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

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Abstract

This paper constructs estimates for the inflow of undocumented migrants to the United States using survey-based micro estimates of the number of successful migrations per apprehension and aggregate apprehensions data reported by U.S. Customs and Border Protection. The robustness of the constructed data is determined 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 analysis in this paper concurs with Hanson and Spilimbergo (1999) finding that the inflow of migrants to the United States is responsive to business cycle conditions.

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1 Introduction

Immigrants have become a significant part of the US economy with foreign-born persons increasing in the share of the population from 6 percent in 1980 to 15 percent in 2006. Moreover, undocumented migrants who crossed the border without proper documentation or remained in the United States past the time required by their visa constitute a sizable share of the foreign-born population and represent a share of the population that fluctuates with economic conditions. This is in contrast to the stable inflow of legal migrants due to the government's constant annual allocation of visas and work permits.

However, the dearth of data about the sizable 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 attempts to remedy the deficiency of data by proposing a new methodology that is consistent with previous estimates of the stock of undocumented migrants and provides a higher frequency than stock estimates are able to construct.

Current estimates of the flow of undocumented migrants can be characterized into two subcategories. First, the 'residual' methodology uses Census or Current Population Survey data to estimate the stock of the foreign-born population residing in the United States. Then by estimating the under sampled populations from post-enumeration surveys, the number of foreign-born without legal documentation is calculated from the residual of the total foreign-born population after removing known legal migrants residing in the United States. Projected populations of undocumented migrants are subject to under-enumeration in the U.S. Census and the Current Population

Surveys and therefore different assumptions about the undercount rate must be made.

This methodology provides valuable information on the stock of undocumented migrants, but provides only coarse estimates of the net flow of migrants when the change in the stock of migrants is averaged over the estimated frequency. However, the infrequent and abbreviated data makes the 'residual' methodology ineffectual in accounting for any increase or decrease in the response rate of migrants to labor market conditions or policy changes. For example, Costanzo et al. (2003) provides estimates of an approximately 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 a net migration of 600,000 per year over the decade. Yet, the data cannot provide an answer to the question of whether the numbers 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. Therefore, it is imperative to have data on the flow of undocumented migrants rather than just the stock to assess the responsiveness of migrants to business cycle conditions.

The second methodology for estimating the flow of undocumented migrants is the apprehension-implied indirect assessment 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 estimates of the inflows of undocumented migrants requires the assumption that the probability of undocumented mi-

grants being apprehended is a function of linewatch hours. The estimates provided hereafter demonstrate that this assumption could bias the analysis of the factors that contribute to increased apprehensions on the border since reported apprehensions per migration has not increased in tandem with the increased border enforcement. Moreover, the indirect estimation of the inflow of migrants provides only relative rather than level estimates of the inflow fluctuations.

This paper attempts to remedy the deficiency of data on the flow of undocument migrants by proposing a methodology that constructs a time-series from the aggregate apprehensions data and the micro-estimates of successful migrations per apprehensions by the Border Patrol. The ratio-implied flow of undocumented migrants will provide more informative data on the timing of migrant inflows during the previous four decades. Moreover, I will measure the implied stock of undocumented migrants from the newly constructed inflow data to test the robustness of the data against the previous estimates of the stock of undocumented migrants.[1]

It should be noted that this paper 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, but 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 rather than visa

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

overstayers. However, this subset of the unauthorized immigrant population is of considerable economic interest, since the proximity of Mexico to the United States and the keen responsiveness of clandestine migrants to economic conditions make them more relevant for business cycle and policy analysis.[2]

The paper is organized as follows. Section 2 will articulate the methodology for the construction of the time-series data. Section 3 contrasts the data series with indirect estimates that also use aggregate apprehensions data to learn about the undocumented migrant flow. Section 4 conducts a robustness check by using the newly constructed inflow data to estimate the implied stock of undocumented migrants residing in the United States to provide a comparison with the residual methodology estimates. Section 5 estimates the responsiveness of migrant inflows to economic conditions in the United States. Section 6 concludes.

2 Estimated Inflows of Undocumented Migrants

With a new and unique dataset that provides information about individual migrations across the border (the 'MMFRP' dataset) and a large sample but limited scope dataset that provides information about the household head (the 'MMP' dataset), a micro-estimate is constructed of the number of successful migrations per apprehension by the Border Patrol (the 'migrant-to-apprehension ratio') in a given year. These estimates combined with the government's data on the number of apprehensions at the border will provide the necessary data to the construct inflows of unauthorized migrants to the

[2]Cornelius, Fitzgerald and Borger (2008) 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.

United States.

2.1 MMFRP Estimated Inflows of Undocumented Migrants

The set of data that provides individual observations of migrations is from the Mexican Migration Field Research Project (MMFRP),[3] 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. Four surveys have been conducted to date, among migrants and potential migrants in *Tlacuitapa*, *Jalisco* (2005, 2007), *Tunkás*, *Yucatán* (2006), and *San Miguel Tlacotepec*, *Oaxaca* (2007). The present analysis makes use of data from the MMFRP's three most recent surveys. The surveys record 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 2006, is a town still in its first generation of international migration. However, the town has had significant earlier migrations to destinations within Mexico, notably *Cancún* 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

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

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.

Table 1 provides a summary of the characteristics of the MMFRP's surveyed communities. Note that the ratio between the communities is similar despite that fact that the composition of undocumented migrants differs in several aspects between the communities. First, the percent of men differs significantly. However, the percent of males in the U.S. undocumented population is 58 percent according to Passel (2006), which is slightly lower than the 64 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.[4]

With information on the number of apprehensions by the Border Patrol and whether the migrant succeeded or failed, the MMFRP migrant-to-apprehensions ratio is calculated in equation (1):

$$R_t = \frac{n - \sum_1^n F_n}{\sum_1^n A_n} \tag{1}$$

[4]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 sample communities are overly representative of migrants from the construction and agricultural sectors which could have cyclical or seasonal components to their migration patterns.

where n is the number of migrants who attempts to cross the border in a given year t, F_n is a dummy variable for whether migrant n was unsuccessful in their clandestine migration, and A_n is the number of times migrant n reported being apprehended by the Border Patrol.

In addition to the estimated migrant-to-apprehension ratio, the aggregate number of apprehensions at the border reported by U.S. Customs and Border Enforcement (CBP) is used to calculated the inflow of undocumented migrants. However, since the frequency of interest in this paper is at a lower frequency than the monthly data and because the migrant-to-apprehension ratio is estimated at an annual frequency, the apprehensions data is seasonally adjusted using the U.S. Census X-12 ARIMA software. 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, this assumption has little impact on overall estimates. Figure 1 exhibits both the unadjusted and adjusted apprehensions data at the southwest border of the United States.

The estimated inflows of undocumented migrants is then calculated on a seasonal adjusted basis by calculating the following:

$$M_t = R_t * APP_t \tag{2}$$

where M_t is the estimated inflow and APP_t is the seasonally adjusted aggregate number of apprehensions per month. Figure 2 exhibits at the quarterly frequency each of the series required for the construction of the MMFRP-estimated inflows of undocumented migrants. Figure 2a displays the estimated migrant-to-apprehension ratio (R_t) and the bootstrapped confidence intervals at the 5th and 95th percentile for the ratio. Note that the period between 1977 and 1992 has very large confidence intervals around the ratio. This is due to the fact that with the small number of observations during these years and the insignificant number of apprehensions reported by migrants in those years. The four large peaks are periods where the number of apprehensions is not statistically different from zero and therefore the number of migrants per apprehension is infinite. The confidence interval was censured at 20 migrants per apprehension. Figure 2b reportes the quarterly apprehensions (APP_t). As demonstrated in Figure 2c, the large confidence intervals around the ratio result in large confidence intervals around the estimated inflows during these periods. Also, note that since the ratio is calculated at an annual frequency, but aggregate apprehensions are reported at a monthly frequency, the inflows are calculated at a monthly frequency by linearly interpolating between ratio observations to prevent significant flucations between the year. The observed ratio is inputted in July. The inflows are then estimated at a monthly frequency but averaged over the quarter for the purposes of reporting the data.

2.2 MMFRP Contiguous Years Distribution Estimate

A second approach to estimating the migrant-to-apprehension ratio is considered to account for the few migrants apprehended in a given year and the small sample of migrants in the previous estimate. Since the data might

contain some recollection bias by some migrants about which year they migrated and the expected similarity between apprehension rates for years surrounding a given year's migration, 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 ratio.[5] The calculation of the MMFRP-3 ratio uses the median observation in the bootstrap methodology drawing from the distribution of observations in periods t, t-1 and t+1 with replacement equal to the number of observations observed during those periods. Then the ratio is calculated according to the following:

$$R_t^b = \frac{\sum_{t-1}^{t+1} n_t - \sum_{t-1}^{t+1} \sum_{1}^{n_t} F_{n_t}}{\sum_{t-1}^{t+1} \sum_{1}^{n_t} A_{n_t}} \tag{3}$$

where n_t is the number of migrant trips observed in period t and R_t^b is the ratio 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 migration-to-apprehension ratio. Figure 3a shows the estimated MMFRP-3 ratio with confidence intervals. As expected, the smoothed ratio over three years provides much tighter confidence intervals. Figure 3c is the estimated quarterly inflows with peaks of around 400,000 undocumented migrants per quarter and troughs of around 200,000.

2.3 MMP Estimated Inflows of Undocumented Migrants

The third approach to constructing an estimate for the inflows of undocumented migrants calculates the migrant-to-apprehensions ratio 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

[5] This approach could be described as a centered 3-year moving average of the migrant-to-apprehensions ratio observed in the MMFRP data.

geographically diverse set of migrant-sending communities in Mexico.[6] The number of observations in the MMP dataset is large, provide much tighter estimates of the migrant-to-apprehension ratio. The estimated MMP ratio was lower on average with 1 successful migration per apprehension whereas the estimated MMFRP ratio was on average 2.1 and 1.7 successful migrations per apprehensions for the observed and smoothed ratio, respectively. (See Table 2) The estimated MMP ratio in figure 4a exhibits trends similar to the MMFRP-3 ratio during the periods of increased border enforcement without any secular trend in the apprehensions rate. However, the MMP survey only gathers apprehensions data from household heads, who are predominately male migrants.

I am able to assess the male-only bias created by the MMP estimates of the apprehensions ratio with the MMFRP data. With information on the apprehensions of both males and females, the MMFRP dataset provides an estimate of the gender differential in apprehensions controlling for fluctuations in apprehensions over time. I find that men are apprehended more often than women. One explanation for this differentiation in apprehension rates between genders is that female migrants often use less conventional and more expensive ways of crossing the border, such as passing through legal ports-of-entry using false documents, and are therefore more likely to elude U.S. immigration officials.[7] The negligible representation of females in the MMP survey would imply that the estimates are biased downward from the true migrant-to-apprehension ratio if both genders were used to

[6] 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.

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

estimate the number of apprehensions recorded. Moreover, this combined with the fact that the apprehensions ratio in the MMP survey is higher than the MMFRP data would imply that the MMFRP estimate is the lower bound of the apprehensions ratio and therefore a conservative estimate of the inflow of undocumented migrants to the United States.

3 Indirect Estimates of the Inflow of Undocumented Migrants

The significant contribution of this paper is that it constructs data series with direct evidence of the frequency of apprehensions by unauthorized migrants and does not need to assume that apprehensions are a function of linewatch hours. Moreover, it provide gross inflow of migrants that will have much more relevance for researchers and policymakers than the net flows previously available from the stock of undocumented migrants. Furthermore, my paper will show that the MMFRP data series are consistent with the indirected estimates of the inflow of undocumented migrants, the stock of undocumented migrants from Mexico and business cycle conditions.

First, the direct evidence of the apprehensions ratio provides similar magnitude of fluctuations with the indirect evidence with the added feature that the data series provides estimates of the level at which these fluctuations take place. Moreover, the indirect evidence required the assumption that the probability of being apprehended was a function of the number of hours Border Patrol spend watching the border. However, the evidence from Figure 8 suggests that the two periods of increased border enforcement in the United States – in the mid-1990s with Operation Hold-the-Line (El Paso sector) and Operation Gatekeeper (San Diego sector), and since 2001 with

the buildup of Border Patrol agents in Arizona – has had little impact on the number of apprehensions per migrant who crossed the border successfully and is not dependent upon which data series is used. This would imply that an assumption held in the literature that apprehensions are an increasing function of border enforcement does not hold in the estimated data series. The previous estimates would overstate the correlation between the probability of apprehension and the increase in border enforcement such that the increase in the number of apprehensions in recent years would be a function of an increase in the number of undocumented migrants attempting to cross rather than the increase in border enforcement. Therefore, estimates relying on border enforcement intensity would overestimate the probability of undocumented migrants being apprehended by the Border Patrol and underestimate the number of undocumented migrants who have succeeded in crossing the border during these periods of tougher enforcement.

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 9 through figure 11 contrasts the demeaned logarithm of the constructed inflow series to provide comparable results with the reduced form estimate of inflow fluctuations in Hanson (2006) with seasonally adjusted apprehensions. The fluctuations are of similar magnitude to the indirect estimates of migrant inflows. However, the sizable fluctuations that correspond to the business cycle frequency provides additional insight into the inflows of undocumented migrants when the apprehensions ratio is directly observed.

4 The Stock of Undocumented Migrants

To estimated the robustness 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 previously estimates in the literature. 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 85 percent of undocumented migrants from Central America. About 15 percent of the stock of undocumented migrants from Central America are from El Salvador, Nicaragua, and Honduras. However, the availability of stock estimate for Mexico provides a consistent measure to compare the implied stock estimates and the previous estimates.

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 or the Current Population Survey. The differentiation between the enumerated and unenumerated population is an important distinction since estimates rely on the cooperation of undocumented migrants to government-based surveys. Estimates in the 1980s used the Alien Registration Program to determine the number of documented immigrants. (See Heer(1979), Warren(1982), Passel (1985) Passel and Woodrow(1985, 1987)) The discontinuation of the Alien Registration Program in 1981 required a projection each subsequent year of new immigrations. Estimates by Costanzo et al. (2001), Bean et al. (2001), INS (2001), and Passel (2005) 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, to estimate the stock of

undocumented migrants 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 9 estimates the stock of undocumented migrants who resided in the United States in the previous period and the probability of return estimated from the micro-estimates in the survey. In addition, the Office of Immigration Statistics estimates the number of undocumented migrants residing in the United States who receive permanent resident status in the United States. These transitions in documentation status of Mexican nationals are subtracted from the stock estimates.

Figures 12-14 reports 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 in the post-2000 census period. One reason for the significant deviations of pre-2000 estimates relative to the post-2000 period could be improved accuracy of sampled populations in more recent periods in the the Hispanic community. Moreover, the differences in the magnitude could be accounted for by the different assumptions that each of the authors made about the unenumerated population 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 12-14. 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. However, the reported stock of undocumented migrants in figure 14 from the MMP estimated inflows would seem to indicate that the MMP ratio provides to low of apprehension rate for what we should have observed in the sample.

5 Business Cycle Analysis

The responsiveness of migrants to economic conditions in the receiving country context has been documented since Jerome's (1926) seminal work *Migration and the Business Cycle* where Jerome argued that increased labor costs moderated the business cycle and this moderating influence is impeded by the movements of immigrants into the labor force. Alternatively, 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 previous inability of researchers to measure the movements of undocumented migrants at high-frequency periods left questions about the impact of the recent and significant influx of migrants 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 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 an 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 business cycle. Figures 12-14 display the estimated inflow series against economic expansions and contractions in the United States. The shadowed boxes represent the periods where the National Bureau of Economic Research (NBER) dates the recessions in the United States and non-shadowed periods are considered economic expansions. In figure 12, the MMFRP estimated inflows vary quarter-by-quarter, but the period for which we have the most confidence, the later period, exhibits an uptrend during the late years of the expansion in the 1990s and a decline just before the start of the recession in 2001. Once the recovery was well underway, we see the inflow of migrants return to their expansion-level peaks despite the increased border enforcement.

In figure 13, the smoothed MMFRP estimated inflows of undocumented migrants show similar declines around recession dates and an increase in the inflow toward the later stages of an expansion. One possible explanation of the negative response of migrants before the actual recession commences in the MMFRP estimates is the increasingly forward-looking nature of migrants to future economic conditions due to the increased costs of migration. Often migrants obtain their employment opportunities through networks in the United States and therefore would be readily aware of difficulties of obtaining a job before they crossed the border. Moreover, the increased border

enforcement policies of the United States during the previous decade and a half has increased the cost of migration through increased 'coyote' fees and thus the amount of time required by the migrant to pay back the fees to family and friends that often assist with the cost of migration.

Likewise, in figure 14, the MMP estimate of the inflow exhibits similar upward trends during expansion phases, but fails to capture any cyclical decline during the recessions in the 1980s and the recession in 1991. One explanation for the differences between surveys is the two groups that are captured in the survey questions. Since the MMFRP data surveys men, women and teenagers, these estimates might provide more cyclical estimates since it is more likely that families would be able to afford the costs of reunification in the United States during economic booms and less likely to migrate during economic recessions. Since women account for 42 percent of the undocumented population according to Passel's (2006) estimates, the household head sample in the MMMP dataset would not representative of the sizable fluctuations in undocumented migrants during the previous two decades.

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. Figure 15 contrasts the inflow estimates with the unemployment rate in the United States. The negative correlation of the MMFRP estimates affirm our expectation that immigrants are responding to job opportunities in the United States. Moreover, the decline in the inflow during periods of high unemployment in the United States would seem to indicate that migrants are more reluctant to make the journey across the border during relatively high unemployment periods whereas the migrant inflows peak to-

ward the end of a business cycle phase when labor is scarce and labor costs tend to rise. This response of migrants contrasts the findings previously 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 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.

Table 3 provides the correlation of the inflow series with economic conditions in the United States to which migrants might respond. With the exception of the positive correlation of the MMP estimate and the unemployment rate, the correlations for the MMFRP-3 estimate and the MMP estimate are strong and in the direction one would expect. Figure 16 through figure 20 demonstrates the cross-correlations between the inflows of undocumented migrants and different aggregate economic indicators. The quarterly lags are indicated on the horizontal axis with the correlation between migrant flows and the indicated variable on the vertical axis. At the point where j=-8, if the graph reports a positive correlation, implies that the economic indicator 8 quarters before is positively correlated with migrant inflows Whereas, when j=0, it represents the concurrent correlation between migrant inflows and the economic variable. The top left of each figure indicates the correlation of the economic indicator and the MMFRP estimate. The top right of each figure is the MMFRP-3 estimate. And the bottom panel in each figure is the MMP estimated inflow series and its correlation with the economic indicator.

The cross-correlation between migrant inflows and the unemployment rate in figure 16 demonstrate that the MMFRP data are consistent with our expectations that migrant inflows should be negatively correlated with periods of low unemployment. The MMP-estimated inflow has a positive correlation such that an increase in the unemployment rate positively influences the rate of inflow of migrants. Figure 17 exhibits the cross-correlations between migrant inflows and output as measured by the Gross Domestic Product of the United States in real terms. The positive correlation for the MMFRP-estimated inflows is expected. However, the different slopes between the MMFRP-3 estimate and the MMP estimate has different implications. The MMFRP-3 inflows would indicate that migrants tend lead with an increase in inflows 6 quarters before there is an increase in output. Whereas the MMP inflows would indicate that migrant lag increases in output by 3-4 quarters. The same is true of the data in figure 18 on the cross-correlations between migrant inflows and service sector employment where the MMFRP-3 inflows imply that migrant lead the increase in employment whereas the MMP implies that an increase in inflows lag an increase in employment in the service sector by 4 quarters. The wages are fairly consistent across the different data series and whether nominal or real wages are used. Figures 19 and 20 exhibit the cross-correlations between the nominal and real wages in the construction industry and the different inflow estimates. The MMFRP-3 estimates and the MMP estimates has similar implications–an increase in the nominal or real wage increases the inflows of undocumented migrants. This result is consistent with the finding in Hanson and Spilimbergo (1999) that migrants are responding to changes in the real wage in the United States as well as changes in wages in Mexico.

6 Conclusion

The construction of a new data set on the inflow of undocumented migrants to the United States using micro-surveys of apprehended as well as unapprehended migrants is an important step in understanding how changing U.S. economic conditions influence migrant inflows. The MMFRP estimated inflows were consistent with the previous indirect estimate of the inflows of undocumented migrants, the estimated stock of undocumented migrants in the post-2000 Census period and the business cycle conditions to which micro-research on migrant behavior would predict them to respond. The MMP estimated inflows implied too high of stock of undocumented migrants throughout the sample period, indicating an elevated migrant-to-apprehension ratio relative to what would be consistent with the data. Moreover, the positive correlation with the unemployment rate in the United States is contrary to how one would expect migrant inflows to respond.

The robustness of the data series aside, 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 economic expansion and decreases during economic contraction. This movement of the gross inflow of migrants provides valuable insight into the factors that contributed to such inflows. Moreover, the fact that migrants' business cycle response was similar during periods with and without high levels of border enforcement has policy implications. For example, if the reduction in undocumented migrants is the result an economic downturn rather than border enforcement, then different policy

prescriptions would be required for U.S. immigration policy. 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 guest worker programs.

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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 excluding 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. However, since the initial analysis uses the inflow estimates to analyze its properties at the business cycle frequency, the monthly estimates were seasonally adjusted using the U.S. Census X-12 ARIMA seasonal adjustment software.

B Tables and Figures

Table 1: Summary Statistics of Undocumented Migrants in Survey Communities

	Tunkás, *Yucatán*	*Tlacuitapa*, *Jalisco*	*Tlacotepec*, *Oaxaca*	
Variable				Total
Generations of Migrants	First	Fourth	Second	
Male Migrants	89.4%	75.7%	67.5%	79.4%
Males In US	75.0%	65.9%	52.4%	64.2%
Coyote Use	91.3%	81.7%	74.5%	79.4%
Apprehension per Migrant	0.88	0.93	1.04	0.81
Standard Deviation	0.72	2.45	1.11	0.29
Percent Apprehended	24.6%	31.5%	46.4%	34.4%
Age	41.4	39.0	35.6	38.6
Age at First Migration	24.2	20.9	21.0	22.0
Married	78.2%	80.1%	75.5%	77.9%
Number of Children	1.9	2.7	2.4	2.3
Employment (Most Recent US Trip)				
Construction	9.8%	53.1%	18.3%	26.5%
Agriculture	1%	6.3%	37.6%	15.5%
Service	67.5%	31.8%	35.6%	45.0%
N	234	222	246	702

Note: Mexican Migration Field Research Program Data.

Table 2: Apprehension Ratio Estimates with MMFRP and MMP Survey

Variable	MMFRP	MMFRP-3	MMP
Surveyed	Male and Female	Male and Female	Male Only
Migrants per Apprehension			
Mean	2.07	1.71	2.76
Standard Deviation	1.78	0.80	0.59
Median	1.40	1.45	2.69
N	702	702	6430

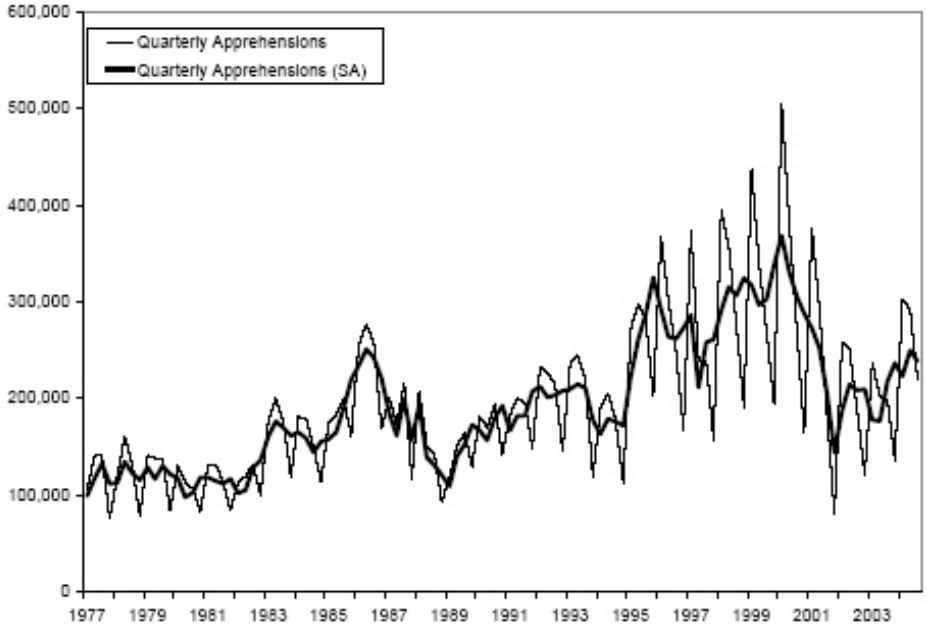
Note: MMFRP is the ratio observed in the Mexican Migration Field Research Program dataset. MMFRP-3 is a constructed ratio drawing from the distribution with replacement of migratory trips across the border from the previous year, the current year and the subsequent year to estimate the current year ratio. 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 3: Statistical Characteristics of Estimated Undocumented Migrant Inflows

Variable	MMFRP	MMFRP-3	MMP
Average Inflow per Quarter	194,661	293,534	522,771
Standard Deviation	65,926	73,597	174,128
Average Deviation from Stock Estimates	1,563,731	606,720	6,744,472
Decomposition of Volatility:			
Contribution of Ratio	65.8%	54.6%	40.2%
Contribution of Apprehensions	34.2%	45.4%	59.8%
Business Cycle Correlations:			
GDP	0.161	0.131	0.202
Unemployment	-0.144	-0.181	0.283
Service Sector Employment	0.173	0.292	0.192
Nominal Wages	0.006	0.204	0.099
Real Wages	0.040	0.150	0.262

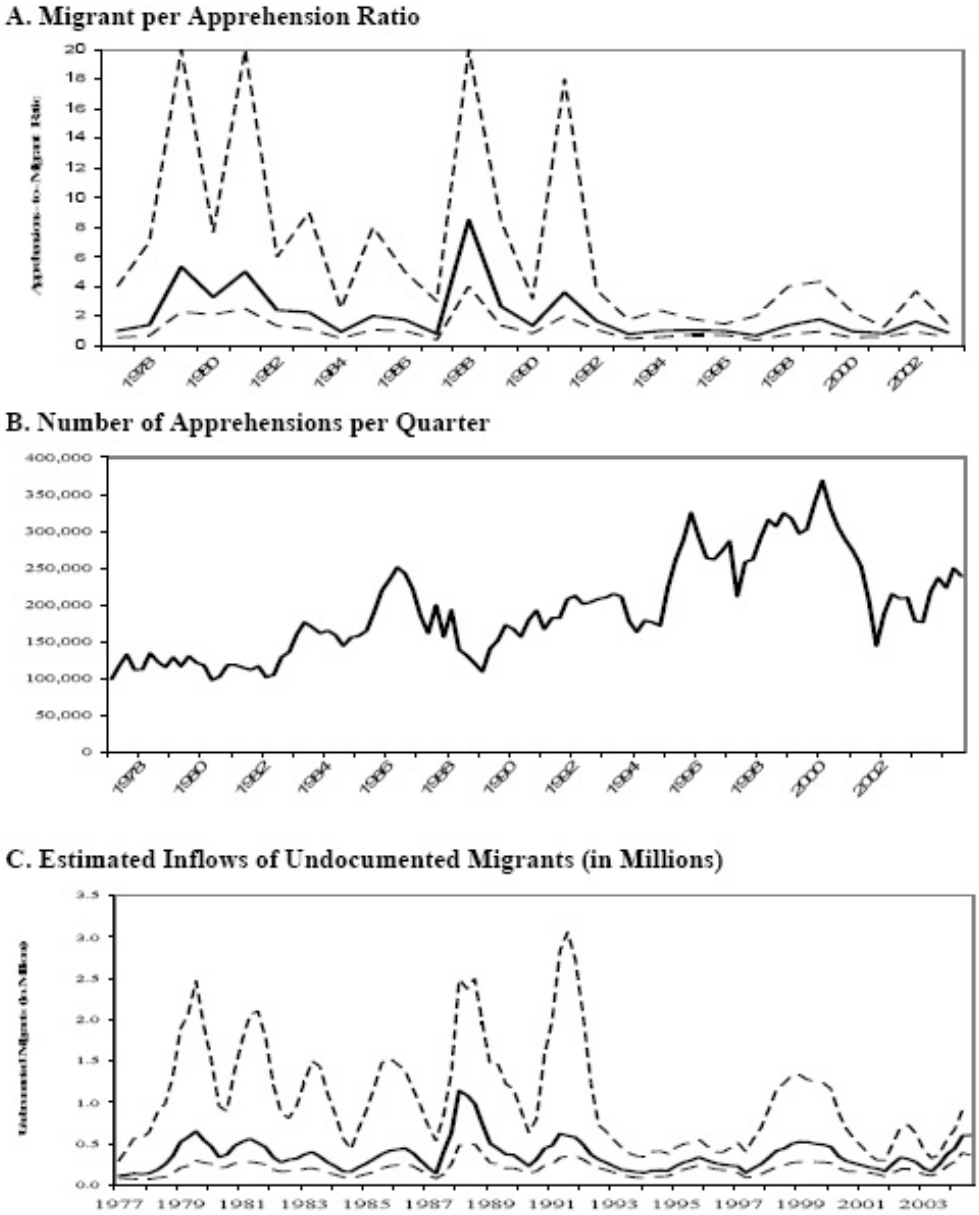
Note: MMFRP is the ratio observed in the Mexican Migration Field Research Program dataset. MMFRP-3 is a constructed ratio drawing from the distribution with replacement of migratory trips across the border from the previous year, the current year and the subsequent year to estimate the current year ratio.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

Figure 1: Apprehensions at the Southwest Border



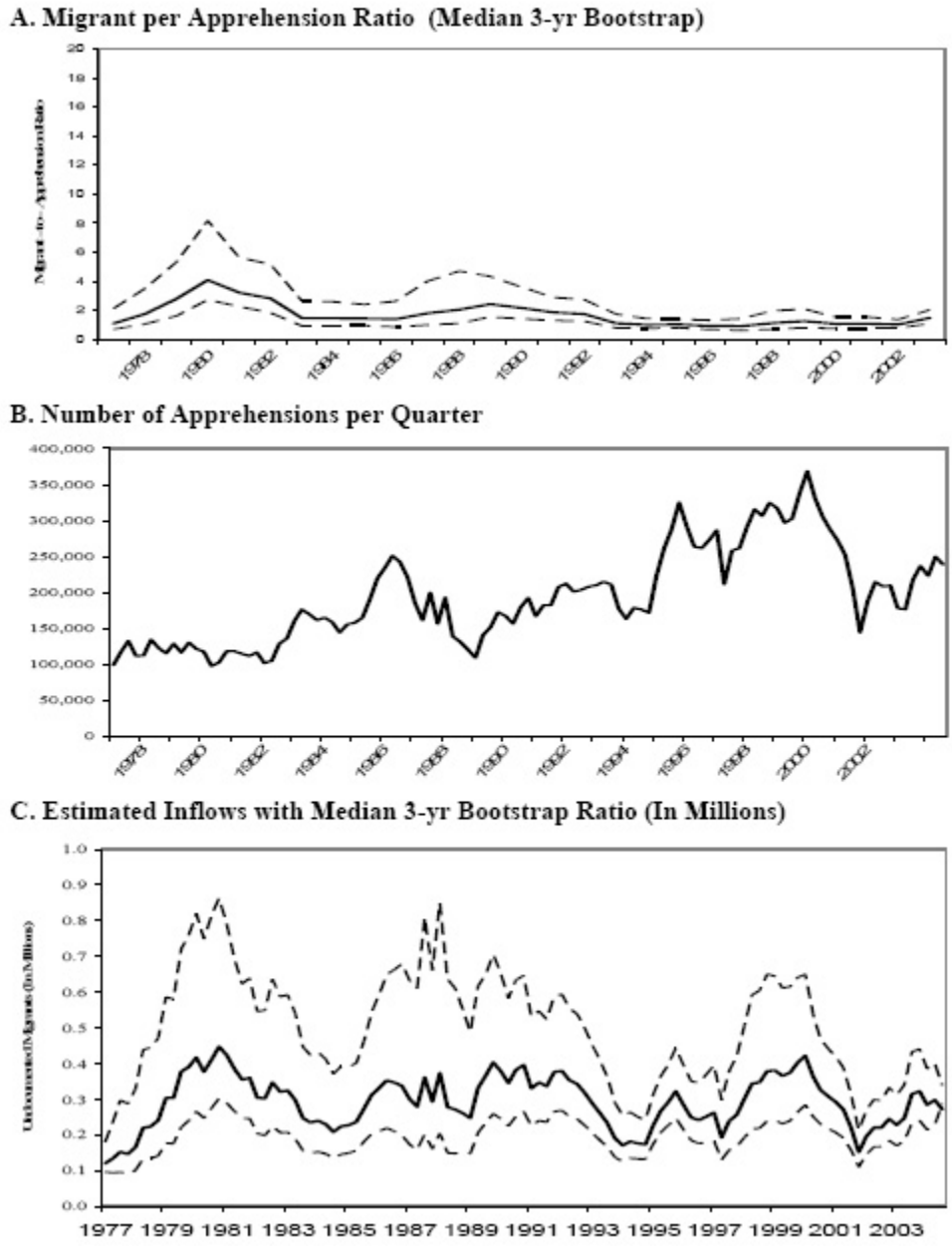
Note: Monthly apprehensions data from U.S. Customs and Border Protection, available at G. Hanson webpage, 1977:1-2004:9. Seasonal Adjustment uses X-12 ARIMA software from U.S. Census Bureau.

Figure 2: Construction of Undocumented Migrant Inflows from Observed MMFRP Ratio



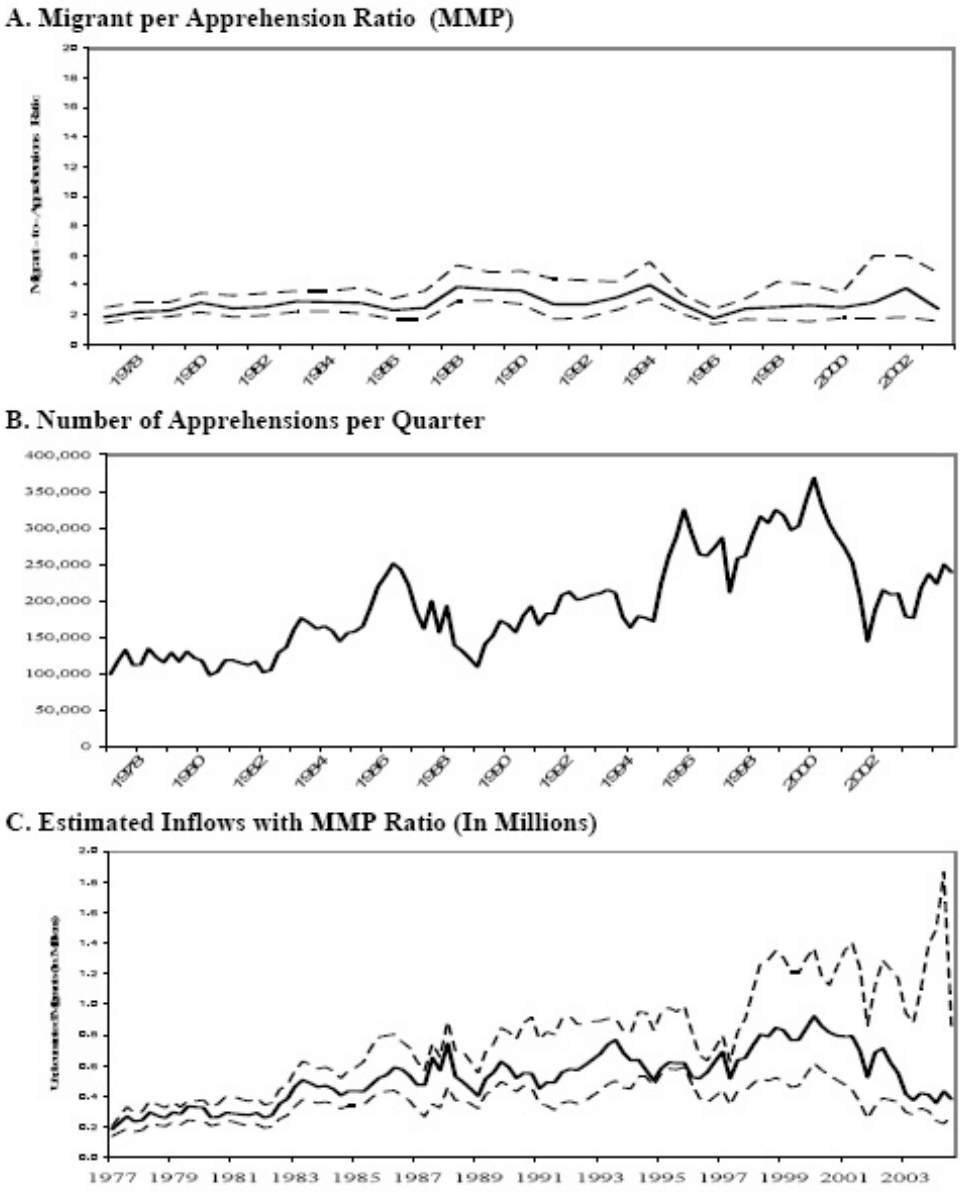
Note: Panel A: Migrant-to-Apprehension ratio observed in the MMFRP data set with the bootstrap-estimated upper and lower confidence bounds at the 5th and 95th percentiles. Estimates for the period 1977 to 2004 reported. **Panel B:** Quarterly apprehensions reported by the U.S. Customs and Border Protection, seasonally adjusted. **Panel C:** The quarterly estimates for the number of migrants combines ratio reported in Panel A and the observations from Panel B, 1977:I-2004:III. The confidence intervals are determined from the upper and lower confidence bounds of the migrant-to-apprehension ratio.

Figure 3: Construction of Undocumented Migrants Inflows with Median Bootstrap Ratio



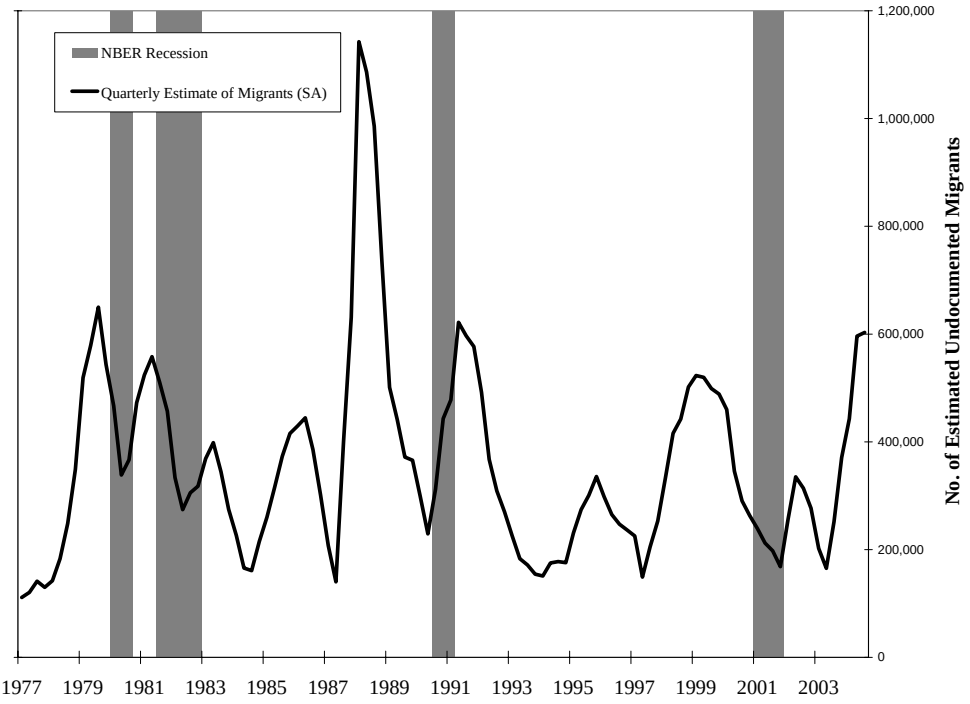
Note: Panel A: Migrant-to-Apprehension ratio estimated from MMFRP data set with the draws from the previous year, current year and subsequent year. Estimates for the period 1977 to 2004 reported. **Panel B:** Quarterly apprehensions reported by the U.S. Customs and Border Protection, seasonally adjusted. **Panel C:** The quarterly estimates for the number of migrants combines ratio reported in Panel A and the observations from Panel B, 1977:I-2004:III. The confidence intervals are determined from the upper and lower confidence bounds of the migrant-to-apprehension ratio.

Figure 4: Construction of Undocumented Migrants Inflows with MMP Ratio



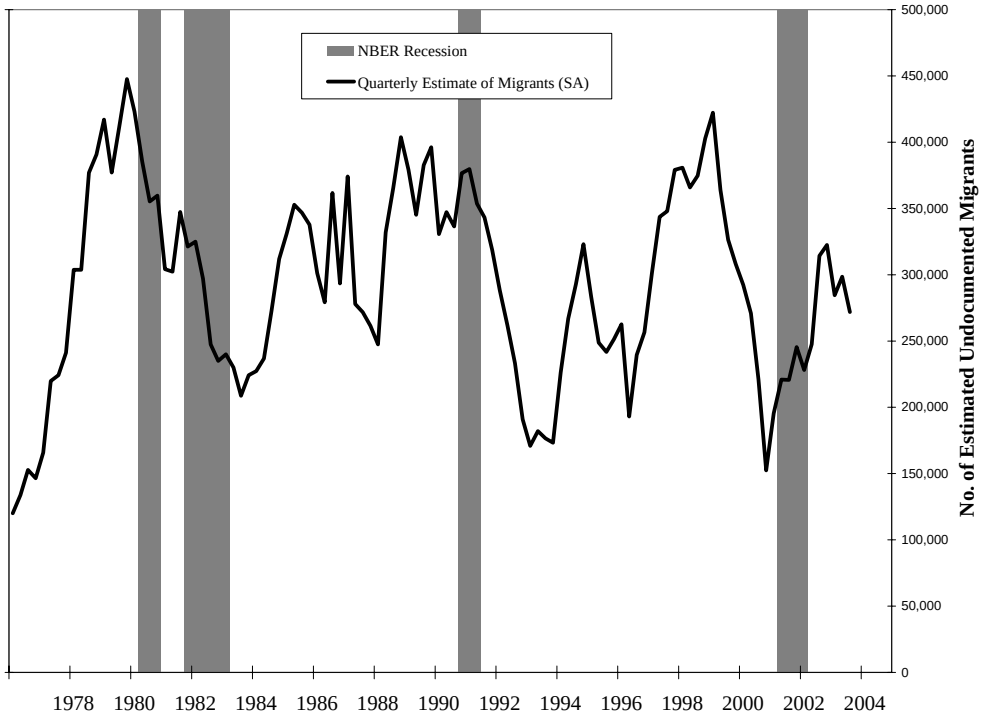
Note: Panel A: Migrant-to-Apprehension ratio observed in the MMP data set with the bootstrap-estimated upper and lower confidence bounds at the 5th and 95th percentiles. Estimates for the period 1977 to 2004 reported. **Panel B:** Quarterly apprehensions reported by the U.S. Customs and Border Protection, seasonally adjusted. **Panel C:** The quarterly estimates for the number of migrants combines ratio reported in Panel A and the observations from Panel B, 1977:I-2004:III. The confidence intervals are determined from the upper and lower confidence bounds of the migrant-to-apprehension ratio.

Figure 5: MMFRP Estimated Inflows of Undocumented Migrants to the United States



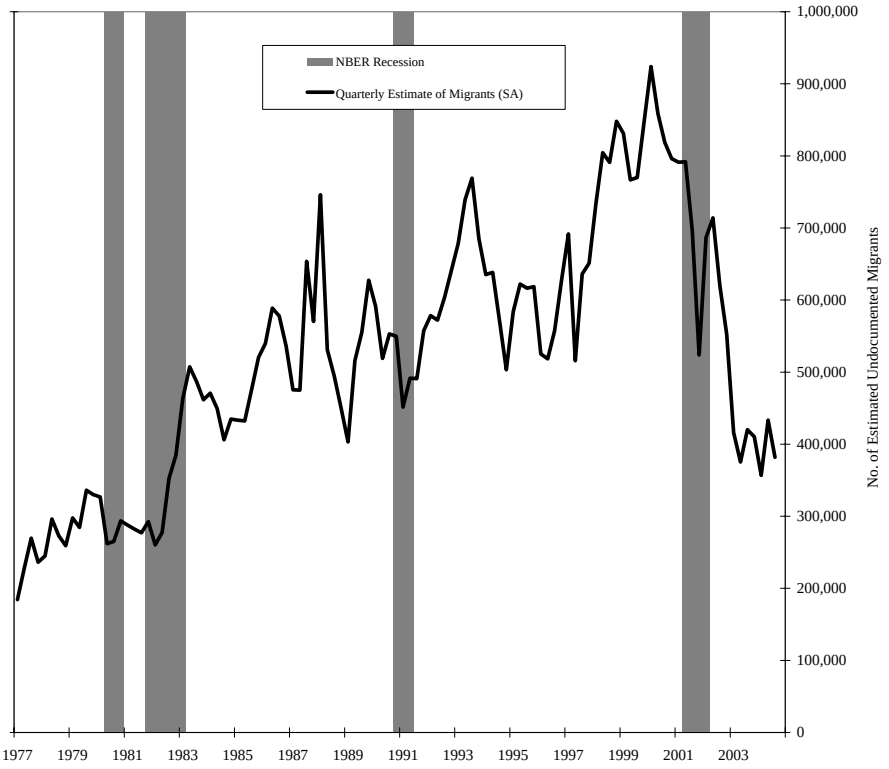
Note: Recession dates from NBER.

Figure 6: MMFRP 3-yr Estimated Inflows of Undocumented Migrants to the United States



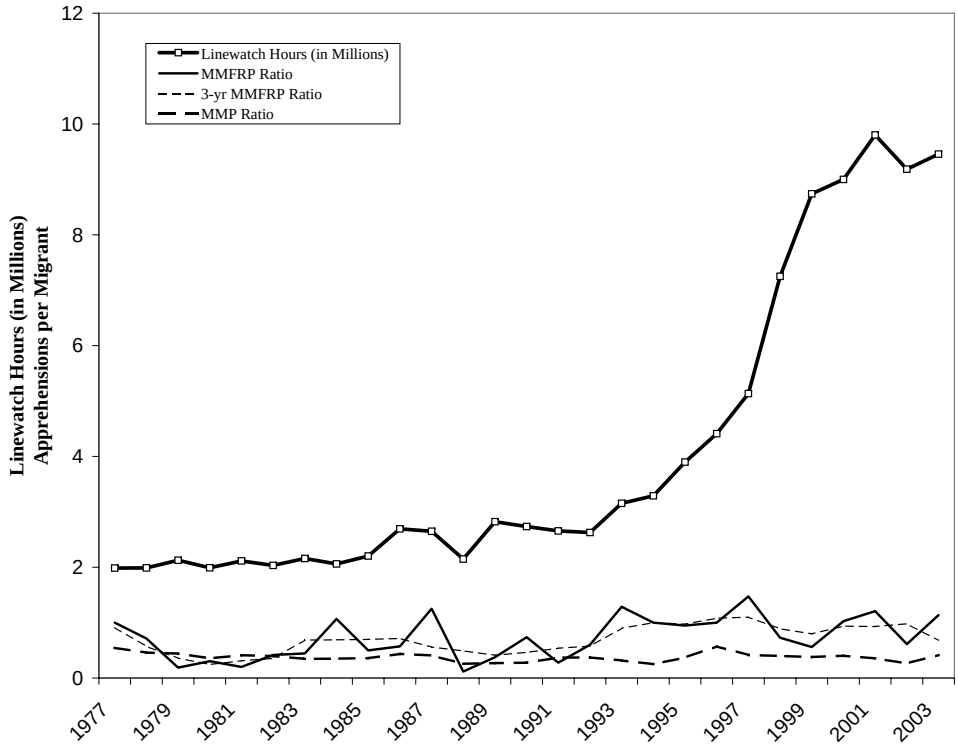
Note: Recession dates from NBER.

Figure 7: MMP Estimated Inflows of Undocumented Migrants to the United States



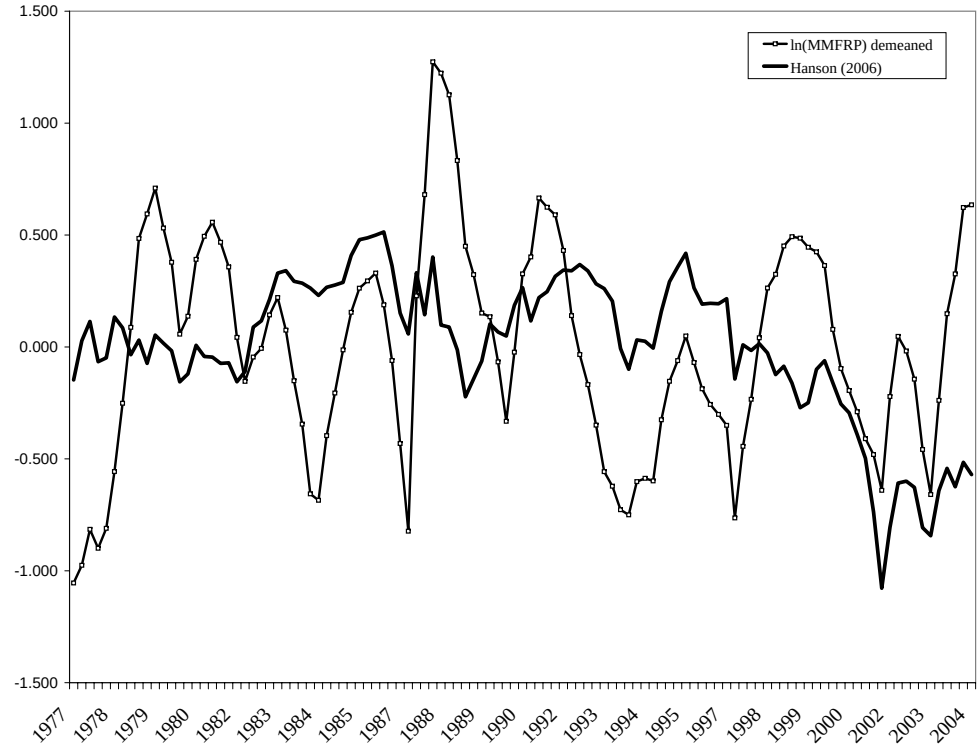
Note: Recession dates from NBER.

Figure 8: Border Enforcement Intensity and the Apprehension-Migrant Ratio



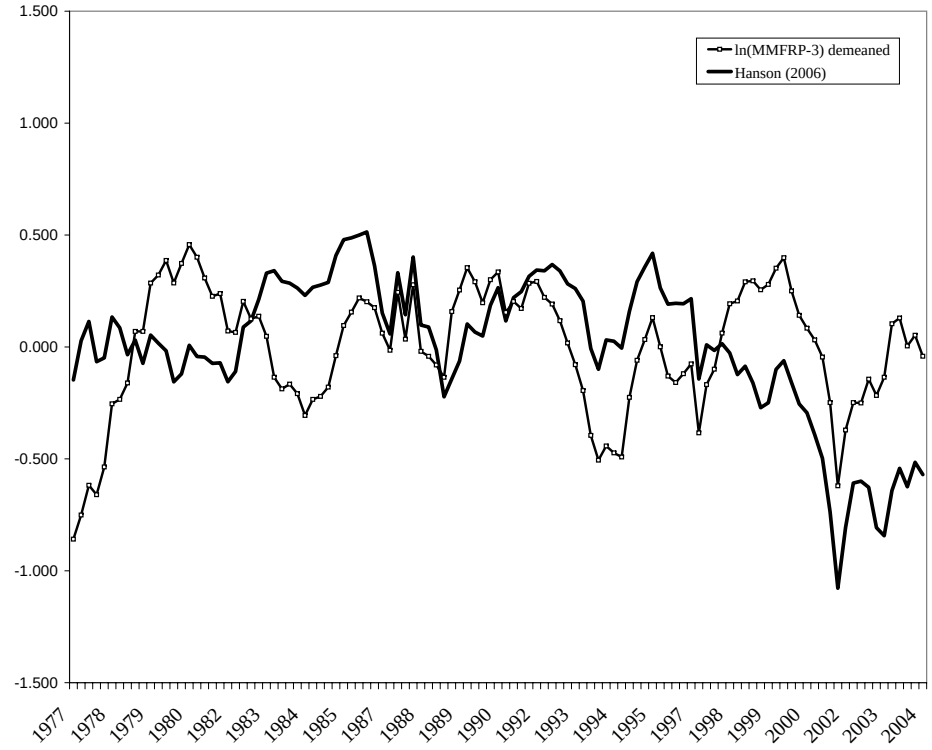
Note: Border Patrol intensity is characterized by linewatch hours – the number of hours per year that Border Patrol agents patrol the southwest border, reported by U.S. Customs and Border Protection. Ratios are calculated from the MMFRP and MMP datasets.

Figure 9: MMFRP and Indirect Estimates of Inflows



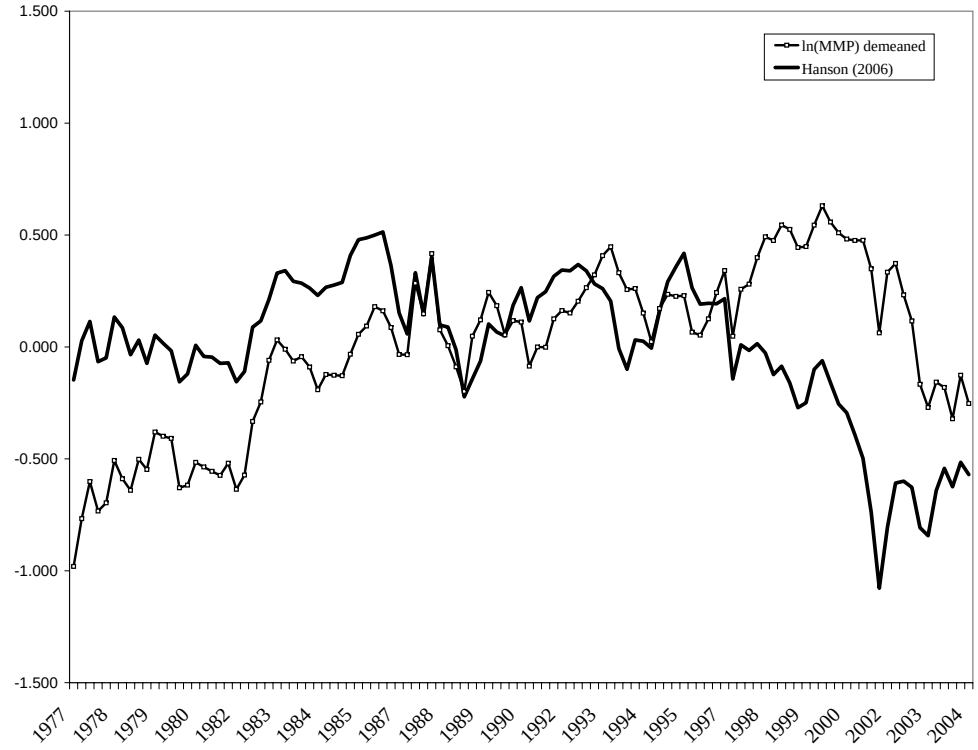
Note: The indirect estimate is the quarterly series of the inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). Seasonally adjusted apprehensions data is used. The MMFRP estimated inflow is transformed by taking the natural logarithm and demeaned to provide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

Figure 10: MMFRP-3 and Indirect Estimates of Inflows



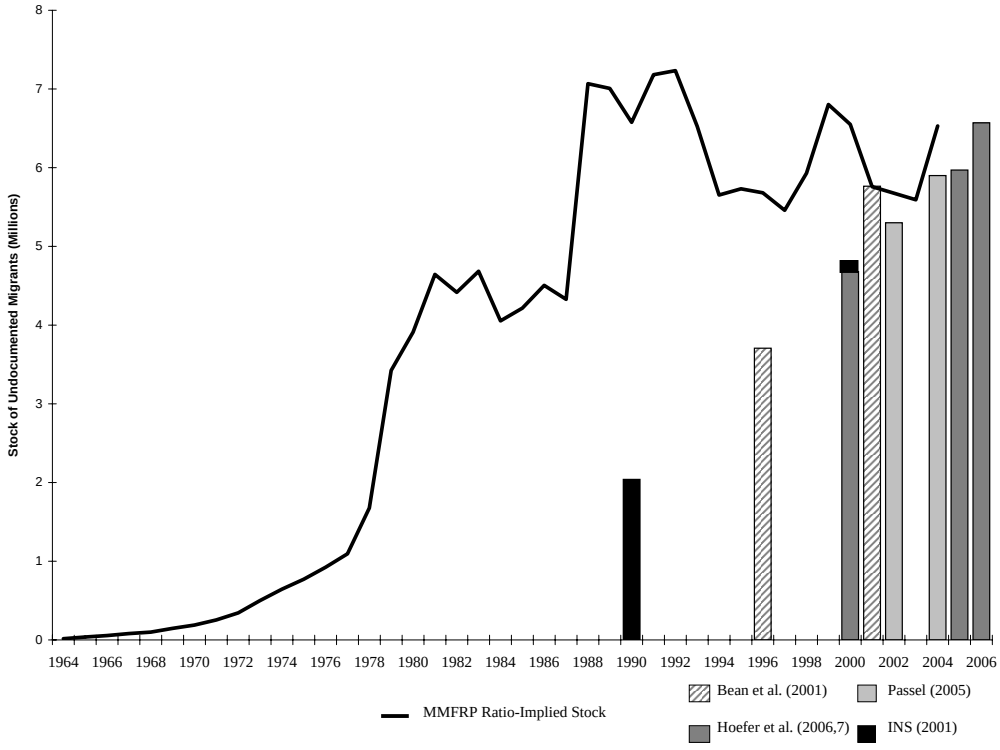
Note: The indirect estimate is the quarterly series of the inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). Seasonally adjusted apprehensions data is used. The MMFRP-3 estimated inflow is transformed by taking the natural logarithm and demeaned to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

Figure 11: MMP and Indirect Estimates of Inflows



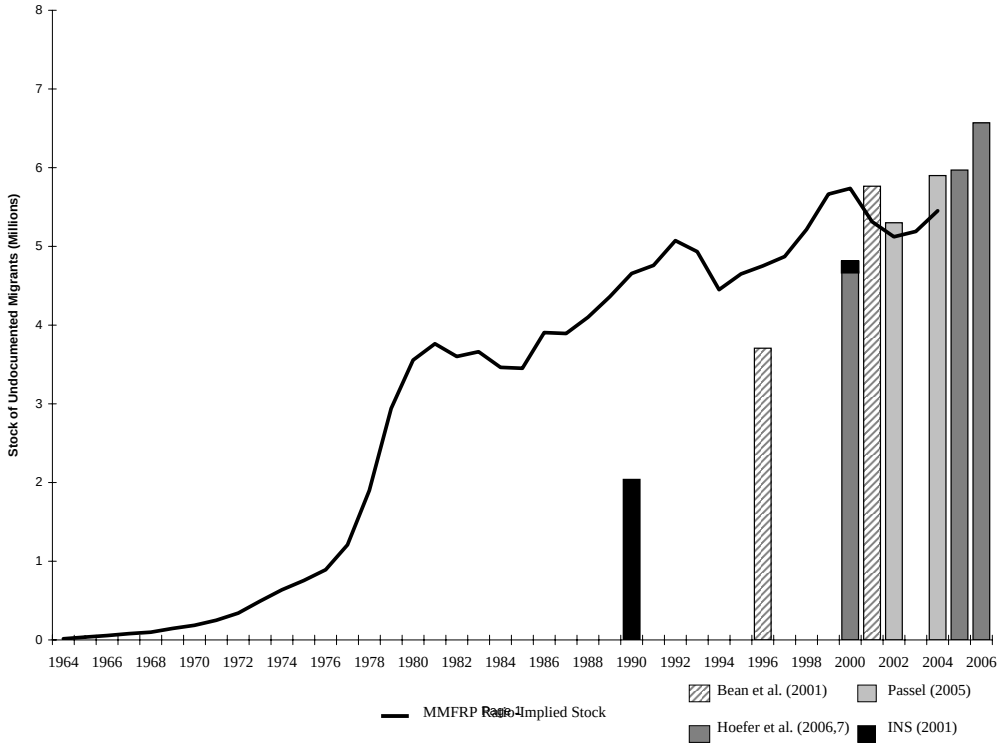
Note: The indirect estimate is the quarterly series of the inflow variation calculated in Hanson (2006) which is a reduced form of Hanson and Spilimbergo (1999). Seasonally adjusted apprehensions data is used. The MMP estimated inflow is transformed by taking the natural logarithm and demeaned to provide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

Figure 12: MMFRP Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



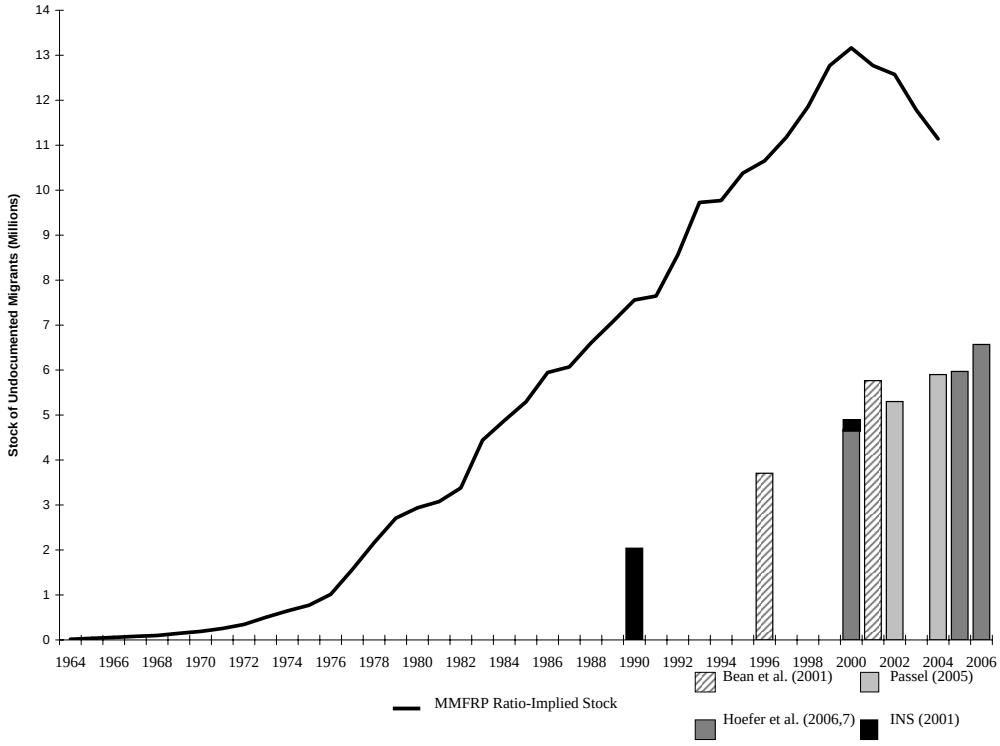
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year, estimated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

Figure 13: MMFRP 3-year Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



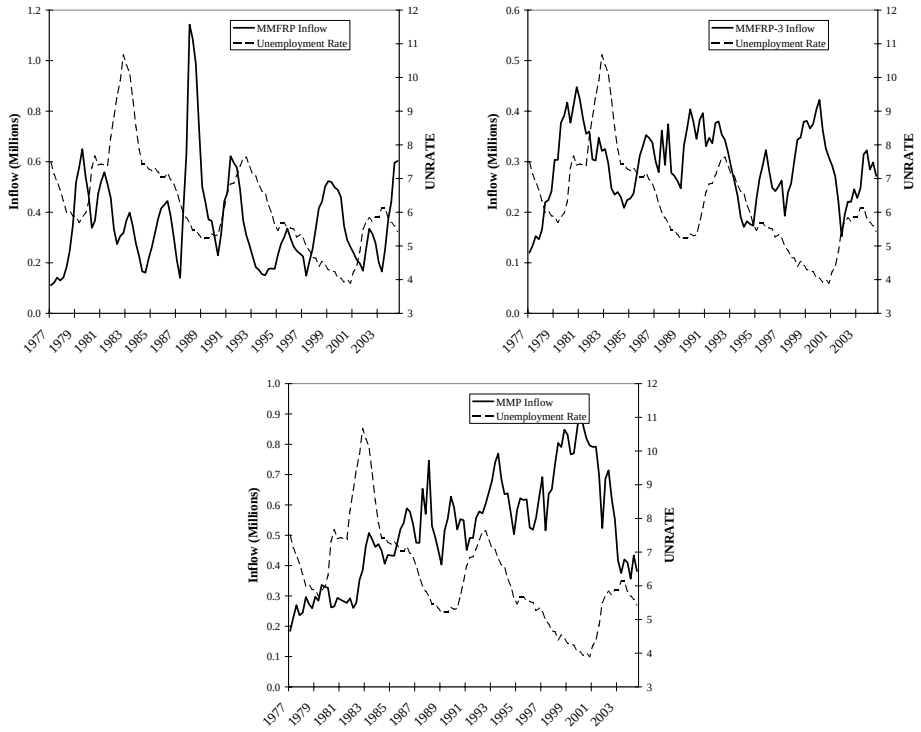
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year, estimated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

Figure 14: MMP Estimate of the Stock of Undocumented Migrants vs. Estimates in Literature



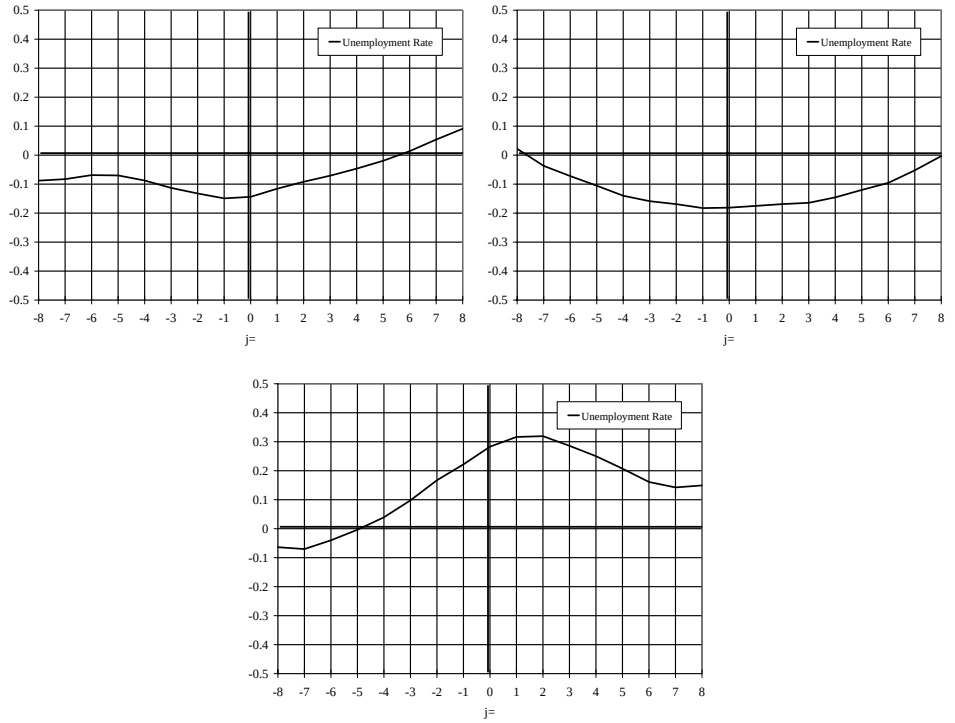
Note: The stock of undocumented migrants is calculated by using the inflow estimates and multiplying the current stock of migrants by the return probability estimated in the MMP dataset. The stock is reduced by the number of unauthorized migrants receiving permanent resident status in a given year, estimated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

Figure 15: Inflow Estimates and the Unemployment Rate



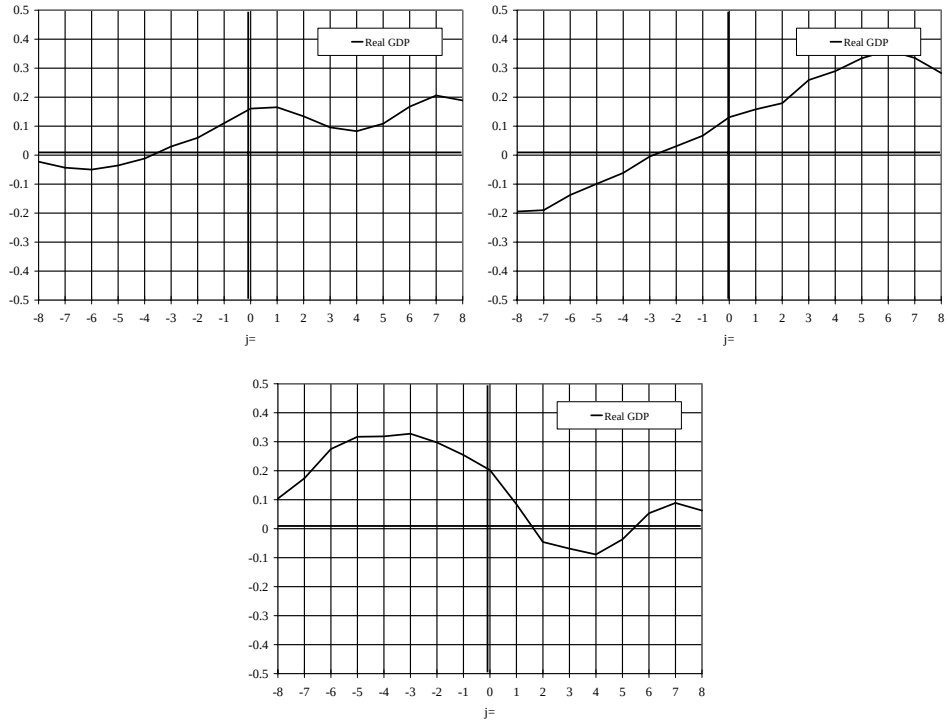
Note: All panels: Unemployment data (dashed line) from BLS, averaged over the quarter, 1977:I - 2004:III. **Top-Left panel:** MMFRP Quarterly Inflow of Undocumented Migrants in millions (solid line), Seasonally Adjusted. **Top-Right panel:** MMFRP-3 Quarterly Inflow of Undocumented Migrants in millions (solid line), Seasonally Adjusted. **Bottom panel:** MMP Quarterly Inflow of Undocumented Migrants in millions (solid line), Seasonally Adjusted.

Figure 16: Cross-Correlations between Migrant Inflows and the Unemployment Rate



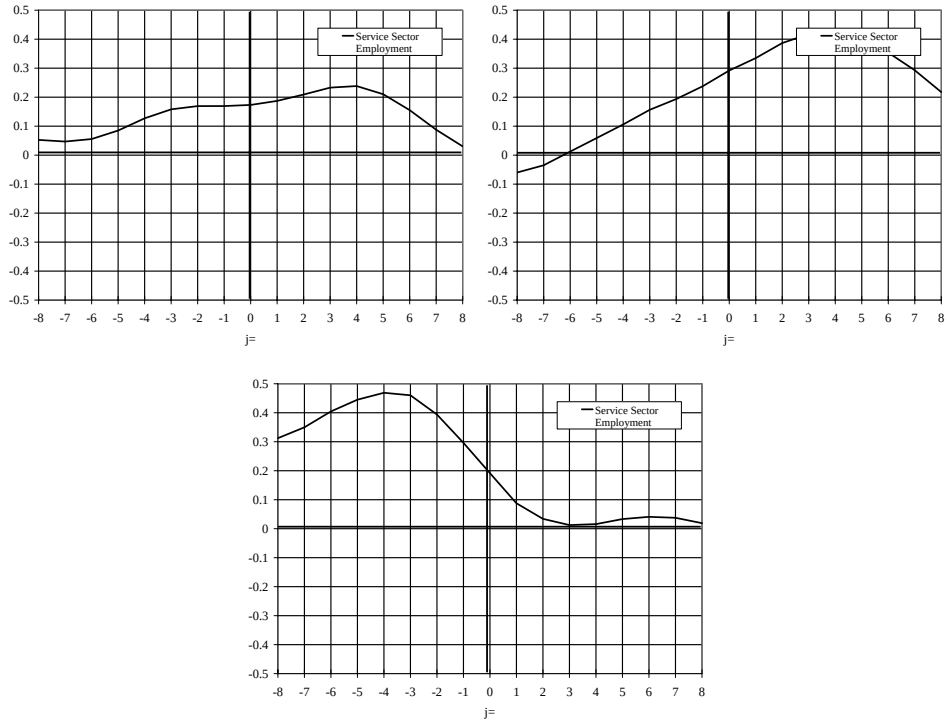
Note: All panels: Cross-correlations between the year-over-year change in the inflow of undocumented migrants at date t and the unemployment rate at date t+j. Unemployment data from BLS, averaged over the quarter, 1977:I - 2004:III. **Top-Left panel:** MMFRP-estimated inflow of undocumented migrants. **Top-Right panel:** 'MMFRP-3'-estimated inflow of undocumented migrants. **Bottom panel:** MMP-estimated inflow of undocumented migrants.

Figure 17: Cross-Correlations between Migrant Inflows and Real GDP



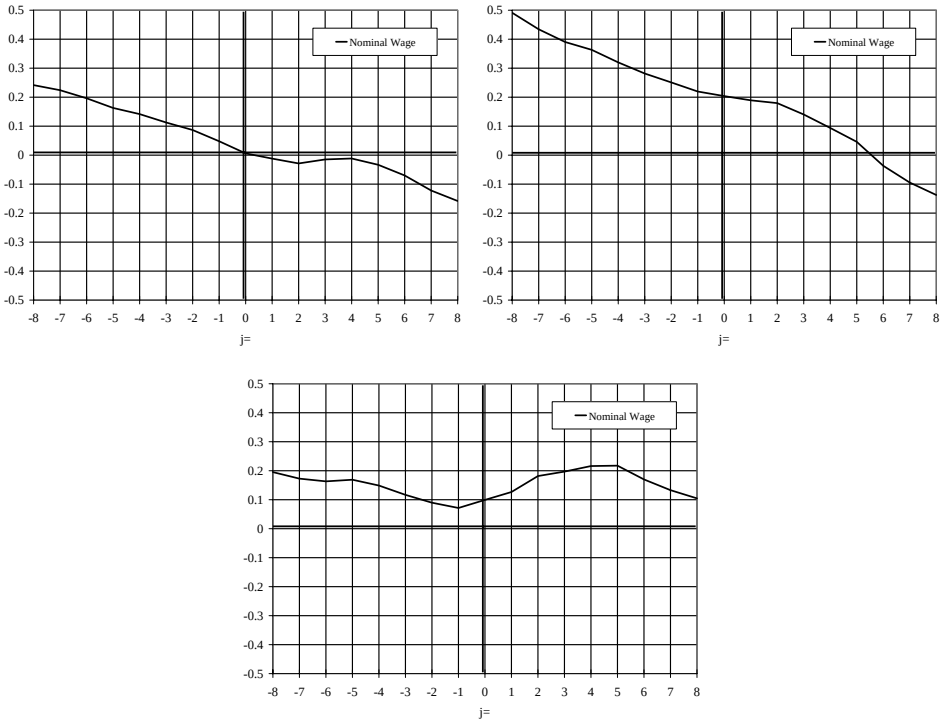
Note: All panels: Cross-correlations between the year-over-year change in the inflow of undocumented migrants at date t and the year-over-year change in Real GDP at date t+j. Real GDP data from BEA, 1977:I - 2004:III. **Top-Left panel:** MMFRP-estimated inflow of undocumented migrants. **Top-Right panel:** 'MMFRP-3'-estimated inflow of undocumented migrants. **Bottom panel:** MMP-estimated inflow of undocumented migrants.

Figure 18: Cross-Correlations between Migrant Inflows and Service Sector Employment



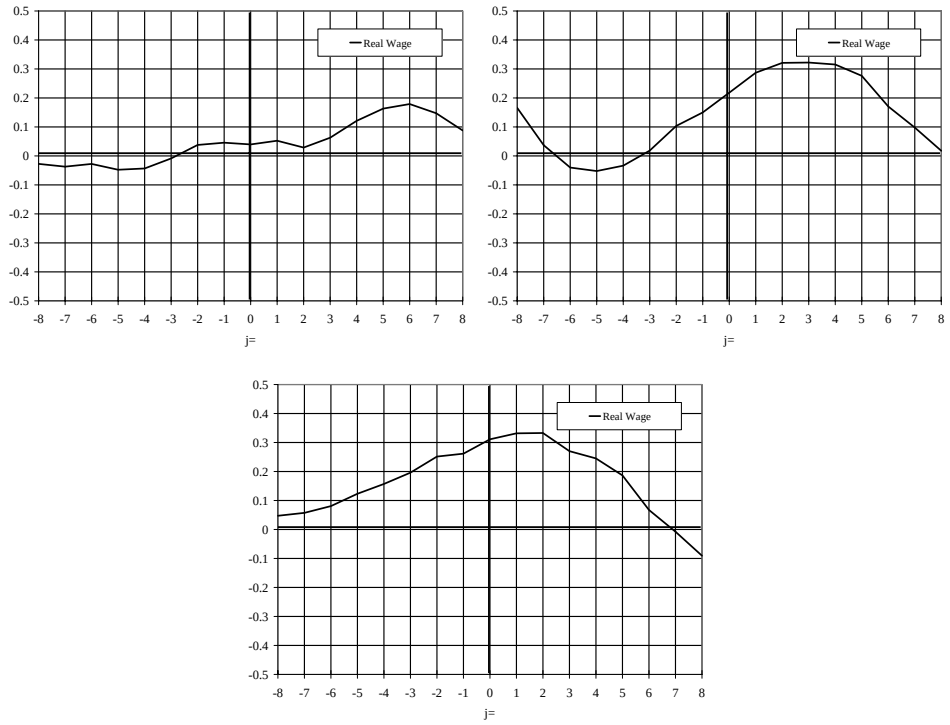
Note: All panels: Cross-correlations between the year-over-year change in the inflow of undocumented migrants at date t and the year-over-year change in service sector employment rate at date t+j. Service sector employment data from BLS, averaged over the quarter, 1977:I - 2004:III. **Top-Left panel:** MMFRP-estimated inflow of undocumented migrants. **Top-Right panel:** 'MMFRP-3'-estimated inflow of undocumented migrants. **Bottom panel:** MMP-estimated inflow of undocumented migrants.

Figure 19: Cross-Correlations between Migrant Inflows and Nominal Wages



Note: All panels: Cross-correlations between the year-over-year change in the inflow of undocumented migrants at date t and the year-over-year change in nominal wages in the construction industry at date t+j. Nominal wages in the construction industry from BLS, averaged over the quarter, 1977:I - 2004:III. **Top-Left panel:** MMFRP-estimated inflow of undocumented migrants. **Top-Right panel:** 'MMFRP-3'-estimated inflow of undocumented migrants. **Bottom panel:** MMP-estimated inflow of undocumented migrants.

Figure 20: Cross-Correlations between Migrant Inflows and Real Wages



Note: All panels: Cross-correlations between the year-over-year change in the inflow of undocumented migrants at date t and the year-over-year change in real wages in the construction industry at date t+j. Real wages in the construction industry used the Consumer Price Index (CPI) to construct the monthly wage in real terms and then averaged over the quarter. The monthly CPI data from BLS, 1977:1 - 2004:9. **Top-Left panel:** MMFRP-estimated inflow of undocumented migrants. **Top-Right panel:** 'MMFRP-3'-estimated inflow of undocumented migrants. **Bottom panel:** MMP-estimated inflow of undocumented migrants.