The Center for Comparative Immigration Studies
University of California, San Diego

CCIS

Estimates of the Cyclical Inflow of Undocumented Migrants to the United States

Scott Borger
Center for Comparative Immigration Studies, University of California, San Diego

Working Paper 181
August 2009

Estimates of the Cyclical Inflow of Undocumented Migrants to the United States

Scott C. Borger[1]
Department of Economics
University of California - San Diego

August 2009

Abstract

This paper constructs estimates for the inflow of undocumented migrants to the United States using survey-based micro estimates of the probability of apprehension per attempt and aggregate apprehensions data reported by U.S. Customs and Border Protection. The robustness of the constructed data is considered by comparing the implied stock from the constructed series with previous estimates of undocumented migrants in the United States. The estimates are within the unenumerated-correction margin of error of the post-2000 Census estimates in the literature. Moreover, the estimated inflow implies a strong correlation with the business cycle in the United States and Mexico with larger influxes associated with economic conditions in Mexico.

JEL: E32, F22, E24, J61, E63.

Key Words: International Migration, Unemployment, Geographic Labor Mobility.

1 Introduction

Undocumented migrants who crossed the border without proper documentation or who remained in the United States past the time allowed by their visas constitute a sizable share of the foreign-born population. However, the lack of a long time-series on the inflows of undocumented migrants in the United States since the 1980s limits our understanding of the correlation between immigration and aggregate economic indicators in the United States. This paper proposes a new methodology to construct an annual inflow of unauthorized migrants across the US-Mexico border that is consistent with (i) previous estimates of the stock of undocumented migrants from Mexico, (ii) indirect estimates of the inflows and (iii) the distribution of migrant trips in micro-surveys. The constructed inflow series is also consistent with the finding in Hanson and Spilimbergo (1999) in that undocumented migrant inflows respond to economic conditions in the United States and Mexico with significant inflows during years where the economy in Mexico is in recession.

Current estimates of the flow of undocumented migrants can be characterized into two subcategories. First, the 'residual' methodology uses Census, Current Population Survey or American Community Survey data to estimate the stock of the foreign-born population residing in the United States. By estimating the under sampled populations from post-enumeration surveys, the number of foreign-born residents without legal documentation is calculated as the residual of the total foreign-born population after removing known legal migrants. The projected population of undocumented migrants are subject to under-enumeration or an undercount in the U.S. Census and the Current Population Surveys and therefore researchers have used different assumptions about the undercount rate.

The residual methodology provides valuable information on the stock of undocumented migrants, but historically provides infrequent estimates before the mid-1990s of the net flow of migrants when the change in the stock of migrants is averaged over the estimated frequency. Hence, the infrequent and abbreviated data makes the methodology ineffectual in accounting for any possible relationship of immigration to the business cycle. For example, Costanzo et al. (2003) estimates an approximate 6 million increase in the stock of undocumented migrants in the United States between 1990 and 2000 at the 20 percent undercount rate. This translates to an average net in-migration of 600,000 per year over the decade. Yet, the data cannot answer the question of whether the number of arrivals per year decreased during the recession in 1991, increased during the economic boom of the late 1990s, or responded to the increased border enforcement that commenced in the mid-1990s. In order to assess the responsiveness of migration to the business cycle, we must augment the existing stock data with new direct measures of the flow of undocumented migrants.

The second methodology for estimating the flow of undocumented migrants is the apprehension-implied 'indirect estimation' in Hanson and Spilimbergo (1999) where the likelihood of apprehension is estimated from border patrol intensity, wages in Mexico and the United States and political economy factors. The intensity of the border control efforts is characterized by linewatch hours – the number of hours that U.S. Border Patrol agents devote to actually patrolling the border, as opposed to administrative and investigative duties. However, the indirect estimation approach provides only relative rather than level estimates of the inflow fluctuations.

This paper remedies the deficiency of data on the flow of undocument migrants by constructing the time-series from the aggregate apprehensions

data combined with micro-estimates of the probability of border patrol apprehension per attempt to cross the border. The probability-implied inflow of undocumented migrants will provide more information on the timing of migrant inflows during the previous three decades. Moreover, I will construct a measure the implied stock of undocumented migrants from the newly constructed inflow data and compare it with the previous estimates of the stock of undocumented migrants.[2]

One disadvantage of this approach is that it does not calculate an estimate of the inflow of overstayers – foreign-born residents in the United States who entered the United States with valid student or travel visas, then overstayed the time permitted by their visa. According to estimates by the Pew Hispanic Center, between 40-45 percent of the stock of unauthorized migrants in the United States consists of visa overstayers.(Passel, 2006) The inflow data reported in this paper will not include any estimate of this subset of undocumented migrants. References hereafter to the inflow of undocumented migrants will be referring to clandestine entrants across the Southwest border rather than visa overstayers. However, this subset of the unauthorized immigrant population is of considerable economic interest given the proximity of Mexico to the United States and the keen responsiveness of clandestine migrants to economic conditions make my estimated flows more relevant for business cycle and policy analysis.[3]

The paper is organized as follows. Section 2 articulates the methodology for the construction of the time-series data and provides a description of the micro-surveys used to construct the estimates. Section 3 conducts a series of robustness checks by using the newly constructed inflow data to (i) compare estimates of the inflow-implied stock of undocumented migrants residing in the United States with the residual methodology estimates, (ii)

compare the magnitude of the inflows with the distribution of migrant trips in a large survey of migrant histories, and (iii) compare the variation in the inflows with the apprehension-implied indirect estimates. Section 4 estimates the responsiveness of migrant inflows to economic conditions in the United States and Mexico. Section 5 concludes.

2 Estimated Inflows of Undocumented Migrants

There are two components to the estimate for the inflow of undocumented migrants. First, aggregate apprehensions by the border patrol provides the scale of the movement of migrants. Second, micro-estimates of the probability of apprehension per attempt to cross the border (the 'probability of apprehension') is required to percentage of migrants that elude detection. The estimate for the probability of apprehension is estimated with a new and unique dataset that provides information about individual migrations across the border – the Mexican Migration Field Research Project ('MMFRP') dataset. The estimates from the MMFRP dataset will provide the series that is consistent with literature, but with larger confidence intervals. In addition, the inflows are estimated with the large sample but limited scope dataset that provides migrant histories of the household head – the Mexican Migration Project('MMP') dataset. The MMP-estimated inflows will provide more precision around the estimates, but the inflows are inconsistent with literature.

Probability of Apprehension and Aggregate Migrations The number of apprehensions in a given period can be deconstructed as the number of people who attempted to cross the border clandestinely and the probability of being apprehended as follows:

$$A = n(1)p(1) + n(2)p(2) + \dots \tag{1}$$

where A is the number of aggregate apprehensions reported in a given year, n(i) is the number of migrants making at least i attempts to cross the border, and p(i) is the probability of being apprehended by the Border Patrol on their ith attempt. The number of apprehensions can also be characterized as follows:

$$A = np + (np\delta)p + (np^2\delta^2)p + \dots \tag{2}$$

where n is the number of migrants attempting to cross the border at least once, p is the constant probability of apprehension in a given period and δ is the faction of migrant attempting to cross the border after being apprehended by the border patrol. In order to characterize equation (1) with equation (2), two assumptions are required. First, the constant probability of apprehension in a given period on different attempts. This assumes that the migrant would not adjust their behavior or methodology after failing to cross the border. Although this is a strong assumption, there is evidence in Cornelius, Fitzgerald and Borger (2009) that similar crossing methodologies are employed by migrants and smugglers until the migrant is able to successfully cross the border. Second, the assumption that the discouragement factor, δ is constant across trips also assumes the migrant will be discouraged from crossing at the same rate on their second trip as on their fifth trip. This is not a strong assumption according to the data. The incredibly low discouragement rate in the data, 1.2 percent in the MMFRP data and 1 percent in the MMP data, indicates that an unsuccessful attempt to cross the border that would not be followed by another attempt is rare and

independent of the number of attempts previously made by the migrant.

Apprehensions then can be simplified as follows:

$$A = np \sum_{s=1}^{S} p^{s-1} \delta^{s-1} \tag{3}$$

where s is an index of the number of attempts and S is the maximum number of attempts that a migrant could make in trying to cross the border in a given period. The total number of migrants who successfully crossed the border can be solved by first calculating the number of migrants who attempted to cross as a function of the aggregate apprehensions data and the micro-estimates on the probability of being apprehended and the rate of discouragement.

$$n = \frac{A}{p\Omega(S)} \tag{4}$$

where $\Omega(S) = \sum_{s=1}^{S} p^{s-1}\delta^{s-1}$ and is the migrant flow factor. The total number of successful migrations can then be characterized by the following:

$$M = n(1)(1 - p(1)) + n(2)(1 - p(2)) + \ldots \tag{5}$$

where M is the number of inflow of migrants to the United States. Using the same assumption above, the number of migrations can be simplified:

$$M = n(1 - p) + np\delta(1 - p) + np^2\delta^2(1 - p) \tag{6}$$

$$M = n(1 - p) \sum_{s=1}^{S} p^{s-1} \delta^{s-1} \tag{7}$$

$$M = n(1 - p)\Omega(S) \tag{8}$$

The number of migrations can be characterized as a function of aggregate apprehensions and the probability of being apprehended without requiring

an estimate of the discouragement rate.[4]

$$M = A\frac{(1-p)}{p} \tag{9}$$

where an estimate of p is calculated as $p_t = \sum A_t / \sum \Lambda_t$ where Λ_t is the number of attempts observed in the sample in the given year t.[5]

It should be noted that while undocumented migrants who cross the southwestern border of the United States are predominately of Mexican origin, the estimates in this paper are dependent upon the probability of Mexican-born migrants having the same propensity as non-Mexican migrants of being apprehended. It is possible that more extensive family networks, language, or access to 'coyotes' (human smugglers) with better knowledge of the border-crossing obstacles give Mexican nationals an advantage in evading the Border Patrol. However, with CBP reporting that more than 90 percent of annual apprehensions are of Mexican citizens, the distortions from this assumption should be minimal on the overall estimates.

MMFRP Estimated Inflows of Undocumented Migrants The set of data that provides individual observations of migrations is from the Mexican Migration Field Research Project,[6] which conducts highly detailed survey studies of the populations of high-emigration communities in rural Mexico and in U.S. receiving cities for migrants from these localities. Five surveys have been conducted to date, among migrants and potential migrants in *Tlacuitapa*, *Jalisco* (2005, 2007), *Tunkás*, *Yucatán* (2006, 2009), and *San Miguel Tlacotepec*, *Oaxaca* (2007). The present analysis makes use of a panel dataset of migrant histories from the MMFRP's three most recent surveys. The surveys record the migrant histories on both sides of the border providing basic demographic information and specific information about

their migrations including documentation status of the migrant, the number of apprehensions by the border patrol, usage of 'coyotes' (human smugglers) and whether the migrant succeeded or failed in crossing the border.

The MMFRP surveys were conducted in three regionally distinct migrant-sending communities with different trajectories of migration to the United States. *Tunkás*, *Yucatán*, surveyed in January 2009, is a town still in its first generation of international migration. However, the town has had significant earlier migrations to destinations within Mexico, notably Cancun and Mexico City. *Tlacuitapa*, *Jalisco*, studied in January 2007, is in its fourth generation of U.S.-bound migration, with little tradition of internal migration. *San Miguel Tlacotepec*, *Oaxaca*, surveyed in December 2007, is in its second generation of migration to the United States. Interviews with U.S.-based migrants from these towns were conducted within a month of the Mexico-based fieldwork, using contacts established in the sending community. Migrants from *Tunkás* and *San Miguel Tlacotepec* were interviewed primarily in Southern California, while $Tlacuitapa's$ US-based migrants were interviewed in Oklahoma City and the San Francisco Bay Area. Additional interviews were conducted across the United States over the telephone.

Table 1 provides a summary of the characteristics of the MMFRP's surveyed communities. First, there a slight differences between the surveyed communities in the percent of undocumented males in the United States. However, the percent of males in the U.S. undocumented population is 58 percent according to Passel (2006), which is slightly lower than the 65 percent found in the MMFRP sample. Second, the type of U.S. employment acquired by migrants from each of the sending communities during their most recent sojourn in the United States differs significantly, with $Tunkás'$

migrants primarily in the service sector, $Tlacuitapa's$ primarily in the construction sector, and $Tlacotepec's$ in both the agricultural and service sectors.[7]

Figure 1 exhibits at the annual data of each of the series required for the construction of the MMFRP-estimated inflows of undocumented migrants. Figure 1a displays the estimated probability of apprehension per attempt (p_t) and the bootstrapped confidence intervals at the 5th and 95th percentile for the probability. Figure 1b reports the annual apprehensions (A_t). Figure 1c is the estimated inflow of undocumented migrants to the United States over the previous three decades with confidence intervals. The estimate inflows are more clearly exhibited in Figure 2 with years in which there was a US and/or Mexico recession shaded accordingly. The years before the Immigration Control and Reform Act of 1986 (IRCA) saw large inflows of undocumented migrants with an estimated 4 million migrants entering the United States during these periods. These years also correspond to periods where Mexico was in an economic contraction while the United States was not. There is also an acceleration in the number of migrants at the end of the economic cycles of the late-1980s and the late-1990s and a contraction in the inflows during the recessions of both 1991 and 2001. Moreover, the decline in inflows since the contraction in the construction sector in 2007 is evidenced with an estimated 338,000 undocumented migrants crossing the border during 2008. This is more than a 90% contraction since its peak in the early 1980s.

MMFRP Contiguous Years Estimate I consider a second approach to estimating the probability of apprehension because of the small sample properties of the MMFRP data and the possibility of recollection bias associated

with migrant history surveys. Since the expected apprehension rates for years surrounding a given year's migration would probably be similar with similar border enforcement policies, I construct a pooled distribution of migrations with observations from the previous year, the current year and the subsequent year to estimate the current year's probability. This approach could be described as a centered 3-year moving average of the probability of apprehension observed in the MMFRP data ('MMFRP-3'). The calculation of the MMFRP-3 probability uses the median observation from the bootstrap drawing with replacement from the distribution of observations in periods t, t-1 and t+1. Then the probability is calculated:

$$p_t^b = \frac{\sum_{t-1}^{t+1} \sum_1^{n(t)} A_t}{\sum_{t-1}^{t+1} \sum_1^{n(t)} \Lambda_t} \tag{10}$$

where $n(t)$ is the number of migrant trips observed in period t, Λ_t is the number of attempted crossings, and p_t^b is the probability calculated from one draw of the distribution. This process is replicated 10,000 times and the median observation is recorded as the estimated MMFRP-3 probability of apprehension. Figure 3a shows the estimated MMFRP-3 probability with confidence intervals. As expected, the smoothed ratio over three years provides much tighter confidence intervals.

Figure 3c is the estimated annual inflows with peaks of around 1.6 million undocumented migrants per year and troughs of around 700,000 migrants. The current period in this model does not look that much different from the inflows in 1995. Note that estimates for 2008 are not possible with this estimation approach and therefore the current level of inflows is not yet observed. Figure 4 places the MMFRP-3 inflows in the context of the business cycles. The smoothing out of the probability of apprehensions also

smooths out some of the business cycle properties. Nevertheless we see constant inflows during the 1980s with inflows between 1.2 and 1.6 million undocumented migrants per year. It should be noted that this was a period of significant circular migration, where the migrant would return to Mexico during the winter months. Therefore many of these inflows could represent the same migrants. The decline in the inflows in 1994 corresponds to the period of increased border enforcement. This deterrent however was short-lived, with inflows reaching their 1980s peaks by the end of the economic expansion of the late-1990s.

MMP Estimated Inflows of Undocumented Migrants The third approach to constructing an estimate for the inflows of undocumented migrants calculates the probability of apprehension using data from the Mexican Migration Program (MMP), a long-term research project now based at Princeton University that has surveyed a larger and a more geographically diverse set of migrant-sending communities in Mexico.[8] The number of observations in the MMP dataset is large and provides much tighter estimates of the probability of apprehension. The estimated MMP ratio was lower on average with a 28% probability of apprehension per attempt compared with an average of 38% and 39% probability in the observed and smoothed MMFRP estimates, respectively. (See Table 2) The estimated MMP ratio in figure 5a exhibits a constant trend in the probability of apprehension which is in contrast to the trends observed in the MMFRP data. The disadvantages of the MMP-inflow estimates are their inconsistencies with previous estimates of undocumented migrants in the literature and with the distribution of migrant trips reported by respondents to the MMP survey.

The probability of apprehension estimate would indicate little effect of

the increase in border enforcement intensity in the mid-1990s and the exponential increase in linewatch hours of border patrol during the most recent decade. This is evidenced in table 2 with the correlation between the MMFRP probability estimates and linewatch hours is 0.51, whereas the correlation between the MMP probability estimates and linewatch hours is 0.27. Moreover, the differences between the MMFRP and MMP data have different implications for the probability of apprehension with increased linewatch hours. The unconditional elasticity of linewatch hours on apprehensions was estimated with a percent increase in the linewatch hours having more than twice the percentage point increase in the MMFRP data as the MMP data. In the context of testing the robustness of the inflow estimates in the next section, the differences between the two estimates will be considered.

Figure 5c exhibits the MMP-estimated inflows which has a distinct upward trend through the early 2000s, in contrast with the MMFRP data and Hanson (2006) that has inflows decreasing over this period. Figure 6 graphs the MMP-inflows at the business cycle frequency in the United States and Mexico. The response of the inflows to economic conditions in Mexico is consistent with previous findings that push factors contribute to migrations to the United States. However, the trough of the flows during the recession in the 1980s misses the acceleration of migrations associated with the legislative process around the Immigration and Control Act of 1986(IRCA).

3 Consistency of the Inflow Estimates

The significant efforts previously made in the literature to estimate the stock of undocumented migrants provides a means to verify the reasonableness of the estimation technique and the underlying data. Hereinafter, I will demon-

strate that the MMFRP-inflow estimate is consistent with the post-2000 stock of undocumented migrants from Mexico, the distribution of trips in the MMP migrant history surveys, and the indirect estimates of the inflow of undocumented migrants. However, the MMP-inflow estimate is inconsistent with these measures.

The Stock of Undocumented Migrants To estimate the consistency of the inflow estimates, I calculate the implied stock of undocumented migrants from the inflow data and compare the implied stock of undocumented migrants with previous estimates of the stock of undocumented migrants from Mexico to test whether the inflow data series provides a magnitude of migrants that is consistent with previous estimates in the literature.

The stock of undocumented migrants has often been calculated by a residual methodology that subtracts the number of legal resident aliens from the enumerated foreign-born population as estimated by the U.S. Census, the Current Population Survey or the American Community Survey. The differentiation between the enumerated and unenumerated population is an important distinction since estimates rely on the cooperation of undocumented migrants with government-based surveyors. Estimates in the 1980s used the Alien Registration Program to determine the number of documented immigrants. The discontinuation of the Alien Registration Program in 1981 required a projection each subsequent year of new immigrations.

Costanzo et al. (2001), Bean et al. (2001), INS (2001), Passel (2005), and Hoefer et al. (2006, 2007) estimate the stock of undocumented migrants residing in the United States by using a residual methodology that subtracts the number of foreign-born persons who are known to reside in the United States through visa entries and exits from the total number of

foreign-born respondents to government household surveys and estimated mortality rates. Then taking into account some undercount in the responses of undocumented migrants, the difference between the survey's estimate of the foreign-born and the known foreign-born population is the estimate of the undocumented population living in the United States.

In addition to the information on the inflows, I also estimate the probability that a documented migrant would return back to Mexico from the MMP data. Unlike the assumption made in the MMFRP data – that idiosyncracies between migrant communities would be insignificantly different in apprehension rates since all migrants would make every effort to elude the border patrol and cross the border undetected – different community customs and migrant trajectories could provide different estimates for the probability of return. Therefore, all return probabilities are estimated over the larger MMP sample with 118 different surveyed communities. Figure 7 exhibits the downward trend in returning back to Mexico. In the 1960s and 1970s, many of the undocumented migrants in the United States were agricultural workers who remained in the United States only for the agricultural season returning back to Mexico during the winter. In the late 1980s and early 1990s the return probability dropped to 20% as families were reunified in the United States and border enforcement intensity increased.

Using the return data, I estimate the stock of undocumented migrants by subtracting off the returned migrants from the stock of migrants in the previous period and then adding the new inflow for the current year. In addition, the IRCA legislation in the 1980s provided a process for legalization for which I need to account. One method would be to use the fact that anyone residing the United States before 1980 received amnesty and therefore start the stock of undocumented migrant from that date. Instead, since receipt of

permanent resident status was over a period of time, I use estimates from the Office of Immigration Statistics to subtract transitions from undocumented to permanent resident status of Mexican nationals. There are two stylized facts the stock of undocumented migrants should be able to replicate. First, the number of undocumented migrants receiving permanent resident status from either the January 1, 1980 threshold or the agricultural workers that worked for 90 days between May 1, 1985 and May 1, 1986 totaled approximately 3 million. Therefore any estimate of the stock of undocumented migrant in the early 1980s should have at least 3 million undocumented migrants. Second, the under-count in the 2000 U.S. Census was much less significant among Hispanics than in previous surveys and therefore would would expect the surveys using the current census weights to provide a better estimation of the undocumented population. Therefore, any estimate should also approximate the recent stock estimates in the literature.

Figures 8-10 report the estimated stock of undocumented migrants who reside in the United States after crossing the Southwest border for each of the constructed series. In addition, the previous estimates of the stock of undocumented migrants from Mexico are provided to demonstrate that the MMFRP constructed data is consistent with both the trend and the magnitude of the post-2000 period. The restriction to Mexican national migrants does underestimate the stock of undocumented migrants who would traverse the border through clandestine entry since migrants of Mexican origin constitute about 90 percent of undocumented migrants from Central America.[9] However, the stock estimate for Mexico provides a constant measure to compare the implied stock estimates and the previous estimates.

The differences in the magnitude could be accounted for by the different assumptions that each of the authors made about the unenumerated popu-

lation in the sample. The INS (2001), Passel (2005) and Hoefer et al. (2006, 2007) use an undercount rate of 10 percent whereas the numbers reported for Bean et al. (2001) was an undercount rate of 25 percent. Other factors that might contribute to the magnitude of the MMFRP-implied stock being higher than previous estimates is that 10 percent of those who traverse the border are not Mexican citizens and therefore are not counted in the estimates reported in figures 8-10. This fact combined with the different assumptions about the undercount rate would indicate that both the magnitude and trend of the estimated stock implied by the MMFRP constructed series are reasonable.

MMFRP and MMP Differences The reported stock of undocumented migrants in figure 10 from the MMP estimated inflows would seem to indicate that the MMP ratio provides too low of a probability of apprehension for what we should have observed in the sample.[10] Since the MMP data is a larger data, it is important to note why the MMP data reports more migrants are successfully crossing the border per apprehension made by the border patrol.

The difference between the two surveys that would account for the differences in the inflow estimates is the construction of the survey question. The MMFRP survey asks how many times the person was *agarrado* which implies caught or stopped by the border patrol. This is in contrast with the MMP survey which asks the respondent on a given trip the number of times the person was *deportaciones* which could imply caught but could also imply the legal proceeding that is much more formal than the self-deportation policies of the last two decades. The distribution of apprehensions in the later period in the MMP data is much more centered around zero and one

than what one would expect from micro-evidence on border crossings since the early 1990s.

In addition, other differences were considered that could account for the differences in reported apprehensions. First, demographic assessments were made between the two surveys with age being significant predictor of the number of times a migrant was apprehended. The older a person attempting to clandestinely cross the border, the more likely they would be apprehended by the border patrol. However, the mean and variance of age in the two samples were almost exactly the same.

Second, gender differences between the two surveys could compose the difference if women were more likely to be apprehended on the border since the MMP data is primarily composed of male heads-of-households with women only representing 2 percent of the respondents to the migration histories. However, in both surveys, women were less likely rather than more likely to be apprehended.[11]

Third, aggregation error could account for the differences in the inflow of undocumented migrants since apprehension differences could be the result of policy differences in different sectors along the border. For example, the initial intensification of border enforcement were in the San Diego and El Paso sectors and could have skewed the aggregate inflows. However, when the data was disaggregated to sectoral apprehension rates and sectoral apprehensions, the difference between the disaggregated estimates and the aggregated estimates were small, with approximately a 5 percent upward bias in inflows. This would not account for the difference between the two surveys.

Distribution of Migrant Trips However, the MMP data provides an information on the distribution of migrant trips of the survey participants over the past half century with surveys that span the last two decades. A characterization of the distribution will provide an additional consistency check on the magnitude and variability in the inflows of undocumented migrants. Trips where the respondent indicated crossing the border without documentation were divided into the year the survey was conducted and the year that the respondent reported crossing their first time and their most recent time. Then randomly drawing 20 times from each of the survey years to prevent over-sampling of the years where the survey was conducted more intensely, I recorded the number of times a migrant trip year was observed. I then replicated this process 10,000 times and averaged the migrant trip years observed.

Figure 11 exhibits the distribution of migrant trips in the MMP data. The trips reported by the migrants are similar to the estimates calculated from the MMFRP data rather than the estimates from the MMP data. The greatest inflows were in the early- and mid-1980s with a significant contraction in the rate of inflows since 2000. Figure 11 also presents a weighted distribution of trips which takes into account the fact that we would observe later years less frequently by the construction of the drawn distributions. Rather than randomly drawing 20 times from each of the survey years, each additional survey year would receive an additional observation such that migrant trips in survey year 2006 would be drawn 40 times whereas 1987 would be drawn 20 times. Although more migrant trips were observed, the shape of the distribution remains remarkably the same.

Indirect Estimates of the Inflow of Undocumented Migrants Hanson and Spilimbergo (1999) model the flow of undocumented migrants indirectly through the use the government data on border apprehensions and the factors that contributed to the probability of being apprehended such as linewatch hours, US wages, Mexico wages, and other factors. In addition, Hanson and Spilimbergo argued that there exists a political economy rationale for different border enforcement policies both over time and during the year and used instruments to capture these effects. Apprehensions at the border are then described by the following equation:

$$A_t = P(H_t, M_t) * M(W_t^{mx}, W_t^{us}, P_t, \Omega_t, \Gamma_t)$$

where A_t is the apprehensions, $P(H_t, M_t)$ is the probability of being apprehended and is a function of border enforcement levels (H_t) and the number of migrants. M(.) is the number of migrants who cross the border, which is a function of wages in Mexico(W_t^{mx}), wages in the United States(W_t^{us}), the probability of being apprehended (P_t), information on the projections of these factors (Ω_t), and individual characteristics (Γ_t). Hanson (2006) estimates a reduced form of the apprehensions equation:

$$\alpha_0 + (1 - \alpha_2) lnM_t = lnA_t - \alpha_1 lnH_t$$

where the relative change in the number of migrants (M_t) are estimated from the number of apprehensions (A_t) and the linewatch hours by the Border Patrol (H_t) using the estimates of α_1 from estimates in Hanson and Spilimbergo (1999).

Figure 12 through figure 14 contrasts the demeaned logarithm of the constructed inflow series to provide comparable results with the reduced form estimate of inflow fluctuations in Hanson (2006). The fluctuations in

the demeaned natural log of the MMFRP inflow estimate are much more volatile than the indirect estimates. However, since the indirect estimates are the reduced form, the significant fluctuations that might be associated with the business cycle might be muted. However, the demeaned natural log of smoothed MMFRP-3 inflow estimates are similar in variation and timing of the fluctuations. In contrast, the MMP inflow estimates are almost exactly inversely related to the indirect estimates with a correlation between the series of -0.83. (See table 3)

Consistency of MMFRP-Inflow Despite its small sample size, the MMFRP inflow more closely matched the stock estimates, exhibited similar magnitudes over the time period in the constructed distribution of migrant trips, and corresponded to the variability in the apprehensions-implied indirect estimates and therefore provides a reasonable estimate of the previous three decades' inflows of undocumented migrants to the United States.

4 Business Cycle Analysis

The responsiveness of migrants to economic conditions in the receiving country context was first documented in Jerome's (1926) seminal work *Migration and the Business Cycle*. He argued that cyclical labor costs moderated the business cycle and this moderation impeded by the movements of immigrants into the labor force. Conversely, Kuznets and Rubin (1954) noted the possibility that foreign labor supply in the United States acts as a stabilizing reservoir over the business cycle assuming unconstrained labor movements by moderating the growth rate of the population. However, the lack of high-frequency data to measure the movements of undocumented migrants left questions about the impact of the recent and significant migrant influx

on the business cycle. The newly constructed data series can provide some insight into this nearly century-long debate.

The cyclical movements in the magnitude of the inflow of unauthorized migrants to the United States is commonly assumed, but the identification of these shifts in immigration due to business cycle conditions has been limited by the data on the inflow. Hanson and Spilimbergo (1999), using the indirect approach, find that apprehensions of migrants, controlling for political economy factors, are responsive to the real wage in the United States. Likewise, I find that each of the estimated inflow estimates possess a strong correlation with the real wage. (See table 3)

Table 3 also characterizes the inflows of each estimated series during four distinct economic periods. The MMFRP estimated inflows increase significant in periods where Mexico is in recession or both the United States and Mexico are in recession. However, when only the United States is in recession, we see that the inflows of undocumented migrants decreases significantly. This indicates strong push factors for migration from Mexico with limited pull factors. The periods of economic expansion for both countries resulted in a very small decrease in the average inflow. The MMP estimated inflows also can be characterized in the same way with smaller, but positive inflows occur during Mexican-only or dual recessions and decrease during US-only recessions.

In addition, in table 3 I display the correlations between the natural log difference of the inflows and the aggregate economic indicators. Since most unauthorized migrants' primary reason for emigration is economic opportunities, one should expect the inflow of undocumented migrants to correspond to periods in the United States when jobs were more plentiful. However, the correlation between unemployment and the real gross domestic product

(GDP) in the United States and the MMFRP inflow estimates are very low. Yet, a decrease in the real wage or GDP in Mexico is correlated with a increase in the inflow of undocumented migrant to the United States. The growth differential between the two countries provides a metric for economic opportunities that might be available to a flexible labor participant. The correlation between the MMFRP inflow estimate and the growth differential between the United States and Mexico is strongly positively correlated at 0.31. The wage ratio between the two countries was more correlated with the smoothed out MMFRP-3 inflow estimate.

The cyclical response of migrants contrasts the previous finding in the literature using net flow measurements from the residual methodology. Passel (2005) found only a slight decrease in response of migrants to economic conditions in the United States, whereas gross flows would indicate that migrants are responding to economic conditions. Davis and Haltiwanger (1992) demonstrated that gross flows rather than net flows, which had been previously done in the labor literature, are necessary to look at the cyclical behavior of the labor market. Apparently, the same is true of unauthorized migrants – a subset of the labor force that migrates across international borders in search of economic opportunities.

5 Conclusion

The construction of a new data set on the inflow of undocumented migrants to the United States with a more frequent time-series is an important step in understanding how changing economic conditions in the United States and Mexico influence migrant inflows. The MMFRP estimated inflows were consistent with the estimated stock of undocumented migrants in the post-

2000 period, the previous indirect estimate of the inflows of undocumented migrants, and the business cycle conditions to which micro-research on migrant behavior would predict them to respond. The MMP estimated inflows implied too high a stock of undocumented migrants throughout the sample period, indicating a lower probability of apprehension relative to what would be consistent with the current stock estimates.

The approach presented in this paper provides an estimate for the inflows of undocumented migrants at a much higher frequency than previous estimates. However, future research that involves migrant histories could provide significant improvements to the precision of the probability of apprehension and therefore precision to the estimate of the inflows. It should be noted that if there exists a legalization process in the future for undocumented migrants, a one page survey in connection with the legalization process that inquired about migrants' trips across the border could provide a much larger sample and a much more precise estimate of the gross flows of undocumented migrants.

The information from constructing inflows of undocumented migrants provide researchers and policymakers a more informative understanding of how the stock of unauthorized migrants residing in the United States evolved. The initial analysis on these inflows would suggest that the United States saw increases in undocumented migrants during periods of US economic expansions and Mexican economic contractions. Moreover, the decrease in recent inflows provides topics for future research on whether the reduction is the results of border enforcement policy or the significant contraction of the economy in the United States. Nevertheless, the movement of the gross inflow of migrants provides valuable insight into the factors that contributed to such inflows. Finally, the level of inflows of unauthorized

migrants provide knowledge to policymakers on the ability of labor markets to absorbed additional workers and inform any decisions on the scale of possible future guest worker programs.

Notes

[1]The author gratefully acknowledges Gordon Hanson, Wayne Cornelius, Valerie Ramey and seminar participants at UC-San Diego and the Office of Immigration Statistics for useful comments and suggestions. Contact: sborger@ucsd.edu. First Draft: June 2008.

[2]Hanson (2006) provides a good overview of the literature on the estimates of undocumented migrants.

[3]Cornelius, Fitzgerald and Borger (2009) find that migrants are able to traverse the border in less than 3 weeks after a relative in the United States reports there is a job available for them when the migrant arrives.

[4]An alternative methodology was used in a previous draft of the paper that estimated the ratio of successful migrations per apprehension. The methodology produced almost identical results as the results reported in this paper, but the probability approach made it more clear to the reader the assumptions required to estimate the inflow of migrants.

[5]Attempts are assumed to occur during the same year. This is a reasonable assumption given that attempts are usually made on consecutive days and nights. *Fuentes* and *García* (2009) provides a good description of the *coyote* industry on the US-Mexico border including information on the technique used by *coyotes*.

[6]MMFRP is an ongoing research project of the University of California-San Diego's Center for Comparative Immigration Studies

[7]Estimates from Passel (2005) on aggregate employment data for undocumented migrants in the United States would suggest 49 percent are in the service sector, 17 percent in construction and 3 percent in agriculture. This would suggest that the sampled communities are overly representative of migrants from the construction and agricultural sectors which could have cyclical or seasonal components to their migration patterns. It should be noted that the sectoral estimates are for both overstayers and clandestine entrants and therefore might not be overly representative of the sectoral divisions in unauthorized migrant employment.

[8]Other surveys such as the Mexican government's *Encuesta sobre Migración en la. Frontera Norte de México* (EMIF), 1993-2004, were considered to estimate the apprehensions-to-migrant ratio, but these surveys either lacked information on apprehensions or the year of the migration.

[9]In contrast to the inflow estimate, the share of nationalities other than Mexico in the stock of undocumented migrants is more due to lower return rates. About 15 percent of the stock of undocumented migrants from Central America are from El Salvador, Nicaragua, and Honduras.

[10]The low probability of apprehension implies a high stock of migrants since more migrants are crossing the border undetected and therefore the aggregate apprehensions are capturing fewer of migrants that would have crossed given the low apprehension probability.

[11]See Cornelius et al. (2009) for discussion on gender differences in crossing the border.

References

[1] Bean, F.D., R. Corona, R. Tuirán, K.A. Woodrow-Lafield, and J. Van Hook. 2001. "Circular, Invisible, and Ambiguous Migrants: Components of Difference in Estimates of the Number of Unauthorized Mexican Migrants in the United States," *Demography* 38(3):411-22.

[2] Cornelius, W., D. Fitzgerald, and S. Borger (eds.). 2009. *Four Generations of Nortenos: New Research from the Cradle of Mexican Migration.* La Jolla, CA: Center for Comparative Immigration Studies.

[3] Costanzo, J., C. Davis, C. Irazi, D. Goodking and R. Ramirez. 2001. "Evaluating Components of International Migration: The Residual Foreign Born Population," U.S. Bureau of the Census Working Paper no. 61.

[4] Davis, S.J. and Haltiwanger, J. 1992. "Gross Job Creation, Gross Job Destruction, and Employment Reallocation," *The Quarterly Journal of Economics* 107(3): 819-863.

[5] Fuentes, J. and *García*, O. 2009. "*Coyotaje:* The Structure and Functioning of the People-Smuggling Industry," In *Four Generations of Nortenos: New Research from the Cradle of Mexican Migration*, eds. W. Cornelius, D. Fitzgerald and S. Borger, 79-100. La Jolla, CA: Center for Comparative Immigration Studies.

[6] Hanson, G.H. 2006. "Illegal Migration from Mexico to the United States," *Journal of Economic Literature* XLIV: 869-924.

[7] Hanson, G.H. and A. Spilimbergo. 1999. "Illegal Immigration, Border Enforcement, and Relative Wages: Evidence from Apprehensions at the U.S.-Mexico Border," *American Economic Review* 89(5): 1337-1357.

[8] Hoefer, M. N. Rytina and C. Campbell. 2006. "Estimates of the Unauthorized Immigrant Population Residing in the United States: January 2005," Office of Immigration Statistics, Policy Directorate, U.S. Department of Homeland Security.

[9] Hoefer, M. N. Rytina and C. Campbell. 2007. "Estimates of the Unauthorized Immigrant Population Residing in the United States: January 2006," Office of Immigration Statistics, Policy Directorate, U.S. Department of Homeland Security.

[10] Jerome, H. (1926). *Migration and Business Cycles.* New York: National Bureau of Economic Research, Inc.

[11] Kuznets, S. and E. Rubin. 1954. *Immigration and the Foreign Born.* New York: National Bureau of Economic Research, Inc.

[12] Passel, J.S. 2006. "The Size and Characteristics of the Unauthorized Migrant Population in the U.S.: Estimates Based on the March 2005 Current Population Survey," Pew Hispanic Center, http://pewhispanic.org/files/reports/61.pdf.

[13] Passel, J.S. 2005. "Estimates of the Size and Characteristics of the Undocumented Population." Pew Hispanic Center Report.

[14] U.S. Census Bureau, Statistical Abstract of the United States. 2008. (127th Edition) Washington, DC, http://www.census.gov/compendia/statab/

[15] U.S. Immigration and Naturalization Service. 2001. "Estimates of the Unauthorized Immigrant Population Residing in the United States: 1990 to 2000."

A Appendix

A.1 Data

Data for the apprehensions ratio used the Mexican Migration Field Research Project (MMFRP) survey data conducted by the Center for Comparative Immigration Studies at the University of California, San Diego. To calculated the stock of undocumented migrants residing in the United States, the return probability was calculated using the Mexican Migration Project survey data, a long-term research project now based at Princeton University that has surveyed 118 migrant-sending communities. The observations for migrant histories is 6430. The return probability was calculated by including only migrants who reported being undocumented on their last migration to the United States. The year of the trip and the duration of the trip were recorded and therefore the year of the return trip could be estimated. Then taking the sample of migrants residing in the United States in a given year, the percent of those migrants who returned to Mexico was calculated.

In addition, the number of undocumented migrants from Mexico gaining permanent resident status was subtracted from the inflow-derived stock of migrants to arrive at the estimated stock. The estimates are provided by the Office of Immigration Statistics in the Department of Homeland Security and they estimate the number of migrants residing in the United States without documentation before receiving their permanent resident status at 48 percent. It should be noted that using only Mexican citizens who gained permanent resident status both overestimates the number of undocumented migrant who resided in the United States in the year before and underestimated the number of undocumented migrants receiving permanent status

from other countries.

Data for the number of apprehensions and the linewatch hours were compiled originally by the U.S. Immigration and Naturalization Service and now are made available through the U.S. Customs and Border Protection. The data from 1963:7 to 2004:9 are available on Gordon Hanson's webpage, http://irpshome.ucsd.edu/faculty/gohanson/data.htm. There are significant seasonal fluctuations of apprehensions at the border with political economy and labor market demand rationales.

Estimates of the MMFRP-implied stock of the undocumented migrants at the business cycle frequency is found in figure A1.

B Tables and Figures

Table 1: Summary Statistics of Undocumented Migrants in Survey Communities

	Tunkás, *Yucatán*	*Tlacuitapa*, *Jalisco*	*Tlacotepec*, *Oaxaca*	
Variable				Total
Male Migrants	63.8%	75.7%	67.5%	67.8%
Males In US	71.8%	65.9%	52.4%	64.5%
Coyote Use	81.3%	81.7%	74.5%	79.4%
Percent Apprehended	27.8%	31.5%	46.4%	34.3%
Age	37.1	39.0	35.6	37.2
Age at First Migration	21.8	20.9	21.0	21.3
Married	74.0%	80.1%	75.5%	76.1%
Number of Children	2.3	2.7	2.4	2.4
Employment (Most Recent US Trip)				
Construction	9.3%	53.1%	18.3%	23.7%
Agriculture	0.5%	6.3%	37.6%	13.1%
Service	64.3%	31.8%	35.6%	47.1%
N	360	222	246	828

Note: Mexican Migration Field Research Program Data.

Table 2: Probability of Apprehension Estimates with MMFRP and MMP Survey

Variable	MMFRP	MMFRP-3	MMP
Probability of Apprehension (1979-2005)			
Mean	0.376	0.387	0.284
Standard Deviation	0.125	0.091	0.052
Median	0.382	0.279	0.380
Correlation of Probability and Linewatch Hours (1979-2004)			
Correlation	0.507	0.617	0.270
Unconditional Elasticity - Prob. and Hours (1979-2004)			
E	0.025	0.026	0.018
(s.e.)	(0.001)	(0.001)	(0.001)
N	828	828	5641

Note: MMFRP is the probability estimated with the Mexican Migration Field Research Program dataset. MMFRP-3 is a constructed probability drawing from the distribution with replacement of migratory trips across the border from the previous year, the current year and the subsequent year to estimate the current year probability. MMP is the probability estimated in the Mexican Migration Project. Linewatch hours or Hours are the number of hours the border patrol spend patrolling the southwest border.

Table 3: Statistical Characteristics of Estimated Undocumented Migrant Inflows

Variable 1979-2004	MMFRP	MMFRP-3	MMP
Average Annual Inflow	1,506,344	1,232,379	2,056,139
Standard Deviation	853,990	258,778	604,699
Deviation from post-2000 Stock Estimates	84,275	-224,718	5,647,334
Decomposition of Volatility:			
Contribution of Prob.	66.0%	56.2%	44.5%
Contribution of Apprehensions	34.0%	43.8%	55.5%
Direct Estimates vs Indirect Estimates:			
Correlation	0.42	0.76	-0.83

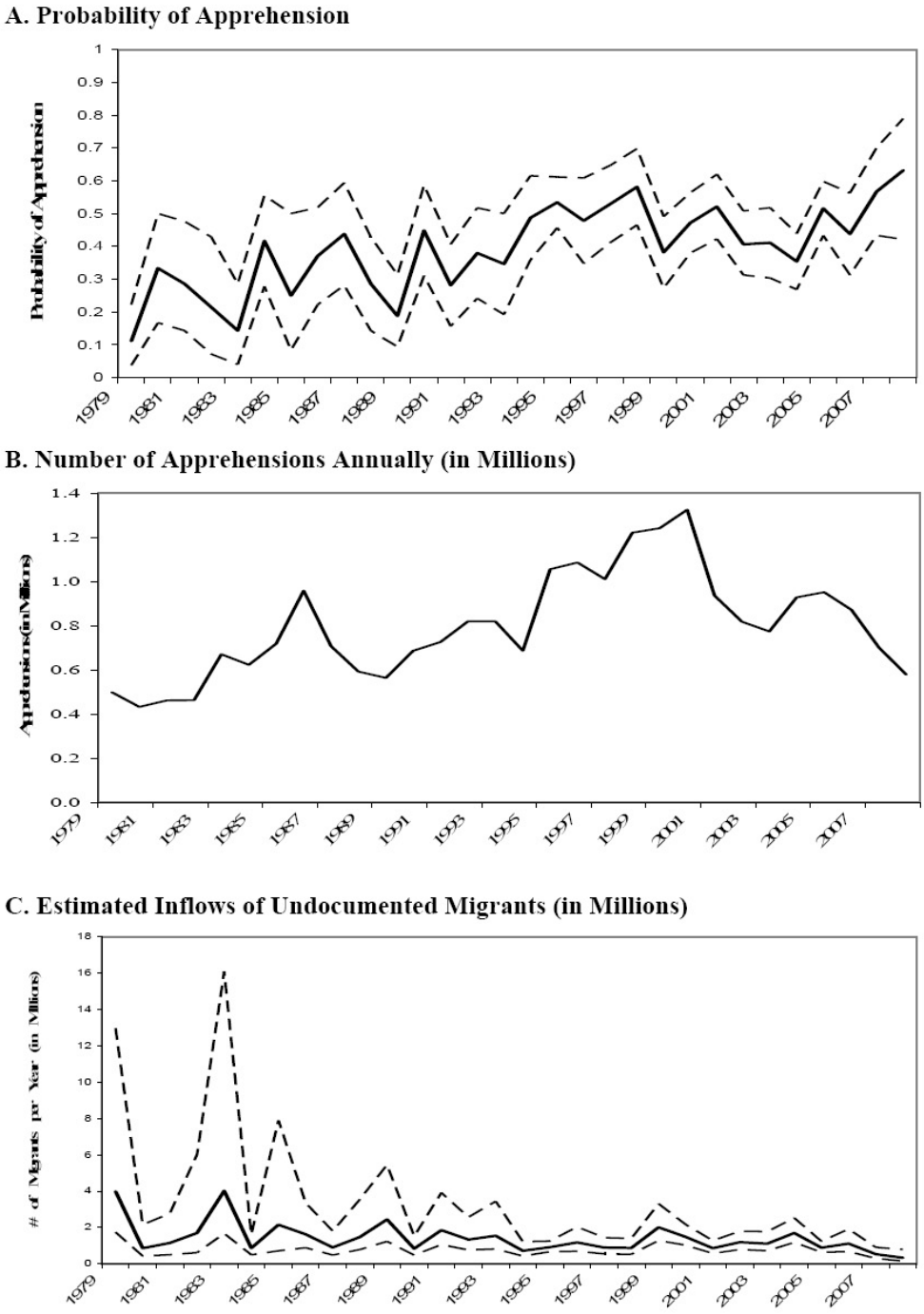
Note: MMFRP is the ratio observed in the Mexican Migration Field Research Program dataset. MMFRP-3 is a constructed ratio drawing from the distribution with replacement of migratory trips across the border from the previous year, the current year and the subsequent year to estimate the current year ratio. The median observation is then taken to be the number of migrants per apprehension. MMP is the ratio observed in the Mexican Migration Project.

Table 4: Business Cycle Characteristics of Estimated Undocumented Migrant Inflows

Variable	MMFRP	MMFRP-3	MMP
Average Deviation from Previous Year Inflow			
Mexico Recession	968,888	-25,543	170,990
US Recession	-771,457	-308,160	-265,099
Both in Recession	850,034	-293,694	74,452
Neither in Recession	-6,199	-26,601	-62,496
Correlation with Aggregate Economic Variables			
US Real Wage	0.305	0.202	0.213
US Unemployment	0.036	-0.013	0.231
US GDP	-0.036	-0.089	0.195
MEX Real Wage	-0.154	-0.478	-0.059
MEX GDP	-0.352	-0.170	-0.041
US/MEX Growth Difference	0.312	0.105	0.141
US/MEX Wage Ratio	0.125	0.347	0.053

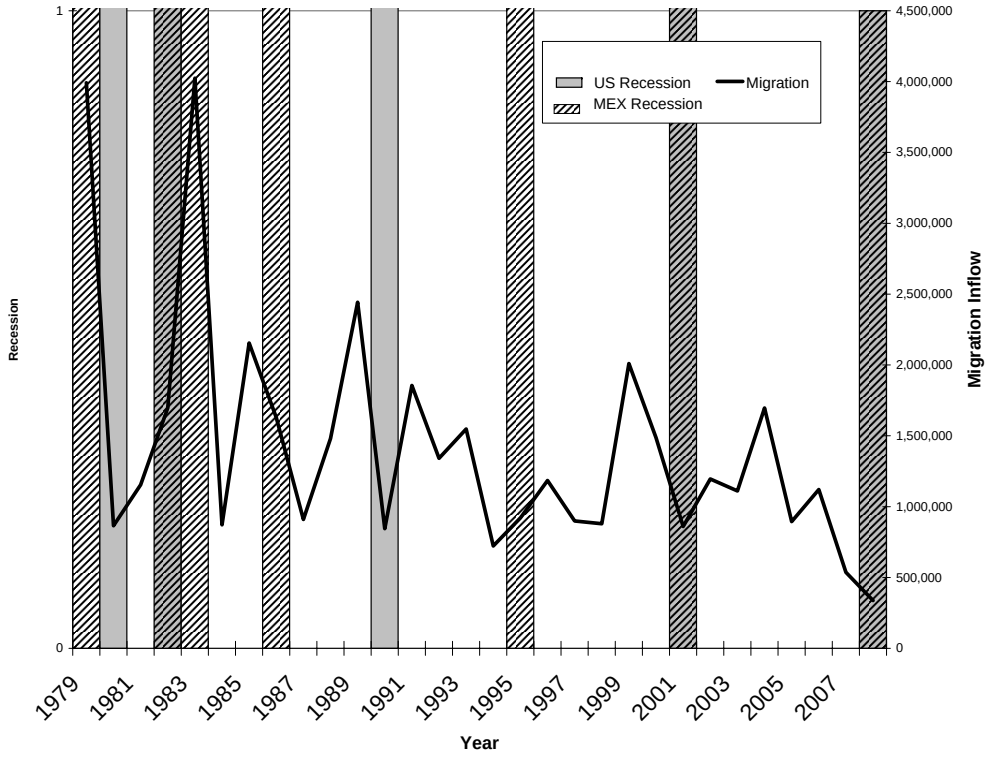
Note: MMFRP is the probability observed in the Mexican Migration Field Research Program dataset. MMFRP-3 is a constructed probability drawing from the distribution with replacement of migratory trips across the border from the previous year, the current year and the subsequent year to estimate the current year probability. MMP is the probability observed in the Mexican Migration Project.

Figure 1: Construction of Inflows from Observed MMFRP Probability



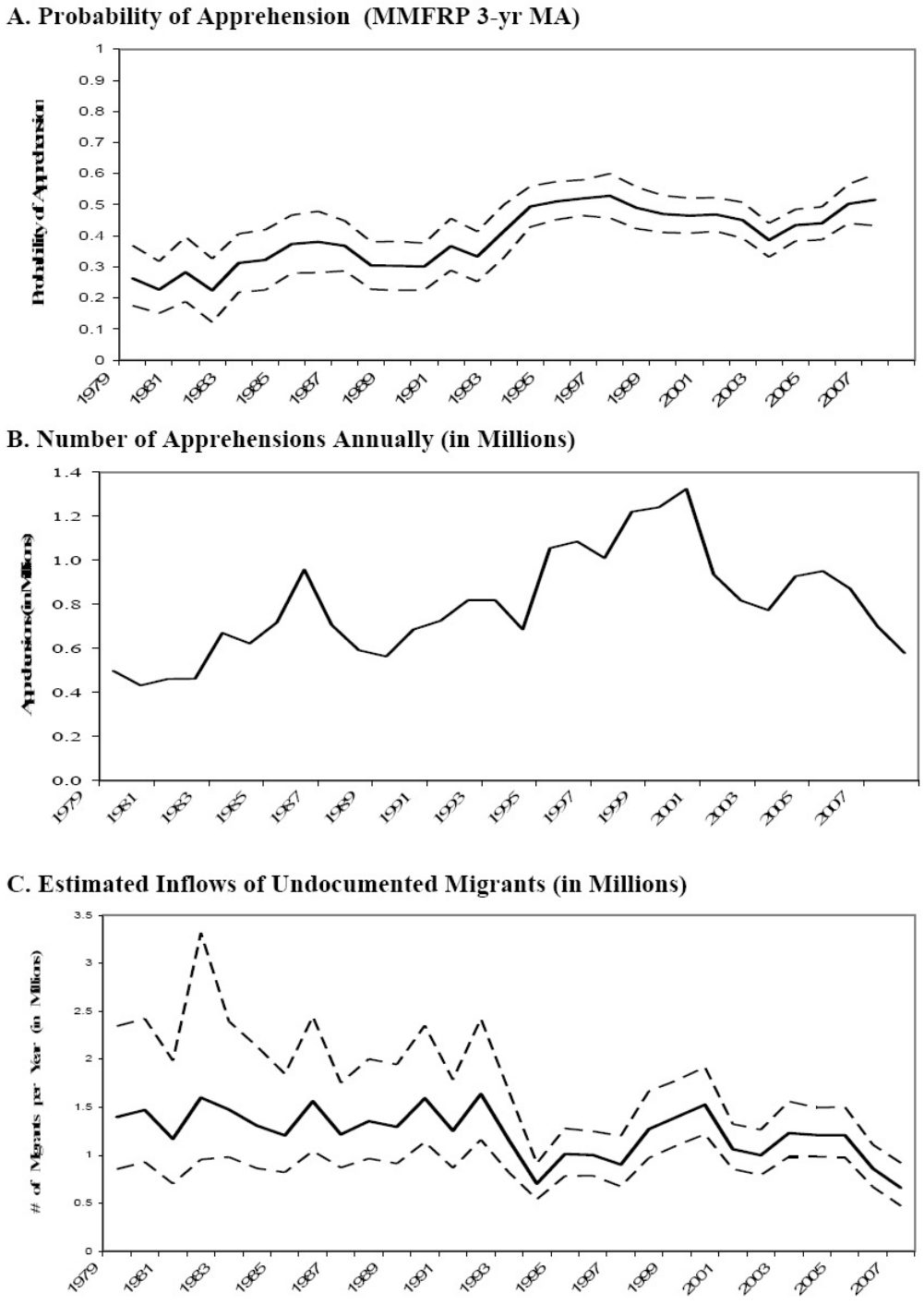
Note: Panel A: Probability of apprehension observed in the MMFRP data set with the bootstrap-estimated upper and lower confidence bounds at the 5th and 95th percentiles. Estimates for the period 1979 to 2008 reported. **Panel B:** Annual apprehensions reported by the U.S. Customs and Border Protection. **Panel C:** Estimate of the inflow of undocumented migrants from equation 9 using the probability of apprehension reported in Panel A and the aggregate apprehensions from Panel B. The confidence intervals are determined from the upper and lower confidence bounds of the apprehensions probability.

Figure 2: MMFRP Estimated Inflows of Undocumented Migrants to the United States



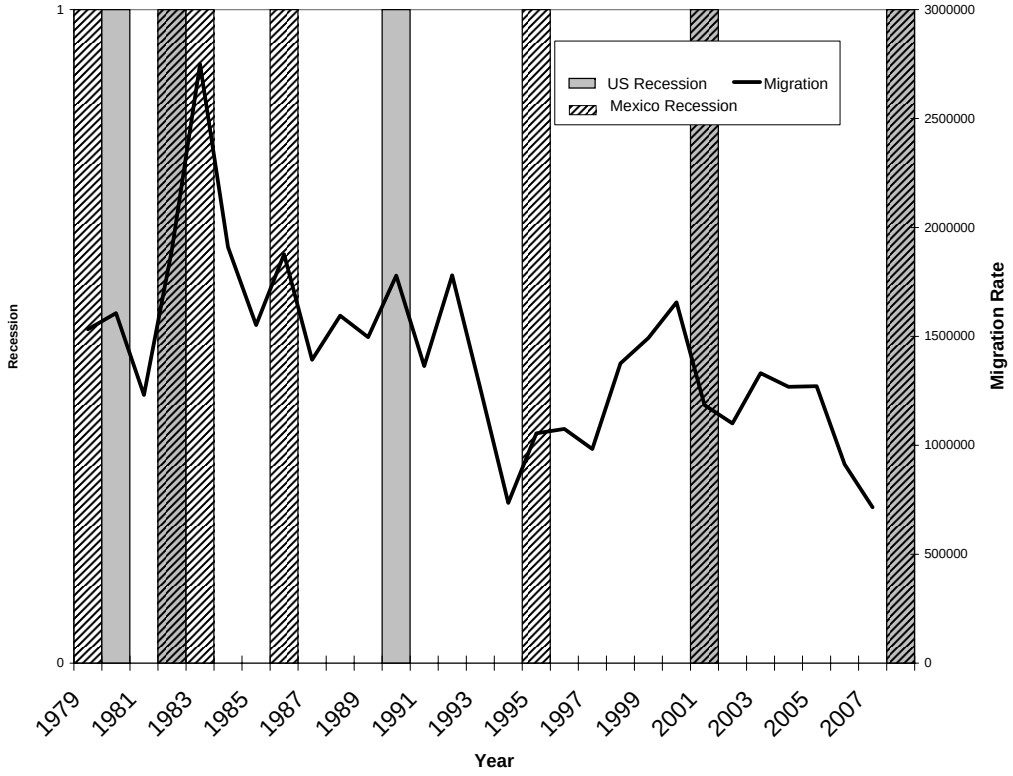
Note: Mexico recession dates (cross-hatched) signifies negative real GDP growth during a given year. US recessions (shaded) are the NBER recession dates.

Figure 3: Construction of Inflows from MMFRP-MA(3)



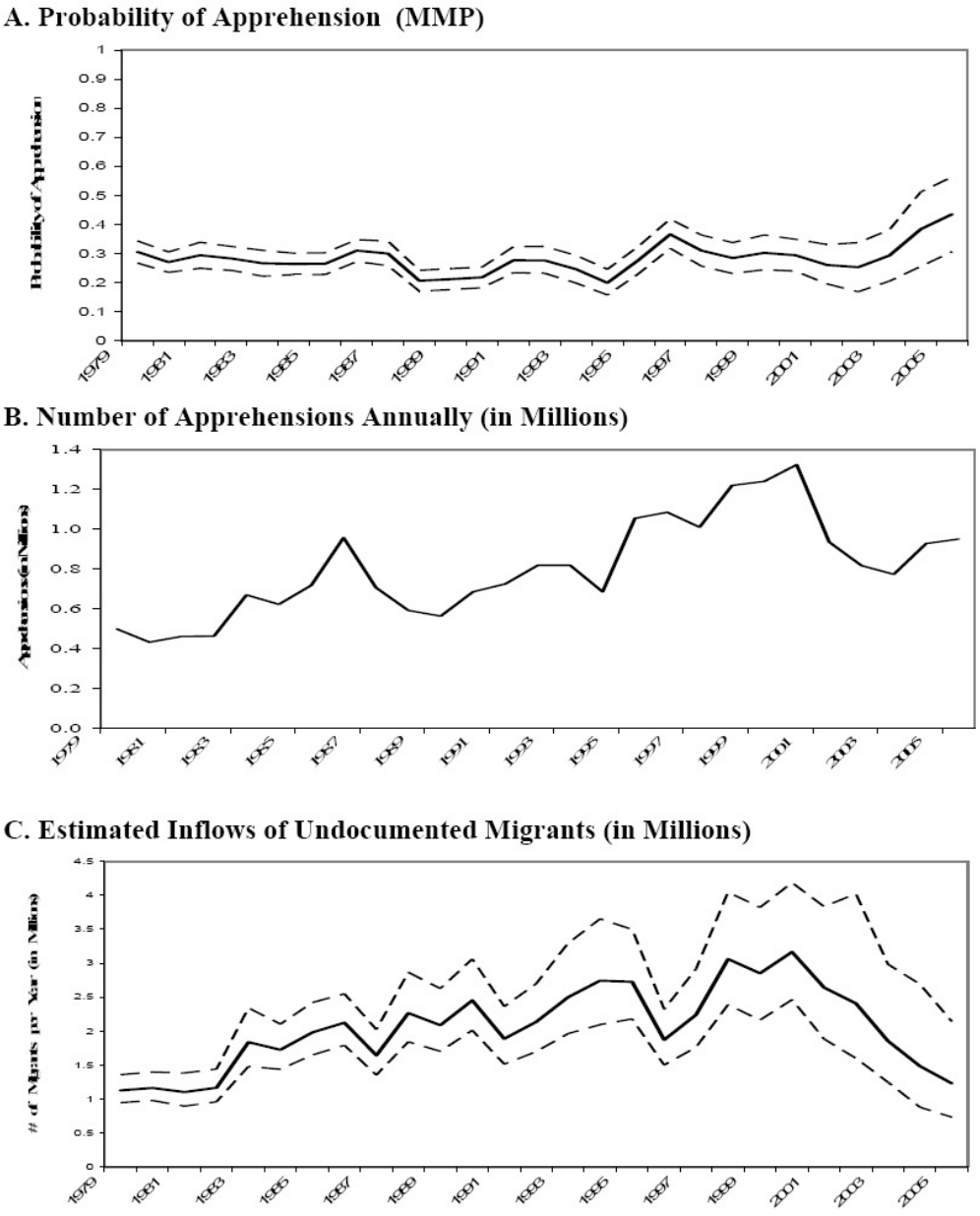
Note: Panel A: Probability of apprehension estimated from MMFRP data set with the draws from the previous year, current year and subsequent year. Estimates for the period 1977 to 2007 reported. **Panel B:** Annual apprehensions reported by the U.S. Customs and Border Protection. **Panel C:** Estimate of the inflow of undocumented migrants from equation 9 using the probability of apprehension reported in Panel A and the aggregate apprehensions from Panel B. The confidence intervals are determined from the upper and lower confidence bounds of the apprehensions probability.

Figure 4: MMFRP 3-yr Estimated Inflows of Undocumented Migrants to the United States



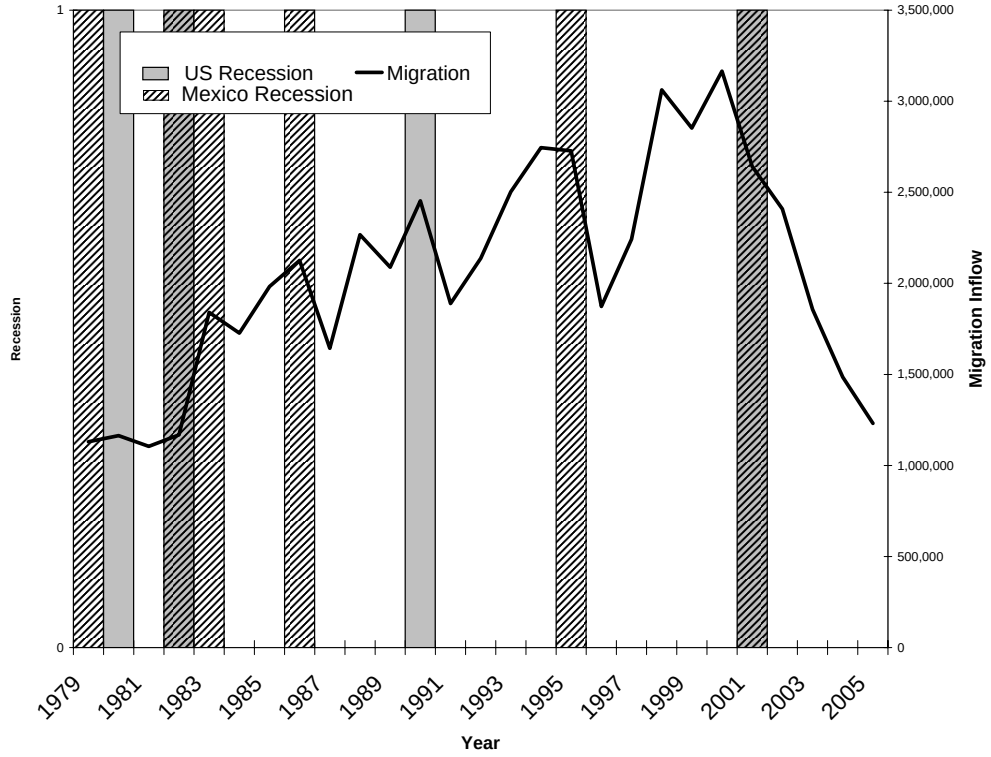
Note: Mexico recession dates (cross-hatched) signifies negative real GDP growth during a given year. US recessions (shaded) are the NBER recession dates.

Figure 5: Construction of Inflows from MMP Probability



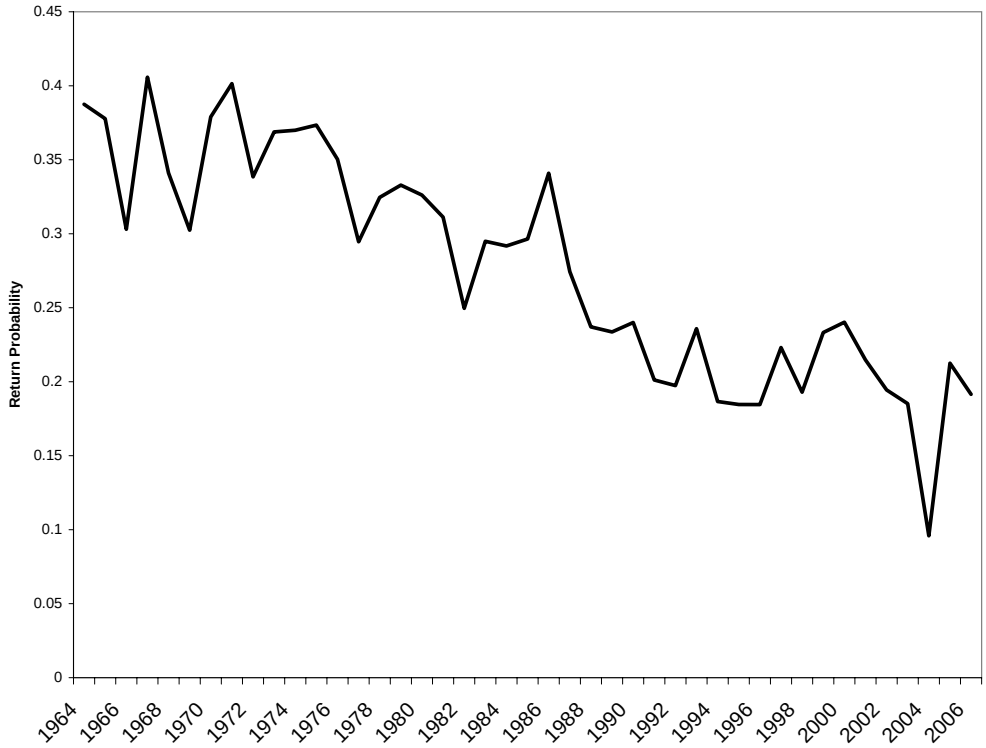
Note: Panel A: Probability of apprehension estimated from the MMP data set with the bootstrap-estimated upper and lower confidence bounds at the 5th and 95th percentiles. Estimates for the period 1977 to 2005 reported. **Panel B:** Annual apprehensions reported by the U.S. Customs and Border Protection. **Panel C:** Estimate of the inflow of undocumented migrants from equation 9 using the probability of apprehension reported in Panel A and the aggregate apprehensions from Panel B. The confidence intervals are determined from the upper and lower confidence bounds of the apprehensions probability.

Figure 6: MMP Estimated Inflows of Undocumented Migrants to the United States



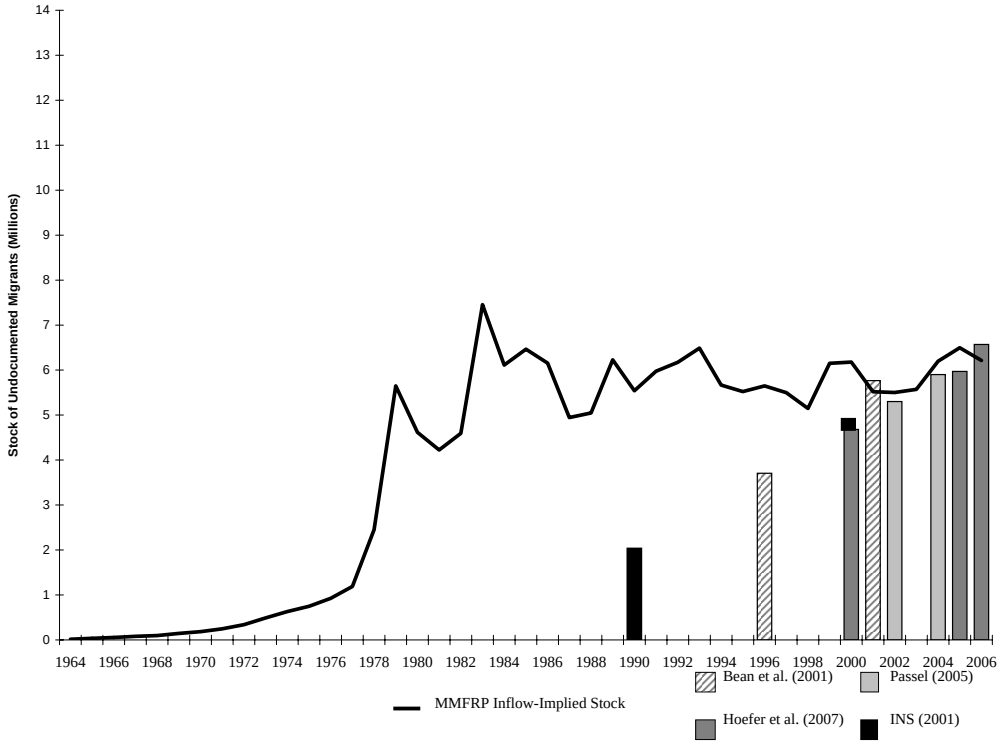
Note: Mexico recession dates (cross-hatched) signifies negative real GDP growth during a given year. US recessions (shaded) are the NBER recession dates.

Figure 7: Probability of Returning to Mexico



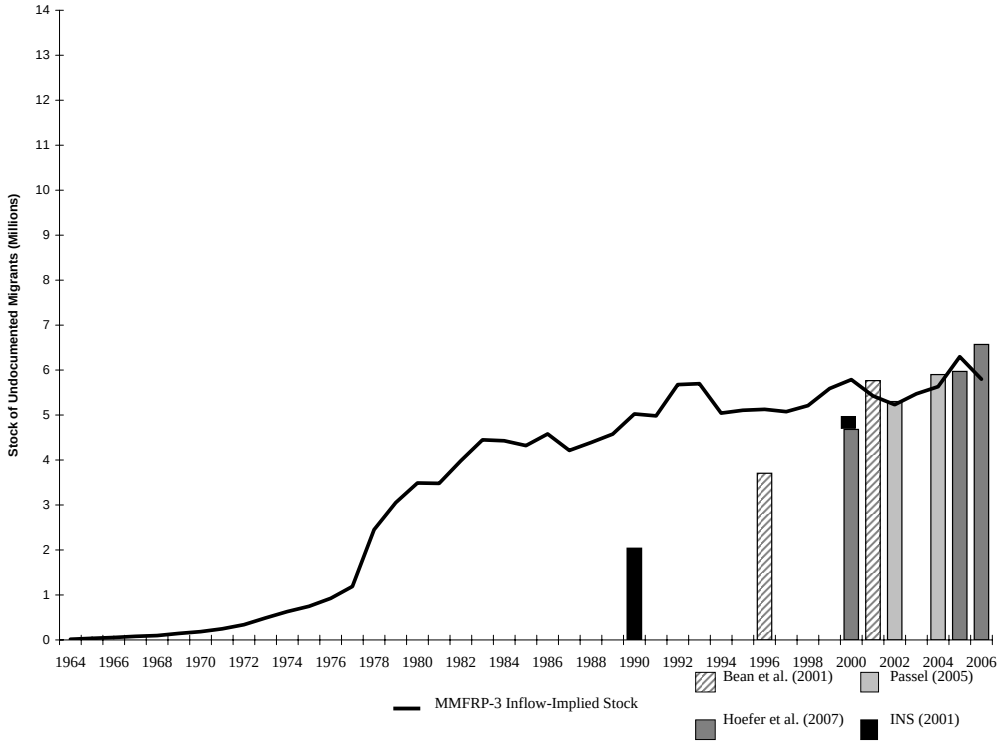
Note: Return probabilities are calculated from the MMP migrant histories of undocumented migrants. Using the reported year of the migrant trip and the amount of time they spent in the United States on a given trip, the number of undocumented migrants who reported returning to Mexico in the sample in a given year was divided by the number of migrants recorded as being in the United States in that year.

Figure 8: MMFRP Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



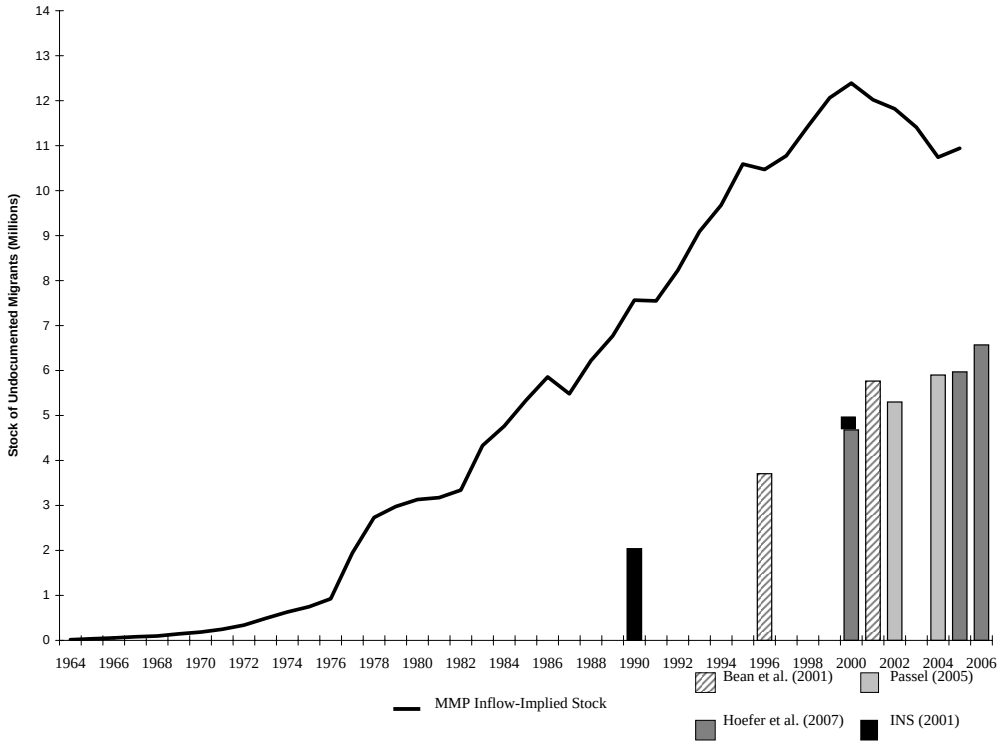
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year, estimated by the Office of Immigration Statistics.

Figure 9: MMFRP 3-year Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



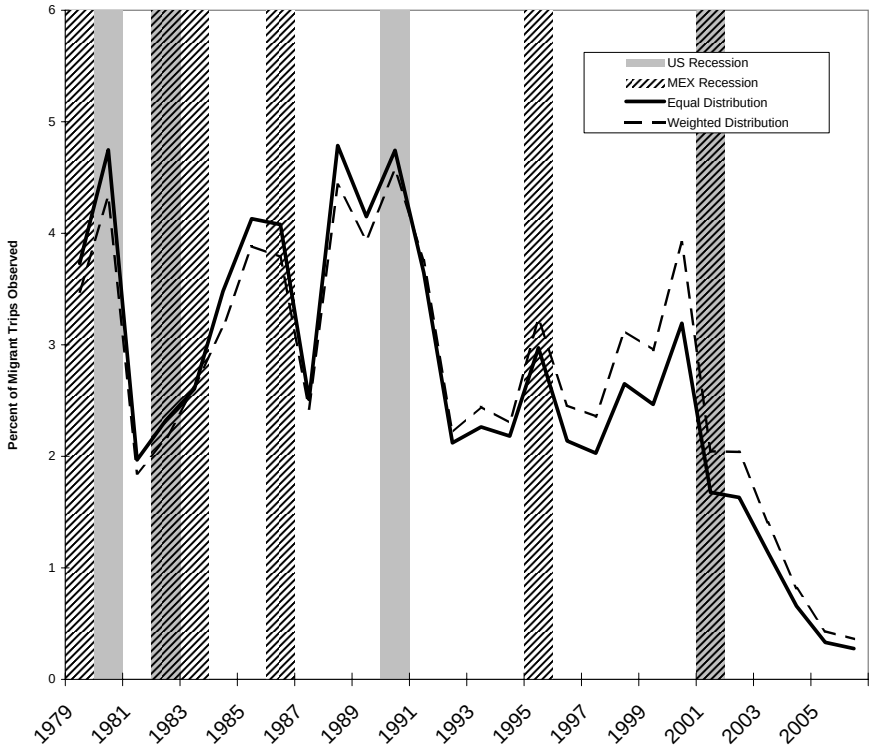
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year, estimated by the Office of Immigration Statistics.

Figure 10: MMP Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



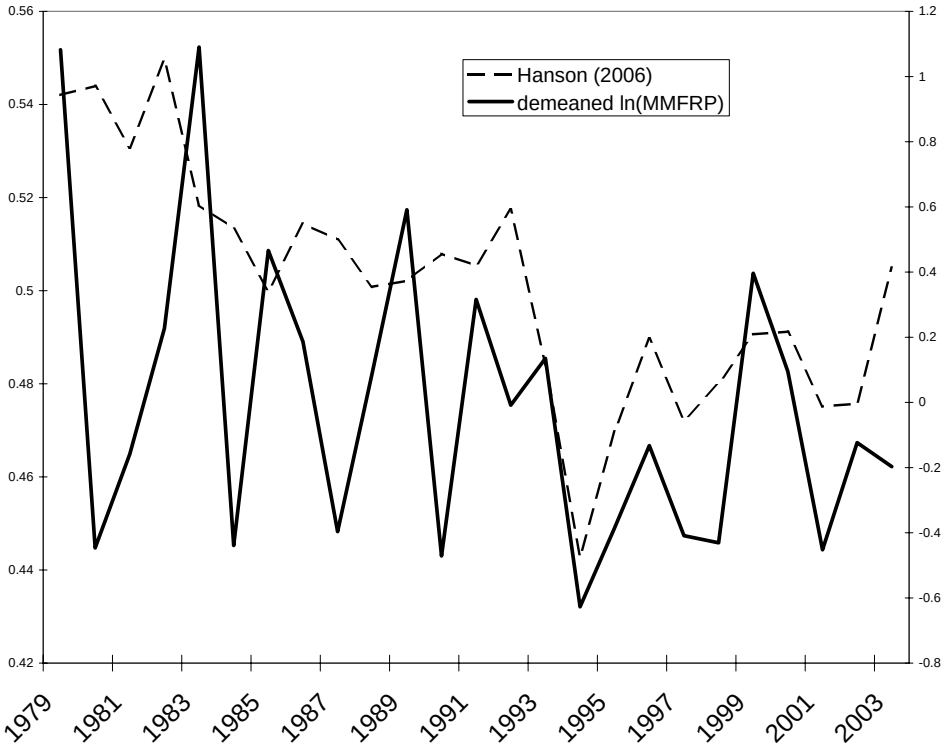
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year. The differences between the stock estimates and the MMP-implied stock estimates is attributable to the lower probability of apprehension which could be a function of the MMP question asking about *deportaciones* rather than *agarrado*.

Figure 11: Distribution of Migration Trips in the MMP Sample



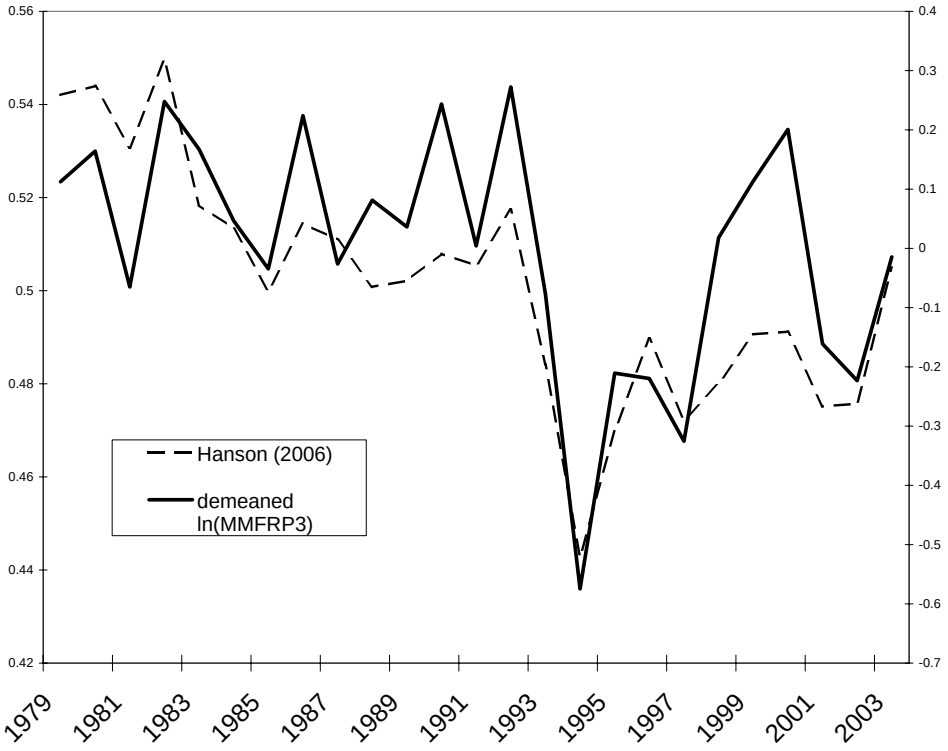
Note: The distribution of migrant trips is calculated over the larger and more diverse sample of migrant trips in the MMP data sampled over the previous two decades. Both equal and weighted samples were randomly drawn from each survey year and replicated 10,000 times to determine the likelihood of observing a migrant trip in a given year. Migrant trips from 1960 to 2006 were estimated. The graph exhibits 1979 to 2006 for purposes of comparison with inflow estimates.

Figure 12: MMFRP and Indirect Estimates of Inflows



Note: The indirect estimate is the annual inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). The MMFRP estimated inflow is transformed by taking the natural logarithm and demeaned to provide a comparison with estimates in Hanson (2006).

Figure 13: MMFRP-3 and Indirect Estimates of Inflows

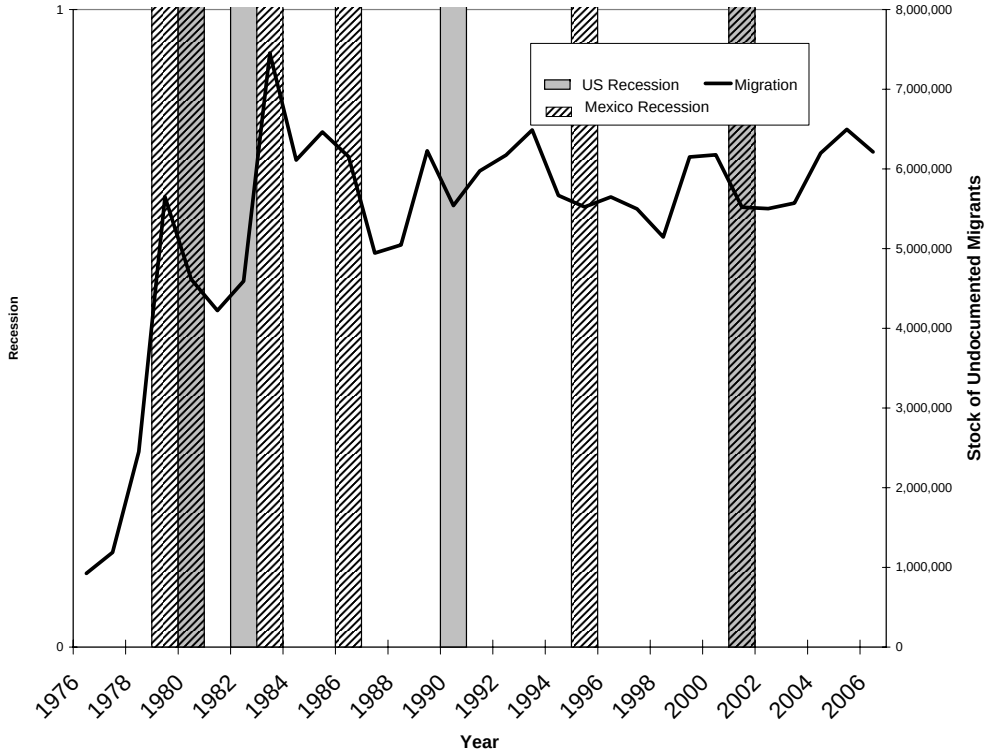


Note: The indirect estimate is the annual inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). The MMFRP-3 estimated inflow is transformed by taking the natural logarithm and demeaned to provide a comparison with estimates in Hanson (2006).

Figure 14: MMP and Indirect Estimates of Inflows

Note: The indirect estimate is the annual inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). The MMP estimated inflow is transformed by taking the natural logarithm and demeaned to provide a comparison with estimates in Hanson (2006).

Figure A1: MMFRP Stock Estimates at Business Cycle Frequency



Note: The MMFRP stock estimates vary at the business cycle frequency with declines during US recessions and increases during Mexico recessions.