with loose links.
– Even in the case of relatively small communities, several networks may co-exist, rather than all migrants and would-be migrants taking part in a single network.
– Networks make it possible for individuals to migrate and/or to migrate earlier than in the absence of networks.
– Migrants remit.

In the next section we present an introductory analysis of two individuals, and we show that in a complete-compliance cooperating scheme, the expected utility from cooperation between the two individuals is always higher than the sum of the utilities from saving for a migration alone, and that cooperation can enable migration even when going alone does not. In Section 3 we study a risk-laden cooperative scheme, alluding to the perceived risk of taking part in an n-person cooperation agreement where the source of the risk is the possibility that an individual who is randomly drawn to migrate will renege so as to enjoy a higher level of utility sooner. We link the probability of reneging with the intensity of interpersonal bonds (affinity) between the cooperating individuals. We find that there exists a finite optimal size of the migration network. We show that the optimal size of the network depends on the rate of decline in the affinity among the members as the size of the network expands. Consequently, we infer that in a community a multitude of networks, rather than a single grand network, will be formed. Section 4 sets out our conclusions.

2. A rewarding two-person cooperation aimed at expedited financing of migration

Let $y(t)$ denote an individual's flow of earnings, measured in income units (IU), in continuous time t, measured in months, such that the individual receives

$$y(t) = \begin{cases} y \text{ IU for working in the home country} \\ Y \text{ IU for working in the foreign country}, \end{cases}$$

and where, to represent the fact that income in the destination country is higher than income in the home country, $Y > y > 0$.

The income of an individual can be divided into two components: consumption and saving.[4] We denote the flow of savings of an individual in time t as $s(t)$. Throughout, we assume a zero rate of interest.[5]

Let the individual's utility function, $u(x(t))$, where $x(t) = y(t) - s(t)$ is the individual's flow of consumption at time t, be a continuous and increasing function. The intertemporal preferences of the individual are expressed by a continuous discount term $e^{-\delta t}$, where $\delta \in (0, +\infty)$ is a discount factor, allowing us to write the utility experienced by an

individual during a lifetime lasting T months as

$$U(x(t)) = \int_0^T e^{-\delta t} u(x(t)) dt.$$

For simplicity, in the notation below we omit the argument $x(t)$ of the function U. The lifetime utility of an individual who spends his entire lifetime in the home country, U_H, is

$$U_H = \int_0^T e^{-\delta t} u(y) dt.$$

Case 1. A single individual (saving alone to facilitate migration)

Let the cost of migration to the destination country be equal to C IU, $C > 0$. Consider an individual who at the beginning of month $t = 0$ decides to save in order to migrate, denying himself utility for a considerable period of time in order to enjoy later on a higher income and utility in the destination country. For simplicity, we assume that in each month the individual saves a constant amount out of his disposable income, a sum of $s(t) \equiv s_A$, which translates into C/s_A months of saving, where the subscript "A" stands for "alone." (Of course, because the saving period cannot be longer than the individual's lifespan, we have that $s_A \in [C/T, y]$.) Then, the lifetime utility of an individual who in order to migrate saves alone at the rate s_A, is equal to

$$U_A(s_A) = \int_0^{C/s_A} e^{-\delta t} u(y - s_A) dt + \int_{C/s_A}^T e^{-\delta t} u(Y) dt. \tag{1}$$

First, to render migration a possible option, the cost of migration must not be exceedingly high in relation to the duration of the individual's lifetime and to his earnings in the home country. Specifically, the cost has to be lower than the lifetime income of the individual when living in the home country, namely, $C < yT$.

Second, to render migration a rational choice for an individual, we assume that the income in the destination country, Y, is sufficiently high to allow the individual to reap gains from migration – compared to living in the home country – in the time span that remains after saving for the migration trip. This requirement can be expressed as the condition

$$\max_{0 \leq s_A \leq y} U_A(s_A) > U_H.$$

Considering U_A as a function of the savings and of the income in the destination country, $U_A(s_A, Y)$, let us denote by Y_0 the level of income in the destination country that equalizes (the optimal) consumption of the migrant and that of an individual living for his entire lifetime in his home country, that is, Y_0 is given implicitly by

$$\max_{0 \leq s_A \leq y} U_A(s_A, Y_0) = U_H. \tag{2}$$

In order for migrating to constitute a gainful option for a single individual, we must then have that $Y > Y_0$.

We refer to the saving rate, $0 \leq s_A \leq y$, that maximizes $U_A(s_A)$ in Eq. (1) by s_A^*. Then, saving at the rate s_A^* in order to accumulate the funds needed to pay for the cost of migration amounts to $T_A = C/s_A^*$ months of saving, and therefore we can write the lifetime utility of an individual who saves for migrating alone as

$$U_A = U_A(s_A^*) = \int_0^{T_A} e^{-\delta t} u(y - s_A^*) dt + \int_{T_A}^T e^{-\delta t} u(Y) dt.$$

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[4] To concentrate on essentials, we assume that covering the cost of migration is the only reason to save; individuals are not interested in "smoothing" their consumption over time or in other activities that depend on intertemporal income (wealth) transfers.

[5] We assume that in the home country capital markets and the banking sector are underdeveloped if not virtually nonexistent, such that no institutionalized saving/credit possibilities are readily available to help pay for the cost of migration. Moreover, even if a credit market were to exist, lenders will presumably be quite reluctant to finance an "escape" of a borrower.

Case 2. A cooperation agreement between two individuals (the formation of a migration network)

We next consider an arrangement of two individuals in the home country joining forces and saving together to cover the cost of migration and then send one of them to the destination country, such that with his boosted income and savings the migrant will be able to help the individual who stayed behind reach the destination country faster than had the latter saved alone. The choice as to who of the two individuals will be the first-to-go migrant (also referred to henceforth as the "winner") is to be made by tossing a fair coin when the two individuals between them have saved enough to meet the cost of migration by one of them.[6] Temporarily we assume a "complete-compliance" type of agreement, that is, we ignore the possibility that the "winner," tempted by the prospect to enjoy higher consumption sooner, will not hold his part of the deal after he arrives at the destination country.

In such a scheme, it is possible, or even likely, that the "winner" will contribute more to the common "pot of savings" after he departed, acting on his boosted income. To resolve this "imbalance," two scenarios then come to mind: in one scenario, the "loser" (the second individual to go) will be required to repay what the "winner" advanced to the second individual to support the latter's migration. Proceeding in this way, the two-way financial transfers are balanced, albeit the second individual is clearly worse-off in terms of the time span earmarked for saving and holding back on enjoyment from consumption compared to the first individual. In the second scenario, just as soon as the second individual arrives at the destination country, both individuals start enjoying their higher earnings. This way, the agreement between the two individuals is fairer in terms of the sacrifices that each of them makes. In the remainder of this paper we will assume the second scenario, which we consider more appealing.[7]

We assume that the individuals choose three optimal saving rates in order to maximize their expected lifetime utility: these rates accrue when the individuals are both in the home country (saving each at the common rate $0 \leq s_{H1} \leq y$ because up to the moment of the draw of who will be the first to migrate they are indistinguishable from each other, accumulating between them $2s_{H1}$ IU per month), and when one individual is in the destination country (saving $0 \leq s_D \leq Y$) while the other is still at home (saving $0 \leq s_{H2} \leq y$). Then, the expected utility of an individual entering a "complete-compliance" two-person cooperation scheme is equal to

$$EU_{Coop}(s_{H1}, s_{H2}, s_D) = \frac{1}{2} U_W(s_{H1}, s_{H2}, s_D) + \frac{1}{2} U_L(s_{H1}, s_{H2}, s_D), \qquad (3)$$

where

$$U_W(s_{H1}, s_{H2}, s_D) = \int_0^{\frac{C}{2s_{H1}}} e^{-\delta t} u(y - s_{H1}) dt + \int_{\frac{C}{2s_{H1}}}^{\frac{C}{2s_{H1}} + \frac{C}{s_D + s_{H2}}} e^{-\delta t} u(Y - s_D) dt$$
$$+ \int_{\frac{C}{2s_{H1}} + \frac{C}{s_D + s_{H2}}}^{T} e^{-\delta t} u(Y) dt$$

and

$$U_L(s_{H1}, s_{H2}, s_D) = \int_0^{\frac{C}{2s_{H1}}} e^{-\delta t} u(y - s_{H1}) dt + \int_{\frac{C}{2s_{H1}}}^{\frac{C}{2s_{H1}} + \frac{C}{s_D + s_{H2}}} e^{-\delta t} u(y - s_{H2}) dt$$
$$+ \int_{\frac{C}{2s_{H1}} + \frac{C}{s_D + s_{H2}}}^{T} e^{-\delta t} u(Y) dt$$

are the lifetime utilities of, respectively, the "winner" and the "loser."

Let us denote by s_{H1}^*, s_{H2}^* and s_D^* the saving rates that solve the maximization problem

$$\max_{0 \leq s_{H1} \leq y, 0 \leq s_{H2} \leq y, 0 \leq s_D \leq Y} EU_{Coop}(s_{H1}, s_{H2}, s_D),$$

and by $EU_{Coop} = EU_{Coop}(s_{H1}^*, s_{H2}^*, s_D^*)$ the optimal level of expected utility from the cooperation. The following lemma formalizes the intuition that saving together is preferable to saving alone.

Lemma 1. *Migration in a complete-compliance cooperative agreement is always preferred by a risk-neutral individual to saving alone, namely $EU_{Coop} > U_A$.*

Proof. The proof is in the Appendix.

Another property of the complete-compliance cooperative agreement is that it can make migration a gainful proposition even when it is not an appealing option for a single individual due to the insufficient increase in the earnings in the destination country. Namely, let us consider EU_{Coop} as a function of the income in the destination country, $EU_{Coop}(Y)$, and let us denote by Y_1 the level of the earnings in the destination country for which

$$EU_{Coop}(Y_1) = U_H.$$

Then we have the following lemma.

Lemma 2. *The complete-compliance cooperative agreement lowers the minimal level of income in the destination country that is necessary to render migration a rational choice below the minimal level of income necessary to render saving alone a rational choice, namely, $Y_1 < Y_0$.*

Proof. The proof is in the Appendix.

Summing together Lemmas 1 and 2, we can state that entering cooperation in order to migrate strictly dominates saving alone in order to migrate and, moreover, entering cooperation can render migration attractive even when the difference in earnings between destination and home is muted.

Stated more forcefully, Lemma 1 informs that a decision to save alone can be considered irrational. In the next section we consider, however, a plausible "dark side" of the cooperation agreement - a cost that the loser could be exposed to upon a failure of the winner to fulfill his part of the agreement. We introduce the possibility of cooperation by more than two individuals and we show that the risk involved limits the optimal size of the cooperating group.

In Stark and Jakubek (2012) we conduct a detailed analysis of the two-person cooperation scheme. Drawing on a linear form of the utility function, we show that in a complete-compliance scheme, a cooperation agreement decreases the opportunity cost of migration, which is measured by the utility forfeited during the period of saving to pay for the cost of migration. Then, introducing the risk arising from the possibility of the first-to-go migrant defaulting after he gets to the destination country, we show that the propensity to enter a risk-laden agreement increases with the cost of migration. Namely, as the cost of migration increases, an individual will be willing to strike a cooperation agreement with a counterpart whom he considers less reliable. The intuition behind this finding stems from the fact that as the cost of migration increases,

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[6] This scheme is somewhat similar to a "premium bidding ROSCA" described by Kovsted and Lyk-Jensen (1999) in which individuals who are heterogeneous in their "business" skills compete for the pot by promising higher contributions after they receive the accumulation in the pot, invest what they get, and reap high returns from their investment. In such a ROSCA, the individual who can make the most from the investment is likely to get the contents of pot the earliest. In our scheme, however, the participants migrate in random order because they do not differ in their "migration productivities."

[7] Under joint utility maximization, when each individual receives an equal weight in the optimization and the individuals have the same concave utility functions, it can easily be shown that this second arrangement is optimal and hence preferable to the first.

the gain from cooperation counters the possible loss (sustained upon a counterpart failing to keep his side of the agreement) through two channels. First, it can be shown that the benefit from successful cooperation, namely the time gained in accumulating the requisite savings, is linearly increasing in C, as is the potential cost of an unsuccessful cooperation, namely the time that a cheated individual loses. Second, because the individual discounts future utility, a gain realized earlier due to cooperation overshadows the possible pain to be sustained farther in the future.

3. The default risk, the inclination to enter cooperation, and the optimal size of the cooperating group

In the preceding section, we saw that entering a cooperation agreement in order to meet the cost of migration strictly dominates saving alone for this same purpose. However, because the second-to-go migrant loses "control" over the first-to-go migrant after the latter's departure, there is a potential risk arising from the "imbalance of powers" between the two individuals: should the first-to-go migrant decide to renege and enjoy higher utility by neglecting to remit to help the loser of the draw to migrate, the latter might have little in the way of reacting. It then stands to reason that an individual will be reluctant to strike cooperation with a "random" individual or a "stranger;" instead, he will prefer a counterpart whom he knows and whom he considers sufficiently reliable so as to render the default risk bearable.[8]

We study a setting that involves possible cooperation between more than two individuals. The questions that we seek to address are as follows: if there are conditions under which cooperation in saving for migration and a phased schedule of departures by two individuals dominate saving alone, then under what conditions will there be pooling of savings by $n \geq 2$ individuals? What are the characteristics of a *group* scheme? In particular, is there an *optimal* group size? And if so, what determines or binds the *size* of the group?

In their study of Mexican migration to the U.S., Massey et al. (1987) catalogue intensities of affinity, including "most important kin relationships in migrant networks [which] are those between fathers and sons, uncles and nephews, brothers, and male cousins," weaker links that are based on friendship or *paisanaje* (a common community of origin), and so on. To quantify the degree of affinity between individuals, we assume that the population of the home country is countably infinite, and that the bond or affinity between a pair of individuals is measured by a single value that ranges between zero and one. The values of the affinities of individual j ($j = 1, 2, \ldots$) towards individuals $i = 1, 2, \ldots$ are given by a sequence $P^j = (p_1^j, p_2^j, \ldots)$, where $0 \leq p_i^j \leq 1$ for $i = 1, 2, \ldots$. Because affinity is mutual, we presume that $p_i^j = p_j^i$.

To ease the analysis, we sort the values of affinity such that the sequence P^j is non-increasing for each j; that is, an increase in the index i yields p_i^j values that correspond to individuals who are increasingly less related to j.[9] For example, members of j's family will be accorded the highest p_i^j values and be numbered by the lowest i's, closest friends a little lower p_i^j's and a little higher i's, and so on. Furthermore, the individual bears no affinity toward individuals who are exceedingly removed from him. Thus, for every individual $j = 1, 2, \ldots$ we have that $p_1^j = 1$; $p_i^j \geq p_{i+1}^j$ for $i = 1, 2, 3, \ldots$; and $\lim_{i \to \infty} p_i^j = 0$.

To calculate the expected utility from cooperation, we assume that individual j interprets a p_i^j value as the probability that the counterpart i fulfills his part of the sequential financing agreement when i is the winner of the draw. The one-to-one mapping between affinity and the probability of migrant i keeping the agreement is premised on the notion that it is hard for an individual to cheat someone who is close to him.[10] Individual j will then compare his expected lifetime utility from cooperation with his lifelong utility from saving alone. Being risk-neutral, he will prefer cooperative saving to saving alone when the expected utility from cooperation is higher than the utility from saving alone. Because in what follows we evaluate the gains from migration only from the perspective of a single individual, the superscript j is dropped.

We consider a setting in which n individuals, $n \geq 1$,[11] save together in order to expedite the migration of the group, and we prove a general property of such a saving scheme, namely the existence of an optimal size of the migration network.

As before, we assume that the choice as to who is the first-to-go, who is the second-to-go, and so on, is made by means of a random draw at each point in time when the group happens to accumulate enough savings to pay for the migration of one member.[12] Therefore, when evaluating ex-ante the gains from a cooperation agreement, an individual uses the mean value of the affinity across the potential participants, $\bar{p}_n = \frac{1}{n-1} \sum_{i=2}^{n} p_i$, as the probability of cooperation being successful at each k-th step, $k = 1, \ldots, n$, in case he is not drawn as the k-th-to-go migrant, an event that occurs with probability $\frac{n-(k-1)-1}{n-(k-1)}$.[13] Assuming a "once beaten, twice shy" type of behavior, the cooperation scheme collapses when the first "deviator" appears among those who already made the trip, and each of the cheated individuals who are still in the home country will then, in order to migrate, start to save on his own, or, if at that point in time migration facilitated by saving alone is no longer attractive, he will forfeit saving and spend his income in the home country.

Thus, the expected utility of an individual who in a group of n individuals enters an agreement is

$$EU_n = \frac{1}{n} U_{n:1} + \frac{n-1}{n} \left[(1 - \bar{p}_n) U_{n:1,Ch} + \bar{p}_n \left[\frac{1}{n-1} U_{n:2} \right. \right.$$
$$\left. \left. + \frac{n-2}{n-1} \left[(1 - \bar{p}_n) U_{n:2,Ch} + \bar{p}_n [\ldots [U_{n:n}]] \right] \right] \right],$$

where $U_{n:k}$ is the utility of an individual who was drawn as k-th-to-go, and $U_{n:k,Ch}$ is the utility of an individual betrayed at step k. That is, at step $k = 1$ a reference individual faces a probability $1/n$ of being the winner of the draw, and a probability $(n-1)/n$ of ending up as the loser of the draw, in which case his "fate" depends on the behavior of the winner whose propensity to fulfill the agreement is $\bar{p}_n$. If the

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[8] The issue of reliability or of the confidence placed in the migrant being a determining factor of the choice of a migrant is not a novelty unraveled by this paper. A quarter of a century ago it was argued that families in the Philippines select a daughter rather than a son as a migrant even though the earnings of a son as a migrant are expected to be higher, and that this selection is made because daughters are considered to be more reliable remitters (Lauby and Stark, 1988).

[9] Strictly speaking, as the ordering of the index i is now different for each j-th individual, we should have denoted the indices as $i(j)$, but because in what follows we evaluate the gains from migration only from the perspective of a single j-th individual, we elected not to clutter the notation for no discernible gain.

[10] Although we do not model this possibility explicitly, another explanation for the presumption that an individual finds it hard to cheat someone who is close to him is that the individual is likely to harbor altruistic feelings towards those close to him, making him enjoy to some extent the greater pleasure that they obtain from a successful cooperation or, conversely, rendering cheating them harder because this would decrease his utility.

[11] For the sake of completeness, we incorporate the case of an individual who saves all by himself.

[12] Alternatively, the order of taking the migration trip could be determined through votings by the group members who, at each round, select the individual who is collectively most trusted, namely, the individual for whom the sum of the affinities is the highest. However, because no individual possesses complete information on the affinity levels of others, the outcome of the voting is not known to the "representative" individual ex-ante. Specifically, the sequence to be chosen by the group will likely be different from the sequence that the "representative" individual will consider optimal. Therefore, in such a case too, the expected gain from a cooperation agreement, as calculated by a "representative" individual, will depend on the mean value of the affinity taken over the members of the group.

[13] For the sake of notational consistency, for $n = 1$ we set $\bar{p}_1 = 1$.

winner does not renege, then at step $k = 2$ the reference individual has a chance to be drawn, this time with probability $1/(n-1)$, or he still stays at home, which happens with probability $(n-2)/(n-1)$, such that his "fate" depends on the second-to-go migrant whose propensity to fulfill the agreement is $\bar{p}_n$. And so on. We do not specify the explicit expressions for $U_{n:k,Ch}$ and $U_{n:k}$, because these utilities depend on the saving rates chosen by the cooperating individuals and, furthermore, $U_{n:k}$ also depends on the behavior of the reference individual (whether he will choose to renege when drawn as k-th-to-go) and on the behavior of those drawn as the next-to-go after he was drawn (in case one of them reneges, the scheme collapses and the promise to contribute to the group savings is no longer binding).

Lastly, and as before, we assume that the income in the destination country is high enough as to make a single individual willing to migrate, namely, as already stated following Eq. (2), that $Y > Y_0$.

We are interested in the gain from entering a cooperation agreement compared to saving alone, namely in the difference

$$\Delta U_n = EU_n - U_A,$$

presuming that if $\Delta U_n > 0$, a risk neutral individual will prefer cooperation in a group of size n to saving alone. We now state and prove the following claim.

Claim 1. There exists an $l \geq 1$ such that $\Delta U_l = \max_{n=1,2,3,\ldots} \{\Delta U_n\}$. Also, the set $\{j : \Delta U_j = \Delta U_l\}$ has a minimum, to which we refer as the optimal membership of the cooperation agreement (the optimal size of the migration network).

Proof. The proof is in the Appendix.

Claim 1 establishes the main result of this section: there exists a finite optimal size of a group of cooperating migrants. Our model predicts that in order to facilitate migration, individuals in the home country will elect to "cluster" in separate groups consisting of members linked by interpersonal ties, a feature that allows for sufficient mutual confidence. Put differently, our model predicts formation of networks of limited size rather than the formation of a single grand network. As indicated by the proof of Claim 1, the optimal size of the network depends on the interplay between the potential increase of the $U_{n:k}$ terms (describing the utility of an individual who participates in the n-individual cooperative arrangement) and the rate of decrease of p_n (the affinity that characterizes the n-th individual who is included in the cooperation agreement) as n grows. Since the $U_{n:k}$ values are similar for poor countries of the same earnings gap with a given country of destination, the extent to which the groups will comprise of members of specific families, clans, villages, and so on will depend on characteristics of the home country population, as displayed by the distribution of P. In particular, from the proof of Claim 1 it follows that if the links between members of a population are strong – a characterization represented by p_n values (and likewise by the value of $\bar{p}_n$) fading to zero slowly (cf. Eq. (A5)) – the optimal size of a network is likely to be large, because the sequence $(\Delta U_1, \Delta U_2, \Delta U_3, \ldots)$ will also decrease slowly. Conversely, if the sequence p_n drops to zero fast – strong bonds in a population are confined to the relatively small circle of the family and closest friends – the networks will be limited in size, and in the case of exceptionally "bonds-less" population, going-alone will be the only option.

4. Conclusions

We modeled the formation of a migration network, viewing the network as an informal financial cooperation between (would-be) migrants, intended to facilitate and expedite their departure to the destination country and enjoy there higher earnings. We showed how intertemporal cooperation can substitute for intertemporal borrowing, and how it can help avoid several of the drawbacks of uncollateralized borrowing such as high interest rates. Our analysis showed how in the presence of commitment, would-be migrants can benefit from jointly financing each other's cost of migration, and that the size of the migration networks is bounded. The arrangement described suggests that it is not necessary for a would-be migrant to either accumulate savings solely from his own home country income, or to become indebted to traffickers. Other considerations being the same, the more likely it is that the conditions exist for striking the kind of cooperative arrangement that we have outlined, the less likely it is that such exploitative organizations will be called upon to facilitate migration.

With an agreement of the type stipulated in our model, migration will be sequential: without an agreement, migration will be simultaneous. The possibility of distributing the departure points over time gives rise to a migration network. Put differently, the possibility of striking an agreement generates a network, and a network constitutes evidence that an agreement has been struck. Thus, cooperation, networks, and sequencing are interlinked. The model of group migration presented in Section 3 stipulates an expedited migration flow that ceases when the last participant in the cooperation agreement ends up migrating. This depiction aligns with a finding of Hanson and McIntosh (2010, p. 807) "[that] the networks created by labor supply-driven migration are self-reinforcing over time only if those networks are new; [Mexican] states in which those networks were already extant show a dampening, rather than an acceleration, over time."

A cost-based rationale for the formation and functioning of a network is clearly not the only possible rationale; as noted in research on the motivation of migrants to remit, motives can range from pure altruism to pure self-interest (Lucas and Stark, 1985; Stark and Lucas, 1988; Stark, 2009). Here, we have explored one of the options motivated by self-interest.

Appendix

Proof of Lemma 1. We consider a saving plan in which, when at home, the two individuals save at the same rate as an optimizing single migrant-to-be, that is, $s_{H1} = s_{H2} = s_A^*$, whereas from the time the first-to-go migrant is at the destination country, he retains the consumption level he had in the home country, thereby saves the entire income increment he has in addition to the rate s_A^*, that is, $s_D = s_A^* + Y - y$. Clearly, because $Y > y$, we have that $s_D > s_A^*$. Obviously, such a saving plan is feasible, and therefore we have that

$$EU_{Coop} = EU_{Coop}(s_{H1}^*, s_{H2}^*, s_D^*) \geq EU_{Coop}(s_A^*, s_A^*, s_A^* + Y - y). \tag{A1}$$

Then, the time needed to save for the two migration trips is shorter than the time it takes a single individual to be able to migrate, as

$$\frac{C}{2s_A^*} + \frac{C}{2s_A^* + Y - y} < \frac{C}{s_A^*}$$

for $Y > y$. Thus, comparing $EU_{Coop}(s_A^*, s_A^*, s_A^* + Y - y)$ with the maximum utility level available to a single migrant, $U_A(s_A^*)$, we have that

$$
\begin{aligned}
EU_{Coop}(s_A^*, s_A^*, s_A^* + Y - y) &= \frac{1}{2} U_W(s_A^*, s_A^*, s_A^* + Y - y) + \frac{1}{2} U_L(s_A^*, s_A^*, s_A^* + Y - y) \\
&= \int_0^{\frac{C}{2s_A^*}} e^{-\delta t} u(y - s_A^*) dt + \int_{\frac{C}{2s_A^*}}^{\frac{C}{2s_A^*} + \frac{C}{2s_A^* + Y - y}} e^{-\delta t} u(y - s_A^*) dt + \int_{\frac{C}{2s_A^*} + \frac{C}{2s_A^* + Y - y}}^{T} e^{-\delta t} u(Y) dt \\
&= \int_0^{\frac{C}{2s_A^*} + \frac{C}{2s_A^* + Y - y}} e^{-\delta t} u(y - s_A^*) dt + \int_{\frac{C}{2s_A^*} + \frac{C}{2s_A^* + Y - y}}^{T} e^{-\delta t} u(Y) dt \\
&> \int_0^{\frac{C}{s_A^*}} e^{-\delta t} u(y - s_A^*) dt + \int_{\frac{C}{s_A^*}}^{T} e^{-\delta t} u(Y) dt = U_A(s_A^*).
\end{aligned}
\tag{A2}
$$

Joining Eqs. (A1) and (A2) we get that $EU_{Coop} > U_A$. $\square$

Proof of Lemma 2. Let

$$G_A(Y) = \max_{0 \le s_A \le y} U_A(s_A, Y) - U_H$$

and let

$$G_{Coop}(Y) = EU_{Coop}(Y) - U_H.$$

Recalling the definitions of Y_0 and of Y_1, we have that $G_A(Y_0) = 0$, and that $G_{Coop}(Y_1) = 0$. Obviously, $G_A(Y)$ and $G_{Coop}(Y)$ are increasing in Y, a fact that together with the inequality $G_A(Y) < G_{Coop}(Y)$ which is implied by Lemma 1, translates into $Y_1 < Y_0$. $\square$

Proof of Claim 1. Clearly, in case of a single individual,

$$EU_1 = U_A,$$

so

$$\Delta U_1 = 0. \tag{A3}$$

For the case $n > 1$, let us denote by $U_{k>1}$ the part in the equation for EU_n which describes the expected utility after the first-to-go migrant turned out to be honest, that is, let

$$EU_n = \frac{1}{n} U_{n:1} + \frac{n-1}{n} \left[(1 - \bar{p}_n) U_{n:1,Ch} + \bar{p}_n U_{k>1} \right].$$

We have that

$$U_{n:k} < U_{Dest}$$

and that

$$U_{k>1} < U_{Dest},$$

for every $k = 1, \ldots, n$, where $U_{Dest} = \int_0^T e^{-\delta t} u(Y) dt < \infty$, as surely the level of utility available to the migrant is lower than the level achievable upon his entire lifetime hypothetically being spent in the destination country, enjoying there the highest level of consumption. Additionally,

$$U_{n:k,Ch} < U_A$$

because a cheated individual has to either start saving from scratch being already "delayed" by unsuccessful group saving, or he chooses to stay in the home country, in which case (cf. Eq. (2)) his utility will be lower than that of an individual who saves alone for migrating.

In consequence, for $n \ge 2$ we have that

$$\Delta U_n = EU_n - U_A = \frac{1}{n} U_{n:1} + \frac{n-1}{n} \left[(1 - \bar{p}_n) U_{n:1,Ch} + \bar{p}_n U_{k>1} \right] - U_A$$

$$< \frac{1}{n} U_{Dest} + \frac{n-1}{n} [(1 - \bar{p}_n) U_A + \bar{p}_n U_{Dest}] - U_A \underset{n \to \infty}{\to} U_A - U_A = 0, \tag{A4}$$

because

$$\frac{1}{n} U_{Dest} \underset{n \to \infty}{\to} 0$$

and because

$$\lim_{n \to \infty} \bar{p}_n = \lim_{n \to \infty} p_n = 0, \tag{A5}$$

which obtains because $\bar{p}_n = \frac{1}{n-1} \sum_{i=2}^{n} p_i$ is a Cesáro mean of the sequence $(p_2, p_3, \ldots)$,[14] we have that

$$\frac{n-1}{n} [(1 - \bar{p}_n) U_A + \bar{p}_n U_{Dest}] \underset{n \to \infty}{\to} U_A.$$

Consequently, the sequence $(\Delta U_1, \Delta U_2, \Delta U_3, \ldots)$ starts at zero (cf. Eq. (A3)) and is bounded from above by a sequence that has a limit equal to zero for $n \to \infty$ (cf. Eq. (A4)). Therefore, one of the following cases is true.

1. $0 = \Delta U_1 = \max_{n=1,2,3,\ldots} \{\Delta U_n\}$; group cooperation is not a viable option (the optimal size of the "network" is equal to one).
2. There exist $j > 1$ such that $\Delta U_j = \max_{n=1,2,3,\ldots} \{\Delta U_n\}$, and $\Delta U_j > 0$, and a number $l = \min\{i : \Delta U_i = \Delta U_j\}, l > 1$, to which we refer as the optimal size of the migration network. $\square$

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[14] The Cesáro mean of a sequence $(a_1, a_2, \ldots)$ is a sequence $(c_1, c_2, \ldots)$ such that $c_i = (a_1 + a_2 + \ldots + a_i)/i$. It is easy to see that if $\lim_{n \to \infty} a_n = A$ then also $\lim_{n \to \infty} c_n = A$.