What Do Networks Do? The Role of Networks on Migration and “Coyote" Use

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ABSTRACT

While a large literature has established that more migration experience among family and community networks tends to encourage migration, there is little research investigating the mechanism by which networks exert such effects. This paper aims to determine the relative importance of three potential benefits provided by networks: information on border crossing, information on jobs, and credit. We develop empirical tests of these network effects based on a simple model of migration that allows individuals to choose between migrating alone or with the help of a border smuggler. Using a unique dataset of undocumented Mexican migrants to the United States, we find that larger family networks encourage both migration and coyote use, consistent with the job information hypothesis. Community networks appear to provide crossing information, as larger networks increase the likelihood of migration and have a negative, though insignificant, effect on coyote use. The finding that family (but not community) networks have a smaller impact for asset holders indicates that at least some of the benefit the family network provides is a source of credit.

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1 Introduction

Social networks are widely recognized to be influential in migration decisions. A large literature has established that more extensive friend and family networks of previous migrants encourage migration. Yet little is known on the mechanisms by which networks exert such effects. Migrant networks can facilitate migration in three different ways: through providing information on the migration process itself; through providing information on destinations and jobs and aiding integration after arrival; and through helping to finance the costs of migration. Assessing the relative importance of these roles is crucial to our understanding of networks, migration, and the design of immigration policies.

This paper aims to distinguish between these three roles. To do this, we take advantage of a unique dataset on Mexican migration called the Mexican Migration Project (MMP). This data is well-suited to our analysis in several ways. First, Mexico represents the largest source of immigration to the United States. Among the foreign-born respondents surveyed in the March 2002 CPS, 9.8 million (30%) were from Mexico, and estimates suggest that Mexicans make up about 57% of undocumented immigrants, or about 5.3 million (Passel 2004). Hence, the data effectively covers a large part of the population of interest. Second, it includes detailed, dated information on the migration experiences of respondents and their families, as well as on their asset holdings, which we use to construct a retrospective panel of respondents' migration histories. Finally, the data contains information on illegal border crossing and the use of border smugglers, known as "coyotes," to help migrants enter the country. This information is critical for accurately capturing the realities of migration. Previous research indicates that around 80% of all newly arrived immigrants from Mexico are undocumented (Passel 2004), and contemporary news accounts have highlighted the widespread use of border smugglers.

This picture finds support in our data: among the sample of Mexican migrants studied here, 74% first migrated illegally, and of these, 66% hired a coyote to help them navigate the crossing. In order to make our analysis realistic and address data issues described below, we focus on illegal migration, and model the illegal migration decision as a choice to migrate with a coyote, without a coyote, or not at all.

We derive a simple model to illustrate the main channels through which networks affect migration decisions. First, *information* about the migration process and border crossing may substitute for coyote services so that migrants are better able to travel alone. Thus, the effect of crossing information should increase the probability of migration and decrease the probability of using a coyote.[1] Second, in contrast, information about *jobs* and help at destination increase the benefits of migration and encourages both migration and coyote use (since it increases the likelihood of crossing successfully). Finally, to the extent that networks substitute for personal wealth in providing a source of *credit*, their effects on migration and coyote use should be greatest among migrants with low asset holdings.

We can assess the importance of these different types of network effects by testing these predictions empirically. Our results indicate that family networks encourage both illegal migration and coyote use, suggesting that migration networks provide their members with information on jobs at the destination. The finding that family networks have a smaller impact for asset holders indicates that at least some of the benefit the network provides is a source of credit. Community networks also encourage illegal migration and coyote use, consistent with the jobs hypothesis, but do not appear to offer credit.

The rest of the paper is organized as follows. Section 2 reviews related literature. Section 3 presents a model of migration and derives testable predictions. Section 4 describes our empirical approach, and Section 5 presents the results. Section 6 concludes.

2 Existing literature

Research has found that networks play a critical role in determining migration patterns. Networks tend to increase the likelihood of migration (Taylor 1986, Grossman 1989, Massey and Espinosa

[1] Such information is unlikely to increase coyote use through identifying reliable or inexpensive coyotes, as smugglers tend to move frequently to avoid apprehension (Conover 1987).

1997, Orrenius 1999, Davis and Winters 2001, Winters et al. 2001, Munshi 2003, and Colussi 2004) and tend to attract migrating members to the same geographic area (see Bartel 1989 for instance). However, much remains to be learned about the functioning of migrant networks. In particular, little is known about the actual mechanism by which networks affect the migration decisions of their members. As discussed earlier, migrant networks could affect migration decisions through three broad channels: information, help at arrival or in finding work, and credit.

Several studies find evidence supporting particular network functions, although we are not aware of other research that specifically aims to distinguish between these functions. Recent work provides support for the role of networks in finding jobs at migrants' destinations. Using Mexican rainfall as an instrument for the size of migrants' U.S. networks, Munshi (2003) finds that larger networks substantially improve Mexican immigrants' likelihood of U.S. employment. Colussi (2004) estimates the same network effect structurally.

Another strand of recent research has emphasized the importance of migration costs and credit constraints in affecting migration decisions. Chiquiar and Hanson (2005) and Orrenius and Zavodny (2005) argue that higher migration costs for the less educated drive their finding of positive self-selection of immigrations from Mexico to the U.S as the cross-country wage differential is larger for the less educated. The presence of credit constraints is one possible explanation for higher migration costs for less educated workers.

The role of networks in alleviating migration costs has been noted by McKenzie and Rapoport (2006, 2007) who find evidence suggesting that community networks tend to lower costs, especially for the less educated. McKenzie and Rapoport (2007) present macroeconomic evidence of a network credit effect. Using historic state-level migration rates and U.S. labor market conditions as instruments for migration, they find an inverse U-shaped relationship between immigration and inequality in Mexican communities. These results are consistent with migrant networks helping current migrants to finance the cost of migration. Family networks are likely to be important too. Orrenius and Zavodny (2005) find that having a father or brother that has migrated to the U.S.

increases the likelihood of migration for male. A related line of research considers the effect of migrant networks and their characteristics on the use of “coyotes" or migrant smugglers. Several studies find that a more extensive network encourages coyote use (Donato et al. 1992, Singer and Massey 1997, Gathmann 2004, Ibarraran and Lubotsky 2007).

In this paper, we use a simple model to derive predictions about the different effects migrant networks have on a member's decision to migrate illegally and use a coyote. The primary contribution of this paper is to test for the three possible effects of networks. In addition, we address three important limitations in the literature described above.

First, we incorporate the choice to hire a coyote into the migration decision in a realistic way. Studies of migrants' decisions that include the possibility of hiring a coyote typically examine coyote use conditional on illegal migration, while these decisions may actually be made jointly. An individual's choice about whether or not to migrate at all may depend on the availability of a reliable and affordable coyote. To address this shortcoming, we analyze the decision to migrate illegally as a choice between migrating illegally without a coyote (alone), migrating illegally with a coyote, and not migrating at all. This strategy allows us to distinguish between the part of the effect actually due to the factor's influence on the migration decision and the part representing its additional effect on coyote use.

Second, most studies of migration decisions rely on cross-sectional analyses for which potential endogeneity issues are particularly accute. For instance, the observation that an individual behaves similarly to other individuals in his network may reflect not the impact of their behavior on his choice, but rather the correlation of preferences among network members. Networks may form because similar individuals choose to join together. We examine retrospective longitudinal data, which allows us to isolate the effects of *changes* in an individual's network or assets over time on his subsequent migration decisions. This approach represents an improvement that allows us to interpret network effects more confidently. However, it is important to recognize that limitations remain. There still may be a dynamic endogeneity effect if changes in an individual's network are not exogenous. As an example, an individual considering migration may encourage other network members to migrate while he makes his decision. Our analysis cannot control for this type of behavior or dynamic unobserved heterogeneity, so some caveats to interpretation remain.

Two exceptions to the cross-sectional studies in the literature are Donato et al. (1992) and Orrenius and Zavodny (2005). Donato et al. use longitudinal data on migrants (an earlier round of the MMP data) to estimate a logit model of the probability of using a coyote. Orrenius and Zavodny use a similar retrospective panel constructed from the MMP to estimate hazard rate models, as we do. However, they consider only a binary outcome of migrating or not, and do not study the effects of migration networks.

Finally, we include a role for wealth in influencing migration decisions. In a world where individuals are likely to be credit constrained, a measure of wealth is essential to the understanding of migration decisions. We use wealth to proxy for lack of credit constraints, since we lack direct information on this, as discussed in Section 4 below.

3 The Effects of Migrant Networks

In order to empirically distinguish between three hypothesized functions of the migration network — crossing information, job information or local help, and credit[2] — we develop a simple model of migration. This allows us to clarify the roles played by networks and assets in migration decisions, and to derive testable predictions about their effects.

Consider a population of individuals indexed by i. Individuals have three possible migration options indexed by $j \in \{n,c,a\}$ and characterized by a probability of success in crossing p_j and a cost q_j. The symbol n stands for not migrating ($p_n = 0, q_n = 0$); a for migrating illegally alone ($p_a > 0, q_a > 0$); and c for migrating illegally with a coyote ($p_c > p_a, q_c > q_a$). Assume also that $\frac{q_a}{p_a} < \frac{q_c}{p_c}$ so that the probability of success relative to cost is higher when crossing with a coyote

[2]One might think that networks could provide information on reliable coyotes, but this is not the case in practice. Conover 1987 and Kossoudji 199 stress that the high turnover and movement among coyotes make any information on a particular coyote readily obsolete.

than when crossing alone. Individuals have additively separable utility functions defined over consumption with utility indicators u_i that are increasing, weakly concave, and exhibit diminishing absolute risk aversion.

Let w_i^{us} be the U.S. wage for individual i, w_i^{mx} his Mexican wage, and $\Delta w_i = w_i^{us} - w_i^{mx} > 0$ his monetary gain from migrating. Assume there are no credit markets. Consider the decision for an individual i who has not yet migrated and whose total cash-in-hand is A_i: he chooses a migration option j, subject to $q_j \leq A_i$, in order to

$$Max_{j\in\{n,c,a\}}\{V_{i,j}(A_i) \equiv p_j u_i(w_i^{us} + A_i - q_j) + (1-p_j)u_i(w_i^{mx} + A_i - q_j)\}. \quad (1)$$

Clearly, a higher return to migration w_i^{us} increases the likelihood of migration. Moreover, the higher the U.S. wage the more attractive using a coyote is as compared to crossing alone, since $p_c u_i'(w_i^{us} + A_i - q_c) > p_a u_i'(w_i^{us} + A_i - q_a)$. As a result, an increase in the return to migration could decrease the likelihood of migrating alone. In contrast, the effect of the Mexican wage w_i^{mx} on the likelihood of migration is ambiguous. On the one hand, it increases the payoff to staying in Mexico, but on the other hand it reduces the risk associated with migration. Similarly, an increase in w_i^{mx} could increase or decrease the relative attractiveness of crossing alone versus crossing with a coyote, depending on whether $(1-p_c)u_i'(w_i^{mx} + A_i - q_c) < (\text{or } >)(1-p_a)u_i'(w_i^{mx} + A_i - q_a)$.

For risk neutral individuals, what matters is the expected monetary gain of migration. The higher Δw_i, the more likely i is to migrate. Moreover, there are two cutoff levels of gain $0 < \Delta_1 < \Delta_2$ so that if $\Delta w_i < \Delta_1$, he does not migrate; if $\Delta w_i \in [\Delta_1, \Delta_2]$, he migrates alone; and if $\Delta w_i \geq \Delta_2$ he migrates with a coyote. The more risk averse an individual, the less he would want to migrate, but the more he would prefer using a coyote than not.[3]

Higher *cash-in-hand* has *ambiguous* effects on the likelihood of migration. If it were not for the credit constraint, one would expect the effect of A_i on the likelihood of migration to be negative. By reducing one's marginal utility, it makes migration less attractive. On the other hand, being richer

[3]With a CRRA utility $u(x) = \frac{1}{1-\rho}x^{1-\rho}$, a higher risk aversion ρ reduces i's incentive to migrate but increases the attractiveness of c over a.

tends to reduce one's risk aversion, thereby making migration more attractive. This effect would also make migrating alone more attractive compared with migrating with a coyote. However, in the absence of credit markets, higher levels of cash-in-hand would increase the likelihood of migration for credit constrained individuals. Individuals are deemed *credit constrained* if migration either alone or with a coyote would maximize their utility, but the costs of this option exceed their cash-in-hand.[4] In this case, an increase in liquidity could allow them to migrate.

Now consider how *networks* would affect the migration decision. First, better information on crossing increases p_a, the probability of successfully crossing alone, thereby increasing overall migration and reducing the likelihood of coyote use. Second, help finding a job and assimilating in the U.S. increases the benefit of migration through w_i^{us}, thereby increasing overall migration and making the use of a coyote more attractive than crossing alone. Third, credit alleviates credit constraints, thereby increasing both migration and coyote use for credit constrained individuals.

Hence, the model predicts that larger migrant networks should have an overall positive effect on the likelihood of migration. The effect of networks on coyote use may be negative if the effect of crossing information dominates or positive if the job and credit effects dominate. For individuals with low levels of cash-in-hand, the credit effect has a positive impact on migration and coyote use. Our empirical analysis will test these predictions in order to determine the specific ways in which networks affect migration and coyote use. We will estimate models of the migration and coyote use decisions and test whether the coefficients on the network measures are positive or negative, in accordance with the predictions. The credit effects of networks can be tested through examination of the coefficient on the interactions of network measures with asset measures.

4 Empirical Approach

4.1 Data

The data we use in our analysis comes from the Mexican Migration Project (MMP). The MMP survey data contains a wealth of information on the demographic characteristics of Mexican house-

[4] Either $V_{i,a}(A_i) = max\{V_{i,j}(A_i)\}$ but $A_i < q_a$, or $V_{i,c}(A_i) = max\{V_{i,j}(A_i)\}$ but $A_i < q_c$.

holds, as well as a unique battery of questions on legal and illegal migration experiences of individuals in the household and on a variety of household assets. This survey began in 1982 and has continued to collect data on migration between the United States and Mexico in nearly every year since 1987. Our study uses the most recently released data, MMP118, which offers a representative sample of households from 118 communities in 21 states in Mexico.[5] Between two and five communities (towns or cities) in each state are covered each year, and roughly 200 households in each community are interviewed.

We focus on household heads as these are the only household members who report information on coyote use. We consider only *first trips* to the U.S. since the determinants of subsequent trips are likely to be different, and in particular, are likely to depend on characteristics of the first trip.[6] In addition, our analysis restricts attention to data from 1968 to 2005. This allows us to avoid potential complications associated with differing migration policies; in particular, the end of the second Bracero Program. Finally, we do not count as migrants the 19 individuals who entered the U.S. as tourists (and did not work during their stay), and exclude the 280 legal migrants in our sample from the analysis.[7]

While the surveys represent cross-sections, their retrospective questions on the dates of respondent and family migration and the acquisition and sale of assets allow the construction of a longitudinal panel of data for the sampled individuals. Thus, we can create a synthetic panel, beginning at age 17, of each individual's migration status, network size, and asset holdings in each year up to the survey year. A disadvantage of the retrospective nature of this data is the possibility of recall bias. However, there are at least two reasons why the data used here may be relatively unlikely to suffer from this problem. First, since the first trip is a relatively significant event, in-

[5]The surveys are fielded yearly from November to February, the off-season for agricultural work, a time when many migrants return. The data are representative of the states included, but are not nationally representative. See http://mmp.opr.princeton.edu and Massey and Zeteno (1999) for more information.

[6]We use the terms migration, trip, and crossing interchangeably throughout.

[7]The small sample does not provide adequate power to model the decision to migrate legally and including these individuals as migrants does not qualitatively change our results.

dividuals may find it easier to recall than subsequent trips. Second, the ordering of events may be more accurate than specific dates of events, and it is the ordering which is most critical to our analysis.

The variables used in our analysis are described in the Data Appendix and include standard demographic characteristics such as birth year, gender, education, and marital and parental status. We also include an indicator for agricultural occupation as well as national-level measures of border enforcement, average U.S. agricultural wages and the U.S. national unemployment rate, the exchange rate, Mexican GDP per capita, an indicator for large communities, and the annual level of rainfall in the (Mexican) state. The most critical, however, are measures of migration, networks, and assets, described below. A detailed Data Appendix as well as a map of the community locations can be found at *http://www9.georgetown.edu/faculty/gg58/GSAppendix.pdf*.

Migration measures. The MMP migration survey includes two sets of questions about household heads' travels to the U.S. One set asks about the individual's first U.S. trip, including the type of documentation used, and the other asks about illegal crossings, including any use of coyotes. The responses to these questions are used to create variables pertaining to migration. We define the migration year as the earlier of the dates of the first U.S. trip and the first illegal crossing. Illegal migrants primarily include those who report that their first U.S. trip was an undocumented migration, only report an illegal crossing, or crossed with a tourist visa and subsequently accepted work. An indicator of coyote use is constructed based on whether an illegal migrant reports using a coyote on his first illegal crossing. For convenience, we say that those not using a coyote migrated "alone," although this does not necessarily mean that they did not travel with other migrants.

Network measures. Our measures proxy for the size of family networks and the density of community networks. Individuals report the date of the first migration of both parents and up to twelve siblings. Using this information, we generate a measure of family network, recording the number of nuclear family members who have made a trip to the U.S. prior to each year. Using the person-level data, we construct a measure of the community network as the proportion of surveyed adults (older than 17) from each community who have made a trip to the U.S. in the ten years prior to each year and lag this variable in the regressions.

Asset measures. We use measures of assets in the previous year to capture wealth and proxy for an individual's lack of credit constraints. Dated information on household assets includes information on land, property, and business holdings. The survey reports the dates of acquisition and sale, if applicable. For each year, we construct '*any asset*', an indicator for whether the individual held or sold any of these assets in the previous year; '*assets*', which takes values from 0 to 3, representing the number of types of assets (land, property and business) owned or sold in the previous year by the individual; and a set of dummy variables to indicate the type of asset held or sold: land, property, or business.

It is important to point out at least three limitations of this simple approach. One is the weakness of our asset measures as proxies for wealth. These crude measures exhibit limited variation and may not accurately reflect differences in wealth, biasing our estimates towards zero. A second limitation is that we ignore coyote prices in order to avoid the selection issue created by the fact that only those who use coyotes report prices, at the cost of greater precision. Another reason to omit coyote prices is their endogeneity to coyote demand, so their estimated reduced form effect is uninformative. This issue has also received little attention.[8] Finally, there is a possibility of dynamic endogeneity if *changes* in an individual's family or community network are not exogenous. An individual's decision to encourage family members to migrate, or move to a community with a large migrant network, may be related to his migration decisions. This type of endogeneity could bias our estimates, most likely in a positive direction if those whose decisions expand their networks are also those who are more likely to migrate.

[8] There are two exceptions. Orrenius (1999) instruments for coyote prices using border enforcement hours. Gathmann (2004) points out that this instrument is invalid if border enforcement responds to coyote demand and supply, and instead instruments coyote prices with the severity of coyote punishment.

4.2 Descriptive statistics

Table 1 presents descriptive statistics for our sample of adult household heads (aged 17 or older). These statistics summarize the migration, demographic, national economic, asset, and network characteristics that will be used in our analysis.

The first two columns present the means and standard deviations at the person-year level for our retrospective panel of adults in the years 1968 – 2004. This sample is composed of 85% males, 71% married individuals, and 84% parents. The average age is about 41 and schooling is just under 6 years. On average, 11% of the sample has a community member who made a trip to the U.S. in the last ten years. Sample members have an average of 0.6 family members who have made a U.S. trip in the past. 65% of the sample owned any land, property, or business in the last year. 16% of the sample has some land, 59% owns some property and 14% have a business.

The remaining columns in Table 1 present the means and standard deviations for the subgroups of non-migrants, those migrating alone, and those migrating with a coyote. The non-migrant subgroup includes the individuals in the survey year, while the migrant subgroups include migrants in their year of migration. In our sample, 27% of all the household heads migrated illegally, and among these illegals, 62% used a coyote and 38% migrated alone.

There are differences between migrants crossing alone and with coyotes. Those crossing alone tend to be older migrants, more educated, and are less likely to hold an agricultural occupation. They also tend to have smaller family and community networks.

Non-migrants also differ from migrants. Compared with migrants in the survey year (not shown), non-migrants are on average 2 years older, 15% more likely to be female, less likely to be married, more educated, more likely to live in metropolitan areas and less likely to be holding an agricultural occupation. Non-migrants are not very different in terms of asset holding, but have less land. They also do have much smaller family and community networks (0.52 family members and 12% of the community for non-migrants compared with 1.8 family member and 20% of the community for migrants).

4.3 Estimation Methodology

We model the migration decision empirically with a duration model. In a first set of regressions, we study the decision of migrating or not. In a second set of regressions, individuals are assumed to choose one of three options each year: migrate alone, migrate with a coyote, or don't migrate at all. These models specify the duration from age 17 until the first U.S. migration as a function of covariates that include network characteristics, asset holding, and their interactions, as well as national and individual characteristics. The appeal of the approach lies in its close conceptual link to the hypothesized theoretical process: individuals evaluate their options in the context of their current networks and assets each year. In order to compare distinct effects of covariates on the decisions to migrate alone or with a coyote, we use a competing risks model in which an individual exits a spell of "non-migration" in one of these two ways.

We model the decision to migrate as a proportional hazard model of duration. In addition to the measured covariates we allow for unobserved community characteristics to influence the decision to migrate. These unobserved community characteristics are treated as a random effect, or *frailty* (Hougaard 1995). In frailty models, the hazard function partly depends on an unobservable random variable acting multiplicatively on the hazard, so that a large value of the variable increases the hazard. Our frailty model specifies that the hazard function for individual i in community c conditional on the frailty is:

$$\lambda_{ic}(t|Z_c) = Z_c \lambda_0(t) e^{(\beta' \mathbf{x}_{ic}(t))} \tag{2}$$

where $\lambda_0(t)$ is the baseline hazard function, $\mathbf{x}_{ic}(t)$ denotes the covariate vector for individual i in community c at time t, and β is the corresponding vector of regression parameters. The hazard ratios e_{β_k} gives the effect of a one unit increase in covariate x_k on the likelihood of migrating for someone who has not migrated yet.

It is assumed that the Z_c's are iid from a gamma distribution with mean 1 and unknown variance θ; the probability density function is thus: $g(z) = [z^{1/\theta-1}e^{-z/\theta}]/[\Gamma(1/\theta)\theta^{1/\theta}]$. Large values of θ signify a closer positive relationship between the subjects of the same group and greater heterogeneity among the groups.

The specific method that we use for the competing risks model follows Lunn and McNeil (1995). This approach involves data augmentation by duplicating the data for each exit or failure type s: $s = 1$ denotes migration alone while $s = 2$ denotes migration with a coyote. We then estimate a proportional hazard regression stratified by type of failure. This does not impose any restrictions on the relationship between the baseline hazard functions for each failure type, λ_{s0} for $s = 1,2$. Separate coefficients for each failure type are allowed by including interactions of covariates $x_i(t)$ with a failure-type dummy taking a value of 1 for migration with a coyote: $\delta_i = I(s = 2)_i$. The coefficients on the interactions may be tested to determine whether there is a differential effect of the covariate on the decision to migrate with a coyote rather than without. The hazard function takes the form

$$\lambda_{si}(t) = \lambda_{s0}(t) e^{\left(\mathbf{b}_1' \mathbf{x}_i(t) + \mathbf{b}_2' \delta_i \mathbf{x}_i(t)\right)} \tag{3}$$

for all $t \geq 0$ and $s = 1,2$. The risk set at time t_i is the set of subjects who have not migrated yet at time t_i and the partial likelihood function for uncensored observations is

$$\Pi_{t_i,\ \delta_i=0} \left(\frac{e^{\mathbf{b}_1' \mathbf{x}_i}}{\sum_{j \in R_i} e^{\mathbf{b}_1' \mathbf{x}_j}} \right) \Pi_{t_i,\ \delta_i=1} \left(\frac{e^{\mathbf{b}_1' \mathbf{x}_i + \mathbf{b}_2' \delta_i \mathbf{x}_i}}{\sum_{j \in R_i} e^{\mathbf{b}_1' \mathbf{x}_j + \mathbf{b}_2' \delta_j \mathbf{x}_j}} \right).$$

The coefficients of this model are the b_{k1}'s and b_{k2}'s for covariates $k = 1, \ldots K$. Easier to interpret are the hazard ratios $e^{b_{k1}}$ and $e^{b_{k1}+b_{k2}}$. These give the effect of a one unit increase in covariate x_k on the risk of migrating alone and migrating with a coyote, respectively, for someone who has not migrated yet. The covariance matrix of the coefficient estimates is adjusted to allow for the correlation of failure types within individuals.

Note that we consider individuals to be “at risk" for migration at age 17, at which point we assume that the migration decision is made by the individual and not by his parents. The data sample is potentially left- and right-censored, as we observe individuals from 1968 until the year in which they are surveyed. In all models we account for the probability of migration prior to 1968 or after individuals are surveyed, correcting for the censoring. As standard practice, we assume the censoring times to be independent of the failure times and, when used, of the frailties Z_i. Our sample is unbalanced, as some sample individuals are observed over a longer period than others.[9]

5 Results

Table 2 presents our estimates from the baseline duration model of migration while Table 3 presents our estimates from the competing risks model of migration that distinguish between migrating alone or with a coyote. These models are estimated on the synthetic panel data set we construct for years 1968 to 2004. The panel includes 16,749 household heads observed for up to 32 years, yielding a total of 326,673 person-year observations.

Tables 2 and 3 presents the estimated regression coefficients from different specifications that all include the same covariates representing demographic and occupational characteristics, economic conditions, border enforcement, and network size, but different measures of asset holdings. Specifications (a) include an indicator of any assets; (b) allow for diminishing marginal returns to assets by including the number of asset types owned (land, properties, and businesses) and its square; and (c) allows for distinct effects of different types of assets by including indicators for land, property, and business. For each specification of the baseline model of migration, we present a specification with and without community *frailties* (or random effects). Our discussion focuses on the estimated effects of key network and asset measures but we also discuss the effects of other factors.

Family Network. Family networks significantly increase the likelihood of migration, as shown earlier, especially migrating with a coyote. Table 2 shows that, in the absence of assets, an additional family member in the network significantly increases the odds of migrating by 35 to 36%. Table 3 shows that the additional family member increases the odds of migrating alone by 28 to 30%, and has a significantly larger effect on migration with a coyote, increasing this likelihood by an additional 7% (although the effect is insignificant when the continuous asset measure and its

[9] As a robustness check, we restrict the retrospective sample period for each household head to the 12 years prior to the survey year. The results were qualitatively similar.

square are included in (b)). This is consistent with the hypothesis that family networks provide job information, help at arrival or credit rather than crossing information, as discussed in Section 3.

Community Network. Community networks also have significant effects on the likelihood of migrating, with initially increasing (up to a network density of between 24% and 30%) then decreasing effects. The quadratic effect of community networks on migration is consistent with the “S-shaped" effect of migrant networks found by Colussi (2004) and McKenzie and Rapoport (2007). This pattern could be explained by a rising wage in the sending communities following migration or by remittances from migrants that improve living conditions in the originating communities. For someone with no assets and at the mean community network size of 11%, an additional 1% of migrants within the community significantly increases the likelihood of migrating by 8% in the specifications without frailty and by 20% when community random effects are included. The same 1% increase raises the likelihood of migrating alone by approximately 8%. Community network density also affects the likelihood of migrating with a coyote, initially decreasing and then increasing this probability. The change in effects occurs just around the average community network size, where the effect of an 1% increase in network density on the likelihood of migrating with a coyote is -0.49. The positive effects of networks on migration present only through migration alone suggest community networks manly provide crossing information.

Assets. Asset ownership *per se* does not significantly affect the likelihood of migrating (alone or with a coyote), consistent with the ambiguous effect of assets in the theoretical model. However, the interaction of assets with family networks has a significant negative effect on the probability of migration in all specifications. We see in Table $2(a)$ that having any assets reduces the effect of the family network on migration by 9 to 10%. Similarly, in (b), owning one more type of asset implies an 8% decrease in the effect of family networks on migration. Table $3(a)$ shows that having any assets reduces the effect of the family network on migrating alone by about 7%, while Table $3(b)$ shows that owning one more type of asset implies a 7% decrease in the effect of family networks on migrating alone or on migrating with a coyote. These substitution effects between assets and family network are consistent with the idea that family networks act as a source of credit though we would have expected these effects to be stronger for the likelihood of migrating with a coyote.

As shown in Table 2(c) the substitution effect varies with the type of asset, but is significant for each type. Land is clearly the most valuable source of credit (reducing the effect of family networks by 16%), and property the least (reducing the effect by 4%). Table 3 c also shows land and business ownership are the drivers of the substitution results, and that the substitution effect of property ownership is stronger on the likelihood of migrating with a coyote.

That no substitution effect is present for community networks reinforces our earlier findings that community networks don't seem to provide credit to migrants.

Demographic and professional characteristics. Few of the demographic characteristics included as controls in the models have significant effects on the likelihood of migration or coyote use. Not surprisingly, men are roughly twice as likely to migrate than female heads of household, and this difference is even larger for the likelihood of migrating with a coyote. There are several potential explanations. Female headed households may tend to be poorer, which suggests that they should be less likely both to migrate and to use a coyote. They may be less likely to use coyotes for other reasons as well. Females may have a comparative advantage at crossing the border alone as INS agents tend to apprehend mainly males (see Donato and Patterson 2004). As female migration is also driven by family reunification, and because their economic gains from migration may be lower, females may be more likely to migrate alone according to the model presented in Section 3. Finally, women may be more likely to avoid coyotes than men due to fear of potential abuse.

Agricultural workers are 21 to 24% more likely to migrate, alone or with a coyote. The greater likelihood of migration could be due to a higher expected likelihood of finding agricultural work in the U.S.; the lack of an additional effect on coyote use is consistent with these migrants tending to be poorer and more credit constrained.

Education decreases the likelihood of migrating with a coyote, suggesting that being educated increases one's comparative advantage of crossing alone.[10] Birth year, marital status, and parent status do not significantly affect the likelihood of migration.[11] However, older and more educated workers are significantly less likely to migrate with a coyote.

Economic conditions are likely to have two opposing influences on migration. For instance better conditions at the origin reduce the incentive to migrate but also make it easier to finance the trip. Hence, we expect macroeconomic factors to have different effects on the likelihood of migrating alone and on the likelihood of migrating with a coyote which is more costly.

The effects of Mexican GDP per capita and annual Mexican rainfall are consistent with these predictions. Mexican GDP per capita has an insignificant effect on migration in Table 2, but Table 3 reveals that this stems from a significant negative impact on migrating alone and a significant positive impact on migrating with a coyote. Annual Mexican rainfall follows the same pattern.

The U.S. agricultural wage and exchange rate (dollars to pesos), which also had insignificant effects in Table 2, have significant positive effects on migration with a coyote but insignificant effects on migrating alone. Similarly, higher U.S. unemployment strongly discourages migration with a coyote, but not migration alone. These effects are consistent with the model in Section 3: higher expected U.S. wages (dependent on both the likelihood of employment and the wage) increase coyote use, as the greater the gain from migration, the greater the willingness to pay to increase the probability of a successful migration.

Finally, individuals in metropolitan areas are more likely to migrate alone and less likely to use a coyote than individuals in smaller communities. Metropolitan status could be proxying for community network size, and reflect that larger community networks can provide border crossing information that helps migrants to cross alone without need for a coyote. However, it could also reflect differences in the market for coyotes in metropolitan and rural areas.

Border enforcement. Border patrol linewatch hours are positively correlated with the likelihood

[10]This finding is consistent with the findings that the return to education is higher in Mexico than in the United States, see among others Borjas (1987) and Ibarraran and Lubotsky (2007).

[11]Using the number of children as opposed to a dummy for parent status does not affect the results.

of migration. To the extent that longer hours proxy for high enforcement, linewatch hours should tend to discourage rather than encourage migration. However, endogeneity could bias the estimate upward as higher enforcement might be a response to more illegal migration (see Gathmann 2004). We see in (d) that including the hours of enforcement used in the nine different administrative sections of the border (from Hanson, 2006) does not affect much our results.[12]

6 Conclusion

Networks can affect migration decisions by providing three types of services: information about border crossing, information about jobs and help at the destination, or credit to finance the trip. Using a simple model of migration, we derive theoretical predictions of the effects of these different services on migration and coyote use, and test them using data on a sample of illegal Mexican migrants who entered the U.S. between 1968 and 2004.

Results indicate that larger family and community networks tend to increase the likelihood of migration. Community networks increase the likelihood of migrating alone, while family networks have a significant positive effect on coyote use. This pattern suggests that family networks help with credit or with jobs at destination, while community networks provide information on the crossing. For those with higher levels of assets, family networks have smaller effects on migrating alone or with a coyote. This indicates that family networks provide credit to migrants. Community networks do not have the same effect, suggesting that they are not an important source of credit.

This study presents evidence that migrant networks provide multiple benefits to their members, and highlights the importance of distinguishing between these types of services. In particular, our findings suggest that the credit role of networks should not be neglected.

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[12] The only significant effect is a negative correlation between the enforcement hours in El Centro and the likelihood of migrating with a coyote.

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Table 1. Descriptive Statistics

	All*		Non-Migrants**		Migrants Alone***		Migrants with Coyote***	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
Year	1985.32	8.64	1996.25	5.29	1983.74	8.68	1985.08	8.75
Individual Characteristics								
Age	40.78	14.54	48.28	15.49	30.00	10.31	28.67	8.79
Female	0.15	0.36	0.08	0.27	0.08	0.27	0.04	0.20
Education	5.55	4.54	6.74	4.44	6.74	4.44	5.56	3.57
Married	0.71	0.45	0.62	0.49	0.62	0.49	0.63	0.48
Parent	0.84	0.37	0.65	0.48	0.65	0.48	0.65	0.48
Agricultural Occ.	0.30	0.46	0.29	0.46	0.29	0.46	0.43	0.50
Assets								
Any asset	0.65	0.48	0.82	0.38	0.40	0.49	0.39	0.49
Assets	0.89	0.79	1.15	0.75	0.50	0.69	0.49	0.68
Any Land	0.16	0.37	0.15	0.36	0.08	0.28	0.10	0.30
Any Property	0.59	0.49	0.77	0.42	0.34	0.47	0.32	0.47
Any Business	0.14	0.35	0.23	0.42	0.08	0.27	0.07	0.25
Network Variables								
Family Network	0.64	1.39	0.53	1.13	0.77	1.47	0.87	1.30
Community Network	0.11	0.10	0.13	0.08	0.12	0.08	0.13	0.09
Economic & Enforcement Variables								
Mexican GDP per capita	13.47	0.20						
US Agricultural Wage	2.89	0.06						
Mexican Rainfall	785.17	354.63						
US unemployment	0.07	0.01						
Exchange Rate	3.30	3.54						
Metropole	0.26	0.44						
Border Patrol Hrs	13.03	0.48						
N	354210		11543		1196		2446	

* All individual-year level observations; ** Non-Migrants in year surveyed; *** Migrants in year of migration

Table 2. Model of migration.

	(a) any assets.		(b) assets.		(c) differentiated assets.	
Individual Characteristics						
Year Born	-0.0113	-0.0049	-0.0110	-0.0047	-0.0109	-0.0045
	-0.0096	0.0097	0.0096	0.0097	0.0096	0.0097
Female	-0.9746 ***	-0.9535 ***	-0.9714 ***	-0.9502 ***	-0.9761 ***	-0.9535 ***
	0.0750	0.0758	0.0750	0.0758	0.0751	0.0758
Education	-0.0368 ***	-0.0338 ***	-0.0361 ***	-0.0329 ***	-0.0362 ***	-0.0330 ***
	0.0042	0.0044	0.0042	0.0044	0.0042	0.0044
Married	0.0358	0.0183	0.0399	0.0231	0.0398	0.0221
	0.0439	0.0449	0.0439	0.0448	0.0439	0.0449
Parent	-0.0016	-0.0008	-0.0021	-0.0015	-0.0021	-0.0025
	0.0496	0.0501	0.0495	0.0500	0.0495	0.0501
Agric. Occ.	0.3226 ***	0.2608 ***	0.3282 ***	0.2660 ***	0.3083 ***	0.2509 ***
	0.0373	0.0403	0.0374	0.0404	0.0381	0.0409
Economic Variables						
Mexican GDP per capita	0.0639	0.1005	0.0550	0.0923	0.0515	0.0905
	0.2050	0.2054	0.2050	0.2054	0.2051	0.2054
US Agricultural Wage	1.0262	0.9564	0.9986	0.9221	0.9843	0.9016
	0.7065	0.7210	0.7064	0.7209	0.7066	0.7211
Mexican Rainfall	0.0001 **	0.0001	0.0001 **	0.0001	0.0001 **	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
US unemployment	-10.2469 ***	-10.1070 ***	-10.2150 ***	-10.0770 ***	-10.2444 ***	-10.1030 ***
	1.7262	1.7297	1.7265	1.7300	1.7269	1.7303
Exchange Rate	-0.0086	-0.0083	-0.0096	-0.0091	-0.0110	-0.0104
	0.0271	0.0273	0.0271	0.0273	0.0271	0.0273
Metropole	-0.2230 ***	-0.3456 ***	-0.2273 ***	-0.3507 ***	-0.2263 ***	-0.3470 ***
	0.0514	0.1044	0.0515	0.1045	0.0518	0.1048
Enforcement						
Linewatch Hours	0.4955 ***	0.5069 ***	0.5052 ***	0.5162 ***	0.5133 ***	0.5213 ***
	0.1383	0.1404	0.1383	0.1404	0.1384	0.1405
Network Variables						
Family Network	0.2988 ***	0.3092 ***	0.3004 ***	0.3105 ***	0.2971 ***	0.3074 ***
	0.0127	0.0131	0.0123	0.0128	0.0124	0.0129
Community Network	12.9787 ***	11.1991 ***	12.9759 ***	11.2363 ***	12.9908 ***	11.2288 ***
	0.6155	0.8418	0.6120	0.8399	0.6157	0.8434
Commty Network	-21.8585 ***	-19.8762 ***	-21.7878 ***	-19.8234 ***	-21.7880 ***	-19.7684 ***
	1.6699	2.1327	1.6687	2.1300	1.6769	2.1372
Assets						
Any asset	-0.0357	-0.0477				
	0.0616	0.0627				
Assets			-0.0162	-0.0237		
			0.0735	0.0745		
Assets squared			-0.0120	-0.0131		
			0.0311	0.0317		
Any Land					0.0219	0.0310

					0.0968	0.1010
Any Property					-0.0596	-0.0626
					0.0657	0.0671
Any Business					-0.0424	-0.0954
					0.1165	0.1181
<u>Assets & Network Interactions</u>						
Any asset*Family	-0.0997 ***	-0.1026 ***				
	0.0219	0.0222				
Any asset*Commty	-0.4529	-0.5247				
	0.4033	0.4116				
Asset*Family Network			-0.0792 ***	-0.0810 ***		
			0.0164	0.0166		
Asset*Commty Network			-0.4088	-0.5004		
			0.2936	0.3000		
Any Land*Family					-0.1591 ***	-0.1645 ***
					0.0456	0.0460
Any Property*Family					-0.0428 *	-0.0446 *
					0.0235	0.0236
Any Business*Family					-0.0930 **	-0.0958 **
					0.0407	0.0410
Any Land*Comty					0.3599	0.0193
					0.6684	0.6938
Any Property*Comty					-0.4220	-0.4938
					0.4407	0.4508
Any Business*Comty					-1.3325	-1.0442
					0.8464	0.8479
<u>Shared Frailty</u>	No	0.1426 ***	No	0.1426	No	0.1430
		0.0298		0.0295 ***		0.0298 ***
Observations	16749	16749	16749	16749	16749	16749
Log likelihood	-34134.7	-34040.5	-34124.2	-34028.1	-34117.6	-34022.5

Notes: Standard errors are below the coefficients. In shared frailty models, standard errors are conditiona

* significant at 10%; ** significant at 5% *** significant at 1%.

Table 3. Competing risk model of migration

	(a) any assets		(b) assets		(c) differentiated assets		(d) border sector	
	Alone	With coyote	Alone	With coyote	Alone	With coyote	Alone	With coyote
Individual Characteristics								
Year Born	0.0180	-0.0412 **	0.0182	-0.0412	0.0186	-0.0416 **	0.0196	0.0072
	0.0170	0.0206	0.0170	0.0206	0.0170	0.0206	0.0346	0.0410
Female	-0.6890 ***	-0.4816 ***	-0.6859	-0.4814	-0.6893 ***	-0.4825 ***	-0.6081 ***	-0.4508 ***
	0.1146	0.1522	0.1146	0.1522	0.1150	0.1525	0.1324	0.1700
Education	0.0063	-0.0672 ***	0.0065	-0.0664	0.0061	-0.0658 ***	0.0081	-0.0657 ***
	0.0065	0.0079	0.0065	0.0079	0.0065	0.0079	0.0073	0.0088
Married	0.0177	0.0295	0.0208	0.0309	0.0228	0.0281	0.0804	-0.0234
	0.0785	0.0940	0.0784	0.0939	0.0782	0.0937	0.0884	0.1046
Parent	-0.0335	0.0503	-0.0331	0.0487	-0.0361	0.0530	-0.0712	0.1068
	0.0875	0.1048	0.0874	0.1046	0.0874	0.1048	0.1008	0.1188
Agric. Occ.	0.2129 ***	0.1284	0.2153	0.1325	0.1940 ***	0.1328	0.2151 **	0.0679
	0.0725	0.0872	0.0725	0.0873	0.0744	0.0897	0.0877	0.1037
Economic Variables								
Mexican GDP per capita	-1.0026 ***	1.5979 ***	-1.0086 ***	1.5949 ***	-1.0156 ***	1.5978 ***	-0.2111	0.3157
	0.3630	0.4389	0.3632	0.4390	0.3636	0.4395	0.6453	0.7817
US Agricultural Wage	-1.5063	4.0534 ***	-1.5293	4.0483 ***	-1.5650	4.0730 ***	2.3392 ***	-0.0230
	1.2472	1.5198	1.2473	1.5197	1.2480	1.5207	3.8948	4.6294
Mexican Rainfall	-0.0006 ***	0.0010 ***	-0.0006 ***	0.0010 ***	-0.0006 ***	0.0010 ***	-0.0006 ***	0.0012 ***
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
US unemployment	-2.2353	-11.8866 ***	-2.2236	-11.8599 ***	-2.2877	-11.8092 ***	-7.9713 *	-10.3587 *
	3.0243	3.7864	3.0243	3.7873	3.0260	3.7891	4.6946	5.7372
Exchange Rate	-0.0866 *	0.1193 **	-0.0874 *	0.1189 **	-0.0904 **	0.1211 **	-0.0339	0.0316
	0.0488	0.0587	0.0488	0.0587	0.0489	0.0588	0.1326	0.1590
Metropole	0.2316 ***	-0.9015	0.2298 ***	-0.9049 ***	0.2280 ***	-0.9008 ***	0.2884 ***	-0.9641 ***
	0.0789	0.1103	0.0792	0.1105	0.0798	0.1112	0.0890	0.1217
Enforcement								
Linewatch Hours	0.6209 **	-0.2377	0.6273 ***	-0.2781	0.6400 **	-0.2371		
	0.2559	0.3079	0.2562	0.3061	0.2567	0.3087		
Hours per border sector							yes	yes
Network Variables								
Family Network	0.2531 ***	0.0666 **	0.2606 ***	-0.2333	0.2503 ***	0.0671 **	0.2659 ***	0.0515 *
	0.0239	0.0263	0.0227	0.3081	0.0236	0.0260	0.0252	0.0282
Community Network	14.7496 ***	-2.5537	14.6789 ***	-2.3532	14.7724 ***	-2.5716	12.3166 ***	-1.4463
	1.5821	1.7902	1.5518	1.7018	1.5624	1.7698	1.7114	1.9204

Commty Network	-30.6545 ***	11.8255 **	-30.5207 ***	11.2952 **	-30.5478 ***	11.8023 **	-25.1423 ***	8.8963
	5.0569	5.5834	5.0454	5.3271	5.0799	5.6063	5.5597	6.0740
<u>Assets</u>								
Any asset	0.0053	-0.0827						
	0.1108	0.1345						
Assets			-0.0195	-0.0144				
			0.1290	0.1583				
Assets squared			0.0094	-0.0284				
			0.0572	0.0692			-0.0965	0.1485
Any Land					0.0169	-0.1808	0.2022	0.2340
					0.1733	0.1527	-0.1007	-0.0225
Any Property					-0.0086	-0.1177	0.1287	0.1556
					0.1164	0.1328	-0.1384	-0.0049
Any Business					0.0148	0.0691	0.2409	0.2855
					0.2160	0.2454		
<u>Assets & Network Interactions</u>								
Any asset*Family	-0.0758 *	-0.0331						
	0.0402	0.0453						
Any asset*Commty	-0.5473	0.3233						
	0.8026	0.9476						
Asset*Family Network			-0.0765 ***	-0.0028				
			0.0278	0.0323				
Asset*Commty Network			-0.3417	0.0367				
			0.5633	0.6729				
Any Land*Family					-0.2876 ***	0.1733 *	-0.2326 **	0.1113
					0.0980	0.1105	0.0979	0.1110
Any Property*Family					0.0220	-0.0953 **	0.0036	-0.0884 *
					0.0387	0.0462	0.0409	0.0489
Any Business*Family					-0.2076 ***	0.1618 *	-0.2269 ***	0.1625 *
					0.0749	0.0875	0.0842	0.0974
Any Land*Comty					1.5167	-1.4592	1.6314	-1.4405
					1.1419	1.4049	1.2551	1.5156
Any Property*Comty					-1.0000	0.9787	-0.0035	0.2726
					0.8692	1.0315	0.9115	1.0783
Any Business*Comty					-0.4616	-1.2044	0.6558	-1.9548
					1.7671	2.1212	1.8949	2.2422
Observations	16749		16749		16749		16002	
	Log likel.	Wald chi2	Log likel.	Wald chi2	Log likel.	Wald chi2	Log likel.	Wald chi2
	-33938.996	3089.6	-33929.149	3094.93	-33918.137	3135.28	-26775	2488.82