Illegal Immigration, Border Enforcement, and Relative Wages: Evidence from Apprehensions at the U.S.-Mexico Border

Gordon H. Hanson

Department of Economics
University of Texas and
National Bureau of Economic Research

Antonio Spilimbergo

Office of the Chief Economist
Inter-American Development Bank

1996

Working Paper Series 328
Washington, D.C.

We thank Steve Bronars, Ricardo Caballero, Karnit Flug, Dan Hamermesh, Ricardo Hausmann, Eduardo Lora, Gerald Oettinger, Ernesto Stein, Kei-Mu Yi, and seminar participants at the NBER, the Inter-American Development Bank, Rice University, the University of Texas, Texas A&M University, and Tulane University for helpful comments. The views expressed in this paper are not necessarily shared by the Inter-American Development Bank.

Illegal Immigration, Border Enforcement, and Relative Wages:

Evidence from Apprehensions at the U.S.-Mexico Border

Gordon H. Hanson and Antonio Spilimbergo

In this paper, we examine the determinants of illegal immigration in the United States from Mexico over the period 1976-1995. The main challenge we face in our empirical work is that we do not observe the number of individuals that attempt to enter the United States illegally; we observe, instead, the number of individuals apprehended attempting to cross U.S.-Mexico border as a function of the number of illegal attempts to cross the border and the level of border-enforcement effort exerted by the U.S. government. We estimate a reduced-form version of the apprehensions function using monthly data from the U.S. Immigration and Naturalization Service on total apprehensions at the U.S.-Mexico border and the number of person hours the U.S. Border Patrol spends policing the border, and data on current and expected wages in the United States and Mexico. We find that a 10% decrease in the Mexican real wage leads to a 7.5% to 8.8% increase in apprehensions at the border. Under plausible conditions this is a lower bound for the effect of the Mexican wage on attempted illegal immigration. It is the purchasing power of U.S. wages in Mexico, more than the purchasing power of U.S. wages in the United States, that matters for border apprehensions, suggesting that prospective migrants expect to remit a portion of their earnings or eventually return to Mexico. There is strong evidence that economic volatility in Mexico contributes to illegal immigration. Border apprehensions are higher in the month following a large devaluation of the peso and higher when the change in the Mexican real wage is negative. Finally, we find that each additional hour the U.S. Border Patrol spends policing the border yields and additional 0.25 to 0.33 apprehensions.

Immigration is once again a major political issue in the United States. What makes the current debate distinct from past debates is a focus on illegal migrants. There is a popular perception that immigration cannot be controlled unless the United States secures its borders against illegal entry. This emphasis is increasingly apparent in policy. The Immigration Reform and Control Act (IRCA) of 1986 raised sanctions on U.S. employers that hire illegal aliens, and since the late 1980s the U.S. government has doubled the personnel it assigns to enforce the U.S.-Mexico border. A major source of concern about illegal immigration is economic instability in Mexico. The persistence of relatively high real wages in the United States creates pressure for immigration, both legal and illegal, from Mexico. The continuing volatility of the peso reinforces these pressures by contributing to periodic steep declines in Mexican wages.

In this paper, we examine illegal immigration in the United States from Mexico. We address two general questions. The first is, how responsive is illegal immigration to changes in U.S.-Mexico relative wages? While long-run U.S.-Mexico wage differences create obvious pressures for immigration from Mexico, short-run movements in relative wages may also contribute to immigration by encouraging Mexican residents to ride out Mexican economic downturns in the United States. The second question is, what effect does border enforcement have on illegal immigration? Current U.S. policy is predicated on the idea that border enforcement reduces attempts at illegal entry, in part by demonstrating that the cost of crossing the border is too high to be worthwhile. We do not know in practice whether such a deterrent effect exists or how costly border enforcement is as a means to control illegal entry.

The main challenge that we face in our empirical work is that we do not observe the number of individuals who attempt to enter the United States illegally. Instead, we observe the number of individuals the U.S. government apprehends attempting to enter the United States illegally and the resources the U.S. government devotes to enforcing national borders. Our approach is to examine illegal immigration indirectly by identifying the factors that determine apprehensions at the U.S.-Mexico border. We develop a simple model of the individual migration decision, in which the possibility of capture by foreign border guards is one component of the cost of migrating abroad. From the model, we derive an aggregate expression for the number of individuals who attempt to cross the border as a function of expected wages in the source and destination country, the expected probabilities of capture by border guards today and in the future, and expenses incurred in crossing the border. We then posit the existence of an *apprehensions function*, which expresses the number of apprehensions at the destination-country border as a function of the number of attempts to cross the border and the level of border enforcement effort exerted by the destination-country government.

We estimate the apprehensions function using monthly data from the U.S. Immigration and Naturalization Service (INS) on total apprehensions at U.S.-Mexico borders and the number of person hours the U.S. Border Patrol spends policing the border, and data on current and expected U.S. and Mexican wages. The empirical results provide evidence on how relative wages and border enforcement affect illegal attempts to enter the United States. We show that under plausible set of assumptions the effect of the U.S.-Mexico relative wage on apprehensions is a *lower bound* of the effect of the relative wage on attempts to cross the border. If the elasticity of apprehensions with respect to the U.S.-Mexico relative wage is large, then it is likely that the corresponding elasticity for attempts at illegal entry is also large. Similarly, by estimating the effect of border enforcement on apprehensions we can determine the marginal cost of border enforcement as a policy to impede illegal immigration.

Most literature on immigration addresses the general questions of how immigrants perform in the host economy and what impact immigration has on the host economy's labor market.[1] The literature on illegal immigration is comparatively small. Either (1985, 1986) develops a theory of legal and illegal immigration, in which a small country chooses how intensively to enforce its borders given an exogenous immigrant supply function. A few papers use the same INS data we use, although for an earlier time period and to address a

[1] See Borjas (1994) for an excellent survey of the recent literature.

different set of issues.[2] Borjas, Freeman, and Lang (1991), using annual INS data, find that apprehensions by the U.S. Border Patrol are positively correlated with U.S. expenditure on border enforcement and the current U.S. real wage. Their interest, however, is primarily in determining the size and growth of the illegal Mexican-born population in the United States. Bean et al. (1990) and Espenshade (1990), using monthly INS data, find that apprehensions declined following the implementation of IRCA. There is no study that uses a dynamic specification of illegal immigration or that considers the impact of expected future enforcement and expected future relative wages on apprehensions. Our contribution is to use an explicit theoretical model to derive an apprehensions function and to use the estimated apprehensions function as a basis for examining the effect of relative wages and enforcement on illegal attempts to enter the United States.

The results of this paper have important implications for U.S. immigration policy and for U.S. policy towards Mexico. Both the $40 billion loan package the U.S. government organized for Mexico in 1995 and the North American Free Trade Agreement were justified along the lines that they would reduce the flow of illegal aliens into the United States. To assess this argument we need to know how responsive illegal immigration is to U.S.-Mexico relative wages. The INS devotes a considerable proportion of its enforcement resources to policing U.S.-Mexico border. An alternative policy for reducing illegal immigration would be to more closely monitor employers that tend to hire illegal aliens. To assess the relative effectiveness of these policies, we need to know how responsive illegal immigration is to different types of enforcement and the costs of different enforcement strategies.

The paper is organized as follows. In section I we present a model of illegal immigration. In section II we describe the data and discuss recent trends in border apprehensions, border enforcement, and U.S.-Mexico relative wages. In section III we present empirical results on the estimation of the apprehensions function. And in section IV we offer concluding remarks.

---

[2] There is also case study literature on illegal Mexican immigration. See Cornelius (1992) and the survey in Duran and Massey (1992).

I. A Model of Illegal Immigration

Economists, beginning with Sjaastad (1962), view migration as an investment decision.[3] An individual chooses to migrate when the expected discounted difference in the stream of income between the new and old location are sufficient to cover moving costs. Once the decision to migrate is taken, the prospective migrant moves with determination? In the context of illegal immigration, individuals must circumvent destination-country authorities to successfully move abroad. We extend the standard model of the migration decision to the case of illegal immigration, in which we highlight the role of international border enforcement.[4]

We analyze the migration decision of an individual agent in a discrete-time, infinite-horizon setting, where D is the one-period discount rate. At the beginning of each period, a prospective migrant decides whether to stay at home or to try to migrate abroad. The individual faces probability P_t of being apprehended by destination-country authorities and returned to his home country. For purposes of illustration, let Mexico be the home country and the United States be the destination country. If the individual stays in Mexico, he earns the expected Mexican wage at time t, w_{mt}; in the following period, he again has the option of staying in Mexico or trying to migrate to the United States. Define V_{mt} as the expected present discounted value of being in Mexico at time t, which includes the option value of migrating in the future.

If the individual attempts to migrate to the United States, we assume that he incurs fixed cost C_t and forgoes the opportunity to earn a wage for the current period. If the individual is apprehended by U.S. authorities and deported to Mexico, he has the option of trying to migrate again in the next period, in which case his expected value of being in Mexico is V_{mt+1}. If, on the other hand, the individual crosses the U.S.-Mexico border successfully, he receives the U.S. wage, w_{ut},. We postulate that $w_{ut} > w_{mt}$ for all t, such that an individual who

[3] See Greenwood (1985) and Stark (1991) for a discussion of migration models.

[4] There is also the possibility of legal migration. In the United States legal migration is a protracted process. There is nothing that precludes a Mexican resident who has applied for legal resident status in the United States from migrating illegally while he awaits the decision of the INS (since there is no documentation on individuals who are apprehended at the border). For simplicity, we ignore legal migration.

is in the United States prefers to stay there forever; the option value of returning to Mexico is zero, and V_{ut}, the expected present discounted value of being in the United States at time t, equals the present discounted value of U.S. wages. We assume further that the individual does not know P_t with certainty, and instead bases his decision on the expected probability of capture, P^e_t.

Formally, the individual migration decision is described by the following rule:

$$w_{mt} + \frac{1}{1+D}V_{mt+1} < \frac{1}{1+D}\left(P^e_t \cdot V_{mt+1} + \frac{1}{1+D}\cdot(1 - P^e_t)\cdot V_{ut+1} - C_t \right. \qquad (1.1)$$

which can be written as

$$w_{mt} + C_t < \frac{1 - P^e_t}{1 + D}\cdot(V_{ut+1} - V_{mt+1}) \qquad (1.2)$$

The inequality in (1.2) has a straightforward interpretation: the individual will attempt to migrate to the United States if the difference between the value of being in the U.S. next period minus the value of being in Mexico next period, discounted by D and the probability of avoiding apprehension, is large enough to compensate for the foregone wage and cost C_t. The prospective migrant takes into account the option value of delaying migration, which will be positive if he expects the probability of being apprehended to be lower in the future.[5]

It is useful to write the migration decision rule in terms of an indicator function:

$$I_{it} \equiv \begin{cases} 1 \ (move) \ if \ \ w_{mt}+C_{it} < \dfrac{1-P^e_t}{1+D}\cdot(V_{ut+1}-V_{mt+1}) \\ 0 \ (not \ \ move) \ o/w \end{cases} \qquad (1.3)$$

$$= I_i(w_{mt}, P^e_t, V_{ut+1}, V_{mt+1}, G_{it}) \qquad (1.4)$$

---

[5] The decision rule in (1.1) is valid if individuals are risk neutral. It can be defined in terms of a Bellman equation that is a variation of the optimal stopping problem (Dixit and Pindyck 1994), in which stopping means trying to migrate abroad:

$$V_{mt} = \frac{1}{1+D}V_{mt+1} + \max\left\{w_{mt}, \ \frac{1-P^e_t}{1+D}(V_{ut+1} - V_{mt+1}) - C_t\right\}$$

where I indexes the individual and G_{it} is a vector of individual attributes, such as age and family status, that determine the migration cost, C_{it}.[6]. In (1.4) we make the simplifying assumption that all migrants have the same actual and expected probability of apprehension.

Adding together all individual indicator functions, we obtain an aggregate expression for M_t, the number of Mexican residents that attempt to migrate to the United States illegally at time t:

$$M_t = \sum_i^{N_t} I_i(w_{mt}, P^e_t, V_{ut+1}, V_{mt+1}, G_{it}) \qquad (1.5)$$

where N_t is the pool of prospective migrants. Equation (1.5) expresses the number of individuals who attempts to cross the U.S.-Mexico border as a function of current and expected U.S. and Mexican wages and the expected probabilities of being apprehended by U.S. authorities today and in the future. Holding economic conditions in the United States and Mexico constant, two factors create a flow of individuals attempting to cross the border over time: increases in N_t, the pool of prospective migrants, and changes in G_{it}, the individual's attributes.

Since P_t is the true probability of being apprehended at time t, it follows by definition that:

$$A_t \equiv P_t(M(w_{mt}, P^e_t, V_{ut+1}, V_{mt+1}, N_t, '_t) \qquad (1.6)$$

where A_t is the number of individuals apprehended attempting to cross the U.S.-Mexico border illegally at time t and $'_t$ is the distribution of individual attributes, from which G_{it} is drawn. Equation (1.6), which we term the *apprehensions function*, is the basis for our empirical work. A_t is increasing in the *actual* probability of apprehension, since a higher P_t implies that more individuals that attempt to cross the border are apprehended,

[6] Individual attributes may also affect wage offers. While heterogeneity likely influences the migration decision, the fact that we have aggregate data on apprehensions makes it difficult to address this issue.

but decreasing in the *expected* probability of apprehension, since a higher P^e_t deters individuals from attempting to cross the border. We do not observe P_t directly, but we do observe H_t, the level of effort U.S. authorities expend enforcing the U.S.-Mexico border. We assume that P_t (and by implication P^e_t) is an increasing function of H_t. It is also likely that P_t is a nonincreasing function of M_t: as more individuals attempt to cross the border, the likelihood that any single individual is apprehended decreases. Replacing P_t with the function $P(H_t,M_t)$ we obtain,

$$A_t = P(H_t, M_t) \cdot M(w_{mt}, P^e_t, V_{ut+1}, V_{mt+1}, N_t, \varepsilon_t) \qquad (1.7)$$

From (1.7), we assume that we can obtain the following reduced-form expression for A_t,

$$A_t = F(w_{mt}, w_{ut}, H_t, \Omega_t) \qquad (1.8)$$

where Ω_t represents the information set available at time *t* that individuals use to generate predictions for future values of w_{mt}, w_{ut}, H_t, and other factors that influence the actual and expected probability of apprehension and current and expected future wages.

II. Data

The apprehensions and enforcement data we use to estimate the apprehensions function in equation (1.8) are from unpublished INS records, which show for each month the number of individuals that the U.S. Border Patrol (which the INS oversees) apprehends attempting to cross U.S.-Mexico border. The data span the period December 1976 to August 1995. INS also maintains records on apprehensions and enforcement hours in the interior United States. To isolate the timing of factors that contribute to illegal immigration, we focus on apprehensions and enforcement at the border.[7]

Consistent with previous evidence, apprehensions show a strong seasonal pattern (Borjas, Freeman, and Lang, 1991). Figures 1a and 1b show monthly means for apprehensions and enforcement hours over the sample period. Apprehensions are relatively stable from January through August, of each year, and then decline steadily from September to December. One factor that contributes to seasonality in apprehensions is that many individuals who attempt to cross the border are itinerant agricultural laborers. The peak months for U.S. agricultural employment are May through August. Many Mexican farm laborers who work in U.S. agriculture during the spring, Summer, and early fall return to Mexico for the winter harvest, during which time demand for agricultural labor is relatively high in Mexico (Morrison and Zabin, 1993). Hence, attempts to cross the border are concentrated during the first eight months of the year. Border enforcement hours, in contrast, show no seasonal pattern.

Since we are primarily interested in illegal immigration by nonagricultural workers, we correct for seasonality in apprehensions by using monthly dummies as independent variables in the regression analysis.[8] There are no available data which allow us to assess agricultural labor demand in the United States or Mexico. The temporal pattern of agricultural employment in the two countries suggests that there would continue to be a flow of agricultural laborers across the border even if U.S. and Mexican wages were equalized. Given that itinerant agricultural workers are likely to be relatively insensitive to short-run (month-to-month) changes in economic conditions, we lose little in controlling for the seasonal component in apprehensions.

Figures 2a and 2b show enforcement hours and (seasonally adjusted) apprehension over the sample

---

[7] In 1994, apprehensions at the U.S.-Mexico border accounted for 66.0% of total apprehensions by the INS. The problem with studying apprehensions in the interior United States is that it is difficult to determine when the individual caught first entered the country.

[8] Using dummy variables to control for seasonality imposes the assumption that the seasonal component in apprehensions is the sum of a deterministic component and an i.i.d random variable. No other variable in our data shows a seasonal pattern, and the regressions we report show no evidence of serially correlated errors. Hence, there is little motivation for allowing the systematic seasonal component in apprehensions to be stochastic.

period. There are large increases in apprehensions in 1983, 1987, and 1995 -- all years that correspond to a devaluation of the peso and a recession in Mexico. Enforcement hours are relatively constant until 1986, when they begin to rise somewhat erratically. Recent changes in U.S. immigration policy have greatly expanded the enforcement budget of the INS. IRCA mandated an increase in border enforcement, and the Bush and Clinton administrations have further increased expenditure on enforcement.[9]

Current and expected U.S. and Mexican wages are additional variables that enter the apprehensions function in equation (1.8). The wage and price data we use for Mexico are from the IMF *International Financial Statistics* (IFS). IFS is the only source of monthly wage data on Mexico for the entire sample period. The IFS wage series is a monthly index of the nominal average hourly wage of production labor in manufacturing. There may be some question whether manufacturing wages are the relevant local wage for prospective migrants in Mexico. One indication that they are is that educational levels among Mexican migrants in the United States are similar to those for manufacturing workers in Mexico. Borjas (1994) reports that in 1990 the average educational attainment of Mexican-born men residing in the United States was 7.6 years; in 1990 average educational attainment among men employed in Mexican manufacturing was 8.1 years. Further, a large fraction of Mexican-born workers in the United States are employed in manufacturing. In 1980 45% of Mexican-born nonagricultural workers in the United States were in manufacturing; in 1990 the figure was 37%.

The U.S. wage we require is the wage that a prospective migrant in Mexico expects to earn if he or she successfully crosses the U.S.-Mexico border. We construct an expected hourly wage based on the labor force participation of Mexican-born individuals in the United States. For the raw wages series, we use U.S. Bureau of Labor Statistics data on monthly average hourly wages for production labor in seven nonagricultural U.S. industries: construction, manufacturing, transportation, wholesale trade, retail trade, finance/insurance/real estate, and services. We calculate the expected U.S. wage as the weighted-average hourly wage in these industries,

[9] The INS enforcement budget increased by 83.9% in real terms between fiscal years 1985 and 1995, compared to a 24.6% real increase in nondefense-related government spending over the same period. See Chiswick (1982) and Bean, Vernez, and Keely (1989) for a discussion of immigration policy and border enforcement.

where we use the industry shares of nonagricultural Mexican-born workers as weights.[10] Table 1 defines the variables and provides summary statistics.

Figure 3 shows the log of the U.S.-Mexico relative real wage over the sample period. The relative real wage is calculated as the weighted-average U.S. nominal wage, deflated by the U.S. CPI, divided by the Mexican nominal manufacturing wage, deflated by the Mexican CPI. The log scale in figures 3 and 4 is adjusted so that the lowest value the wage variable takes in any period is zero. Over the sample period there is a 61% difference between the highest and lowest values of the relative real wage. During just one eight-month period in 1982, the relative real wage increased by 42%! Most of the variation in the U.S.-Mexico relative real wage is the result of variation in the Mexican real wage. Figure 4 shows the log Mexican real wage and the log U.S. real wage. Over the sample period, the U.S. real wage declined steadily, showing a total drop of 18%, while the Mexican real wage moved erratically, showing a total variation of 62%.

The model in section I specifies the migration decision as a function not just of current U.S. and Mexican wages but also of the expected discounted stream of future earnings. We construct estimates of the present discounted value of the difference between U.S. and Mexican real wage streams using time-series forecasts. Given that our real-wage measures are indices, we express the difference between the U.S. and Mexican real wage for any time period as the log relative real wage (U.S. real wage/Mexican real wage). We first estimate ARMA models for the log relative real wage using rolling samples of eight years. Then, for each month, we forecast the log relative real wage far enough into the future that it converges to its long-run mean value. We calculate the present discounted value of the log relative wage for each month using a monthly discount rate of .995.[11] We use the constructed series of present discounted values to measure the expected discounted difference between U.S.

---

[10] The weights are calculated using employment data on Mexican-born individuals from the Public Use Microsample of the 1980 and 1990 *U.S. Census of Population*. We calculate the weight as the average industry share Mexican-born employment in 1980 and 1990; hence, the weights are held constant over the sample period.

[11] In the estimation results described in section III we also used present discounted value relative wage series based on monthly discount rates of .98, .9, and .5. The choice of discount rate matters little for the results.

and Mexican real wage streams.

The graphs in figure 5 show comovements between (seasonally adjusted) border apprehensions and two key variables in our analysis, border enforcement hours and the U.S.-Mexico relative real wage. For comparison, we also show comovements between apprehensions and measures of other economic factors that may be relevant to the migration decision, the U.S.-Mexico real exchange rate, and the U.S. unemployment rate. All variables are in logs. Apprehensions show strong contemporaneous correlations with border enforcement, the U.S.-Mexico relative real wage, and the U.S.-Mexico real exchange rate, and a weak contemporaneous correlation with the U.S. unemployment rate.

III. Empirical Results

III.A The Apprehensions Function: Specification and Estimation Issues

The specification of the apprehensions function we estimate is,

$$\begin{aligned} lnA_t = \alpha + \sum_{i=1}^{n} \beta_i \ln A_{t-i} + \gamma_1 lnH_t + \gamma_2 lnH_{t-1} + \gamma_3 lnW_{mt} + \gamma_4 lnW_{mt-1} \\ + \gamma_5 \ln W^1_{ut} + \gamma_6 \ln W^1_{ut-1} + \gamma_7 \ln W^2_{ut} + \gamma_8 \ln W^2_{ut-1} + \sum_{s=1}^{11} \phi_s d_s + \pi t + \mu_t \quad (3.1) \end{aligned}$$

Since we do not observe illegal attempts to cross the U.S.-Mexico border, following equation (1.8), we substitute into the apprehensions function a log-linear reduced-form expression that contains variables our model suggests determine aggregate illegal attempts to enter the United States. The explanatory variables we include are current and lagged enforcement hours (lnH_t); current and lagged values of the U.S.-Mexico relative real wage (lnW_{mt}), a dummy variable for whether the peso was devalued in the previous month ($PESO_{t-1}$), lagged border apprehensions (lnA_t), lagged apprehensions by the Border Patrol in the U.S. interior (lnA^I_t); dummy variables for the month (d_s); and a time trend (t).[12] All variables are in log levels.[13]

We discuss each set of regressors in turn (see table 1). Current enforcement hours represent the contemporaneous effect of border enforcement on apprehensions; past enforcement hours capture the effect of past enforcement behavior on future attempts at illegal entry. There is no means through which prospective migrants can obtain exact information about present and future border enforcement. One indicator of future enforcement is what the INS is observed to have done in the past.[14] The effect of past enforcement on current apprehensions can be thought of as embodying the deterrent effect of enforcement on attempts to cross the border. We discuss this and other interpretations in more detail below.

We use two measures of the expected U.S.-Mexico relative real wage: the actual U.S.-Mexico relative real wage ($lnRW$), and the discounted sum of forecasted U.S.-Mexico relative real wages (PDV). Specifications with PDV as a regressor include an explicit forecast of expected relative wages. We include both current and past values of relative wages in the regression, since some individuals may respond to wage changes immediately while others -- due to transit time in getting to the border -- may respond with a lag. As an additional measure of relative economic conditions, we include a dummy variable for whether there was a devaluation of the peso in the preceding month.[15]

---

[12] We also include fiscal year dummy variables for all years after 1986 (when IRCA became law).

[13] In unreported results, we performed augmented Dickey-Fuller tests for nonstationarity on log apprehensions and log enforcement hours. We reject the null hypothesis of nonstationaity at the 10% level for both variables.

[14] An alternative measure of expected future enforcement would be an ARMA-based forecast of enforcement, similar to our treatment of expected future relative wage streams. The problem with this approach is that using a rolling sample to estimate expected enforcement would severely reduce the sample size.

[15] During most of the sample period, Mexico had a crawling-peg exchange rate, so that, technically speaking, the peso

Finally, we include lagged values of apprehensions as regressors. Individuals who are apprehended by the U.S. Border Patrol attempting to cross U.S.-Mexico border illegally are detained temporarily in the United States and then returned to the Mexican side of the border. Since these individuals are returned to the border, instead of to their actual residence, they are likely to attempt to cross the border again in the near future, even if economic conditions change. Including lagged apprehensions as a regressor controls for dynamic adjustment in attempts to cross the border that are due to U.S. deportation policy. As a further control for the effect of apprehensions on illegal attempts to cross the border, we include lagged values of Border Patrol apprehensions in the interior United States as a regressor.[16]

Several estimation issues merit further discussion. Equation (3.1) can in principle be estimated by OLS. OLS is useful as a first pass to check for serial correlation in the disturbance term and to search for the appropriate lag structure on the regressors. One source of concern is that the specification of the apprehensions function in (3.1) is a reduced form of equation (1.8). If the variables that we include in the reduced form are imperfect measures of the true variables that determine attempts to cross the border, then our specification may be subject to measurement error. In this case OLS will produce inconsistent coefficients estimates.

A related estimation problem is that enforcement hours may be simultaneously determined with apprehensions. The INS is the agency responsible for enforcing the U.S.-Mexico border. While the INS is constrained by the enforcement budget the U.S. Congress sets in the previous fiscal year, it may have discretion over deploying budgeted resources. In particular, the INS may shift enforcement resources from the interior to the border in response to observed changes in attempts to cross the border or to observed changes in the U.S. or

---

was being devalued daily. To capture unanticipated movements in the peso (which primarily take the form of maxi-devaluations), we define a devaluation as a greater than two standard deviation (F= 6%) increase in the peso-dollar exchange rate. There were 11 such episodes over the sample period.

[16] Apprehensions of illegal aliens by the U.S. Border Patrol in the U.S. interior are the result of road check points and patrol sweeps in the border region (but not at the actual border). Since these individuals are also deported to the Mexican side of the border, they form a ready pool of prospective migrants. (Given we do not know when these individuals first crossed the border, interior apprehensions are not an appropriate sample for study on its own.)

Mexican economies. Border enforcement, then, may be a function of the same variables that determine attempts to cross the border. Additionally, shocks to enforcement hours may be correlated with unobserved shocks to apprehensions. Suppose, for instance, that the INS acquires new enforcement technology. This could lead to a simultaneous increase in enforcement hours to implement the technology. This could lead to a simultaneous increase in enforcement hours to implement the technology, and in apprehensions as the technology takes effect. Correlation between enforcement hours and unobserved shocks to apprehensions would also produce inconsistent OLS coefficient estimates.

To correct for the effects of measurement error and the endogeneity of enforcement hours, we estimate equation (3.1) by GMM (Hamilton 1994). We allow for the possibility that all continuous regressors are correlated with the error term.[17] The instruments we use are lagged values of employment and average weekly hours in U.S. nonagricultural industries, lagged values of Mexican imports, and the projected INS budget for the current fiscal year.

III.B Estimation Results

Table 2 shows OLS and GMM estimation results for equation (3.1). GMM estimates are robust to heteroskedasticity and first-order serial correlation in the errors. Theory provides little guidance on the appropriate number of lags to include on the regressors. We show results for specifications that obtain the lowest value of the Schwartz Bayesian Information Criterion (SBIC). In OLS regressions. For both relative wage variables, this specification has as regressors current enforcement hours and its firs lag, the current relative wage and its first lag, and the first two lags of border and interior apprehensions. In OLS regressions, Durbin's h statistic shows no evidence of first-order serial correlation in the errors.[18] GMM results show a chi-square test

[17] The variables we treat as exogenous are the peso devaluation dummy variable, monthly dummy variables, fiscal year dummy variables, and the time trend.

[18] We show Durbin’s h statistic given that the regressions contain lagged values of the dependent variable. Using Breuch-Godfrey tests, we find no evidence of higher order serial correlation.

of overidentifying restrictions on the instruments; in all cases, we fail to reject the null hypothesis that the instruments are uncorrelated with the error term. GMM and OLS coefficient estimates are similar, although GMM estimates are somewhat larger in absolute value for most variables. This mainly reflects differences in the short-run dynamics of the estimated system, since the long run elasticities in OLS and GMM regressions are in most cases close in value.

There is a strong positive correlation between current border apprehensions and the first lag of either border apprehensions or interior apprehensions. This is consistent with the idea that apprehensions of illegal migrants today contribute to attempts to cross the border illegally tomorrow by increasing the supply of prospective migrants at the U.S.-Mexico border. Alternatively, the results could also be due to serially correlated shocks to apprehensions. The effect, whatever its source, is not long lived. Unreported results show that additional lags of border and interior apprehensions are jointly statistically insignificant.

Current enforcement hours are, as expected, positively correlated with apprehensions, which suggests that the marginal product of enforcement is positive. The variable is highly statistically significant in all regressions. Lagged enforcement hours, in contrast, are negatively correlated with apprehensions. This finding is consistent with the existence of a deterrent effect: higher enforcement today signals higher enforcement tomorrow, which, all else equal, reduces attempts to cross the border (and apprehensions at the border) tomorrow. An alternative interpretation is that the effectiveness of enforcement declines over time. An increase in enforcement today may surprise migrants, causing apprehensions to increase, but over time migrants may change their border-crossing strategies in a manner that diminishes the long-run effectiveness of the higher enforcement level. We also show the estimated long-run elasticity of border apprehensions with respect to border enforcement, $\partial lnA/\partial lnRW$, which ranges in value from 0.92 to 0.96 in OLS regressions and from 0.79 to 1.03 in GMM regressions. Hence, there are near constant returns to scale in enforcement.

One question of interest for immigration policy is how costly border enforcement is as a means to impede illegal immigration. To address this issue, we calculate the marginal product of enforcement, $\partial nA/\partial H$, at mean values for the explanatory variables. Table 2 shows the results. Based on OLS, an additional enforcement hour yields and additional 0.28 to 0.32 additional apprehensions; based on GMM, an additional enforcement hour yields 0.24 to 0.30 additional apprehensions. These results suggest that for the U.S. Border Patrol to apprehend an additional illegal immigrant at the border requires 3.1 to 4.2 additional person hours. The main alternative policy to border enforcement is monitoring employers that tend to hire illegal aliens. To the extent that an additional hour of employer monitoring yields substantially more than 0.3 additional apprehensions of illegal aliens, our results suggest that the INS should substitute enforcement resources at the margin from border enforcement to employer monitoring.

The results on both relative real wage variables show a similar pattern: apprehensions are positively correlated with the current relative wage and negatively correlated with the lagged relative wage. For ease of interpretation, we present results in the form of coefficient estimates on the current relative wage and the change in the relative wage. The current relative wage, measured as either the actual level or the presented discounted value of the forecasted level, is highly statistically significant in all the regressions; the change in the relative wage is precisely estimated only in the regressions that use the present discounted value wage measure.

That border apprehensions are positively correlated with the change in the relative real wage is consistent with the idea that an increase in relative earnings in the United States leads to an increase illegal attempts to cross the border and an increase in apprehensions at the border. Apprehensions are highly sensitive to changes in U.S.-Mexico relative wages. For the actual relative wage (*lnRW)*, the long-run wage elasticity of apprehensions is 0.95 in the GMM regression and 1.07 in the OLS regression, implying that a 10% increase in the U.S. real wage relative to the Mexican real wage gives rise to 9.5% to 10.7% increase in apprehensions at the U.S.-Mexico border.[19] We argue below that under plausible conditions the wage elasticity for apprehensions is a lower bound of the wage elasticity for illegal attempts to cross the border.

---

[19] The elasticity of the present discounted value of the relative wage is difficult to interpret given an index number problem the relative wage we use is the difference in log wages, not the difference in wage levels.

That border apprehensions are positively correlated with the change in the relative real wage in consistent with the idea that the direction of change in relative economic conditions in the United States and Mexico matters for the illegal migration decision. Further evidence of a link between relative economic volatility and illegal immigration is that border apprehensions are positively correlated with the peso devaluation dummy variable; in all regressions the variable is statistically significant. A devaluation of the peso -- defined as a more than two standard deviation increase in the peso-dollar exchange rate -- in the previous month is associated with a 6.5% to 8.2% increase in border apprehensions.

An empirical link between economic volatility and migration was first established by Jerome (1926), but there has been little work on this subject in recent years. Changes in relative economic conditions provide information about the relative time required to obtain employment in the two countries. Mexico has experienced repeated episodes involving a peso devaluation, a sharp drop in real output and employment, and a steep decline in the real wage. Although such wage declines may be temporary, they may still lead to an increase in attempts to migrate to the United States. Two types of individuals are likely to migrate in response to a temporary real wage decline: Mexican residents who were planning to migrate in the future and who move their date of departure ahead in time, and Mexican residents in insecure jobs who prefer to ride out the Mexican economic downturn in the United States.

III.C Interpreting the Results

While the results on apprehensions are interesting in their own right, the motivation for the empirical exercise is what it can teach us about the factors that determine illegal attempts to cross the U.S.-Mexico border. Consider the estimated long-run elasticity of apprehensions with respect to the relative real wage, $\partial lnA/\partial lnRW$. From the apprehensions function in (1.7), $A_t=P_t*M_t$ where A_t is border apprehensions, P_t is the probability that the typical migrant is apprehended, and M_t is illegal attempts to cross the border, this elasticity can be written as,

$$\frac{\partial lnA}{\partial lnRW} = (1 + \frac{\partial lnP}{\partial lnM})(\frac{\partial lnM}{\partial lnRW} \qquad (3.2)$$

The term of interest is $\partial lnM/\partial lnRW$, the elasticity of illegal attempts to cross the border with respect to the U.S.-Mexico relative real wage. As discussed in section I, it seems likely that $\partial lnP/\partial lnM \leq 0$, or that the probability an individual will be apprehended decreases with total attempts to cross the border. Indeed, it is difficult to imagine conditions under which, for a given level of enforcement, more attempts to cross the border would increase the likelihood that an individual migrant will be caught. If $\partial lnP/\partial lnM \leq 0$, then $\partial lnA/\partial lnRW$ is a lower bound for $\partial lnM/\partial lnRW$.[20] In this case, our estimates suggest that a 10% increase in the U.S.-Mexico relative real wage gives rise to at least 9.5% to 10.7% increase in attempted illegal immigration.

A similar argument applies to the interpretation of the enforcement elasticity of apprehensions. From equation (1.7), the estimated long-run elasticity of apprehensions with respect to enforcement, $\partial lnA/\partial lnH$, can be decomposed as follows:

$$\frac{\partial lnA}{\partial lnH} = \frac{\partial lnP}{\partial lnH} + (1 + \frac{\partial lnP}{\partial lnM})(\frac{\partial lnM}{\partial lnH} \qquad (3.3)$$

The term, $\partial lnP/\partial lnH$, is the elasticity of the apprehensions probability with respect to enforcement, which is the direct effect of enforcement on apprehensions. The term, $\partial lnM/\partial lnH$, is the elasticity of illegal attempts to cross the border with respect to border enforcement, which can be thought of as the deterrent effect of border enforcement on illegal immigration and which can be thought of as an indirect effect on apprehensions. Enforcement impedes illegal immigration in two ways: by capturing those who attempt to cross the border and

[20] This result requires that Rw_t have no effect on P_t. One case in which this condition may be violated is where the relative wage influences the composition of individuals who attempt to cross the border. Suppose, for instance, that some individuals face a higher probability of apprehension due to limited border crossing experience. These individuals would require a higher relative wage than other migrants to attempt to cross the border. An increase in the relative wage would shift the composition of border crossers towards those with less experience, which, if experience matters, could cause the average probability of apprehension to rise P_t would then be increasing in the relative real wage and it would not necessarily follow that $\partial lnA/\partial lnRW \geq \partial lnM/\partial lnRW$. As long as such composition effects are small at the margin, we can ignore the implied missing term in (3.3), $\partial lnP/\partial lnRW$.

by deterring those who would attempt to cross the border at a lower level of enforcement. From the above discussion and empirical results, we expect that $0 \leq 1 + \partial lnP/\partial lnM \leq 1$. A deterrent effect would imply that $\partial lnM/\partial lnH \leq 0$, which would make the second right-hand term in (3.3) negative and imply that $\partial lnP/\partial lnH \geq \partial lnA/\partial lnH$. To the extent that a deterrent effect exists, we underestimate the marginal product of enforcement and overestimate the marginal costs of enforcement. Hence, our estimate of $\partial A/\partial H$ is a lower bound of the true marginal product of enforcement.

III.D Further Results and Sensitivity Analysis

In this section, we present an additional set of results to examine the robustness of our findings. So far, we have constrained U.S. and Mexican real wages to have a coefficient that is of opposite sign and the same in absolute value. We now relax this restriction. An additional issue is whether we are using the correct measure of the U.S. real wage. Many Mexican-born individuals in the United States remit a portion of their earnings to Mexico (Cornelius, 1992). To the extent that prospective migrants plan to support family members in Mexico, they may evaluate U.S. earnings in terms of its purchasing power in Mexico, rather than in terms of its purchasing power in the United States. As a way of pursuing this idea, we use two measures of the real U.S. wage, the constant dollar U.S. wage (U.S. nominal wage/U.S. CPI) and the constant peso U.S. wage (U.S. nominal wage*peso-dollar exchange rate/Mexico CPI).

Table 3 shows OLS and GMM results in which we replace the relative real wage with the Mexican real wage *(lnWMX)*, the constant dollar U.S. real wage *(lnWUS1)*, and the constant peso U.S. real wage *(lnWUS2)*. Since the results on enforcement hours and lagged apprehensions are very similar to those in Table 2, we focus on the results for the wage variables. There is a strong negative correlation between border apprehensions and both the level and the change in the Mexican real wage. The Mexican wage in levels is statistically significant in both regressions; the Mexican wage in changes is statistically significant in the OLS regression only. The long-run elasticity of apprehensions with respect to the Mexican wage is -0.75 in the GMM regression and -0.88

in the OLS regression. Consistent with the results in table 2, border apprehensions -- and, by implication, illegal attempts to cross the border -- are highly sensitive to variation in the Mexican real wage.

Both the constant dollar U.S. wage and the constant peso U.S. wage (in levels) are positively correlated with border apprehensions. The estimates for the constant dollar U.S. wage, however, vary considerably between the OLS and GMM regressions, and sensitivity analysis that we present in table 4 shows that coefficient estimates on the variable are unstable and in general imprecisely estimated. The results for the constant peso U.S. wage, in contrast are stable across specifications. Hence, there is strong evidence that prospective migrants care about the purchasing power of U.S. wages in Mexico and only weak evidence that they care about the purchasing power of U.S. wage in the same regression, we are in effect including the real exchange rate as a regressor. This may explain why the coefficient estimate on the peso dummy is smaller than that in table 2 and no longer statistically significant.

The long-run elasticity of apprehensions with respect to the constant peso U.S. wage is less than half the absolute value of the elasticity for the Mexican wage, suggesting that apprehensions are more sensitive to Mexican wages than to U.S. wages. This result is somewhat surprising given that empirical studies of migration tend to find that pull factors, which in this case are U.S. wages, matter much more than push factors, which in this case are Mexican wages (e.g., Shaw, 1986). One possible explanation for this finding is that the relative volatility of the Mexican economy gives Mexican wages greater weight in the illegal immigration decision.

It is natural to imagine that prospective migrants take economic conditions besides wages into account in making the migration decision. Unemployment rates in the United States and Mexico are obvious predictors of the relative likelihood of finding a job in the two countries. In table 4 we show results in which we include unemployment rates and other measures of economic activity in the estimation. For expositional ease, we present results in terms of estimated long-run elasticities. We use the overall U.S. unemployment rate, but we do not include the Mexican unemployment rate. One reason for excluding Mexican unemployment is practical; Mexican unemployment data (and most other data on Mexican economic activity) are not available on a monthly basis until after 1985. A second reason is that, given the definition of the labor force that the Mexican government uses, the Mexican unemployment rate is not very informative.[21] The other measure of economic activity we include as a regressor is average weekly hours worked by U.S. nonagricultural laborers.

Most regression results are quite stable across specifications. The long-run elasticities of enforcement hours, the Mexican real wage, and the constant peso U.S. wage are similar to those we report in table 3. As indicated, estimates for the elasticity of the constant dollar U.S. wage vary regressors, there is a weak negative correlation between apprehensions and the current U.S. unemployment rate *(lnUNUS)*. The estimated long-run elasticity is -0.13 in the OLS regression and -0.18 in the GMM regression, but it is statistically insignificant in both cases. There is a weak positive correlation between apprehensions and average weekly hours worked by U.S. nonagricultural laborers *(lnHRUS)*. While the estimated long-run elasticity for the variable is quite large, it is statistically insignificant in both regressions. Despite the lack of statistical significance, it is interesting that average weekly hours worked have a larger estimated effect on apprehensions than does unemployment. Given the fluidity of the labor markets in which many illegal immigrants are employed, average weekly hours worked may be a better indication of business cycle factors that affect demand for their labor.

In unreported results we experimented with additional regressors and with additional specifications of the apprehensions function. We found no statistically (or economically) significant correlation between apprehensions and other measures of economic activity in either the United States (industrial production, nonagricultural employment, California and Texas unemployment rates), or Mexico (imports). Moreover, the inclusion of these variables had little impact on the results we report in Tables 2 to 4. GMM results are robust to the exclusion of individual variables from the set of instruments and both OLS and GMM results are robust

[21] The Mexican government defines the working population to be all persons over 12 years of age who worked at least one hour in exchange for payment during the previous two months. Not surprisingly, Mexico's unemployment rate is relatively low and stable; over the period 1985-1994 -- during which Mexico experienced a severe recession -- the average unemployment rate was 3.4% (with a range of 2.1%-5.7%) in Mexico compared to 6.4% (with a range of 5.0%-8.2%) in the United States. In unreported results we found no correlation between apprehensions and Mexican unemployment for the period 1985 to 1995.

to the inclusion of additional lags on border apprehensions. We also examined whether there was a structural break in the regression equation following the implementation of the Immigration Reform and Control Act in 1986 and whether the regression parameters were stable across the four seasons of the year. In either case, we fail to reject the null hypothesis that the regression parameters are stable over time.

IV. Concluding Remarks

This paper uses data on apprehensions by the U.S. Border Patrol at U.S.-Mexico border to examine illegal immigration from Mexico to the United States. We find a strong negative correlation between the Mexican real wage and border apprehensions and a positive correlation between U.S. real wages and border apprehensions. The long-run elasticity of border apprehensions with respect to the Mexican real wage is -0.75 to -0.88, which is consistent with the hypothesis that attempted illegal immigration is very sensitive to changes in Mexican wages. It is the purchasing power of U.S. wages in Mexico, more than the purchasing power of U.S. wages in the United States, that matters for border apprehensions. This suggests that, consistent with case-study evidence, prospective migrants expect to maintain links with Mexico, either through return migration or through supporting family members who remain at home. We also find that economic volatility in Mexico contributes to border apprehensions. Border apprehensions are higher in the month following a large devaluation of the peso, higher when the change in the Mexican real wage is negative, and higher when average weekly hours worked in U.S. nonagricultural industries are higher. Finally, we find that each additional hour the U.S. Border Patrol spends policing the U.S.-Mexico border yields an additional 0.25 to 0.33 apprehensions. This estimate represents a productivity benchmark against which other methods of controlling illegal immigration can be compared.

The importance of Mexican wages for border apprehensions suggests that factors that reduce the U.S.-Mexico wage gap will also reduce illegal Mexican immigration. These findings offer support for claims by the U.S. government that policy initiatives such as NAFTA -- to the extent that they raise Mexican wages relative to U.S. wages -- will reduce the northward flow of labor across the U.S.-Mexico border. This is not as obvious an implication as it may at first seem, given that many studies of migration find that push factors, including source country wages, matter relatively little for immigration. The large impact of Mexican wages on border apprehensions that we find suggests that it is a key factor in the illegal migration decision. The relative variability of the Mexican wage is an additional factor that contributes to immigration. Occasional drops in the Mexican wage, associated primarily with exchange rate crises, compound the effect of U.S.-Mexico wage differentials by giving Mexican residents a strong incentive to seek safe haven in the United States during times of economic turmoil.

An important topic for future research is whether economic volatility affects the composition, and not just the level, of attempted illegal immigration. Borjas (1992, 1994) finds that since 1970 there have been changes in the labor force characteristics of Mexican-born residents in the United States. Over this time period, there has also been a sharp increase in the volatility of the Mexican economy. To the extent that the individuals who account for temporary upsurges in illegal Mexican immigration following periods of economic instability differ systematically from those who compose the flow of illegal immigrants under stable economic conditions, the recent increase in relative economic volatility in Mexico may account for some portion of the change in the composition of Mexican immigration in the United states. This issue has important implications to stabilize the Mexican economy, such as the $40 billion package of loan guarantees extended in 1995, may represent an indirect means of selecting type of individuals who attempt to become illegal immigrants.

Data Appendix: Border Apprehensions and Border Enforcement Hours

This appendix describes the border apprehensions and enforcement hours data that we use. All data are from unpublished files of the INS. The INS distinguishes between two types of U.S. Border Patrol activities: "linewatch" activities, which occur at international boundaries, and "non-linewatch" activities, which occur in the interior of the United States. We use monthly data on the number of individuals apprehended by U.S. Border Patrol officers on linewatch duty and the number of person hours U.S. Border Patrol officers spend on linewatch duty. The importance of the linewatch data is that, since apprehensions occur at an international border, we know the moment in time (the month) when the individuals apprehended attempt to enter the United States. This makes it possible to match apprehensions data to data on economic conditions in the United States and Mexico. Non-linewatch apprehensions occur at U.S. Border Patrol traffic checkpoints, raids on businesses, and patrols in the U.S. interior (Bean et al. 1990). We have no way of determining when individuals apprehended by Border Patrol officers on non-linewatch duty first entered the country. A further problem with this data is that a consistent monthly series on non-linewatch enforcement hours only exists for fiscal years 1977 forward. Over the period 1977-1996, linewatch apprehensions account for 61.2% of total apprehensions.

While most linewatch apprehensions and most linewatch Border Patrol activity occur at the U.S.-Mexico border, some linewatch apprehensions and enforcement activity do occur at other locations in the United States, most of which are international ports. We have two data series from the INS: linewatch apprehensions and enforcement hours for the entire United States, which are available for fiscal years 1964 forward, and linewatch apprehensions and enforcement hours for the U.S.-Mexico border only, which are available for fiscal years 1977 forward. Given that the two series are very similar, we use the linewatch data for the entire United States, which give us a much longer time series. Table A.1 reports sample means and sample correlations for the two series over the period for which they overlap, 1977 to 1996.

Table A.1: INS Apprehensions Data, 1977-1996

Linewatch Apprehensions	Mean	Std. Error	Correlation	N
All Border Patrol Sectors	55,874	20,725	0.999	243
Border Patrol Sectors on U.S.-Mexico Border only	55,424	20,649		243
Linewatch Enforcement Hours				
All Border Patrol Sectors	214,754	56,323	0.998	243
Border Patrol Sectors on U.S.-Mexico Border only	197,235	54,160		243

Nearly all linewatch apprehensions occur at the U.S. border with Mexico. Over the period 1977-1996, an average of 99.2% of linewatch apprehensions occur at the U.S.-Mexico border. Not surprisingly, the two linewatch apprehensions series are nearly perfectly correlated, with a sample correlation of 0.999. A slightly lower fraction of linewatch enforcement hours occur at the U.S. border with Mexico. Over the period 1977-1996, an average of 91.6% of linewatch enforcement hours occur at the U.S.-Mexico border. The two linewatch enforcement hour series are also nearly perfectly correlated, with a sample correlation of 0.994. While it is possible that the two linewatch data series deviate over the earlier period 1964-1976, for which we cannot make a comparison, we believe this to be unlikely. The Statistics Division of the INS reports that since the early 1950s the vast majority of U.S. Border Patrol apprehensions have occurred at the U.S.-Mexico border. To verify that using linewatch data for the entire United States does not influence our results, in unreported regressions we estimate the apprehensions function in (3.1) for both linewatch data series (all United States, U.S.-Mexico border only) over the period that they overlap, 1977-1996. We obtain nearly identical coefficient estimates for the two series. These coefficient estimates are also very similar to those we report in Tables 3-5.

References

Bean, F.D., T.J. Espenshade, M.J. White, and R.F. Dymowski. 1990. "Post-IRCA Changes in the Volume and Composition of Undocumented Migration to the United States: An Assessment Based on Apprehensions Data." In F.D. Bean, B. Edmonston, and J.S. Passel, eds., *Undocumented Migration to the United States: IRCA and the Experience of the 1980s*. Washington, DC: The Urban Institute, pp. 111-158.

Bean, F.D., G. Vernez, and C.B. Keely. 1989. *Opening and Closing the Doors: Evaluating Immigration Reform and Control*. Washington, DC: The Urban Institute.

Borjas, G.J. 1992. "National Origin and the Skills of Immigrants in the Postwar Period." In G.J. Borjas and R.B. Freeman, eds., *Immigration and the Workforce: Economic Consequences for the United States and Source Areas*. Chicago: University of Chicago Press, pp. 77-100.

Borjas, G.J. 1994. "The Economics of Immigration." *Journal of Economic Literature* 32: 1667-1717.

Borjas, G.J., R.B. Freeman, and K. Lang. 1991. "Undocumented Mexican-Born Workers in the United States: How Many, How Permanent?" In J.M. Abowd and R.B. Freeman, eds., *Immigration, Trade, and the Labor Market*, Chicago: University of Chicago Press, pp. 77-100.

Burda, M.C. 1995. "Migration and the Option Value of Waiting." Mimeo, Institute for International Economic Studies (Stockholm).

Chiswick, B. 1982. *The Gateway: U.S. Immigration Issues and Policies*. Washington, DC: American Enterprise Institute.

Cornelius, W.A. 1992. "From Sojourners to Settlers: The Changing Profile of Mexican Immigration to the United States." In J.A. Bustamente, C.W. Reynolds, and R.A. Hinojosa, eds., *U.S.-Mexico Relations: Labor Market Interdependence*, Stanford: Stanford University Press, pp. 155-195.

Crane, K., B.J. Asch, J.Z. Heilbrunn, and D.C. Cullinane. 1990. *The Effect of Employer Sanctions on the Flow of Undocumented Immigrants to the United States*. Urban Institute Report 90-8.

Dixit, A.K. and Pindyck, R.S. 1994. *Investment under Uncertainty*. Princeton: Princeton University Press.

Durand, J., and D.S. Massey. 1992. "Mexican Migration to the United States: A Critical Review." *Latin American Research Review* 27: 3-42.

Espenshade, T.J. 1990. "Undocumented Migration to the United States: Evidence from a Repeated Trials Model." In Bean, Edmonston, and Passel, pp. 159-182.

Ethier, W.J. 1985. "International Trade and Labor Migration." *American Economic Review* 75: 691-707.

Ethier, W.J. 1986. "Illegal Immigration: The Host-Country Problem." *American Economic Review* 76: 56-71.

Greenwood, M.J. 1985. "Human Migration: Theory , Models, and Empirical Studies." *Journal of Regional*

Science 25: 521-545.

Hamilton, J.D. 1994. *Time Series Analysis*. Princeton: Princeton University Press.

Jerome, H. 1926. *Migration and Business Cycles*. New York: National Bureau of Economic Research.

Morrison, A.R. and C.A. Zabin. 1993. "Two-Step Mexican Migration to the United States: The Role of Mexican Export Agriculture." Mimeo, Tulane University.

Shaw, R.P. 1986. "Fiscal versus Traditional Market Variables in Canadian Migration." *Journal of Political Economy* 94: 648-666.

Sjaastad, L. 1962. "The Costs and Returns of Human Migration." *Journal of Political Economy* 70: 80-93.

Stark, O. 1991. *The Migration of Labor*. Cambridge: Basil Blackwell.

Table 1: Variable Definitions

Variable	Definition	Mean (Std Dev)
lnA	Apprehensions by the U.S. Border Patrol of individuals attempting to cross U.S. borders illegally (dependent variable).	10.83 (0.35)
lnA^I	Apprehensions by the U.S. Border Patrol of illegal aliens in the interior United States.	10.26 (0.33)
lnH	Person hours spent by the U.S. Border Patrol policing the U.S.-Mexico borders (does not include person hours spent policing the interior United States).	12.12 (0.20)
lnRW	U.S. weighted-average nominal hourly wage/U.S. CPI. (Mexico average nominal hourly manufacturing wage/Mexico CPI).	2.35 (0.14)
PDV	Present discounted value of forecast of lnRW (monthly discount rate = .995).	4.49 (12.76)
lnWMX	Mexico average nominal hourly manufacturing wage/Mexico CPI.	0.02 (0.15)
lnWUS1	U.S. weighted-average nominal hourly wage/U.S. CPI.	2.37 (0.05)
lnWUS2	U.S. weighted-average nominal hourly wage*peso-dollar exchange rate/Mexico CPI.	-1.22 (0.20)
PESO	Equals one if there was a greater than two standard deviation increase (F = 6%) in the peso-dollar exchange rate during the current month (11 total episodes).	0.05 (0.22)
lnUNUS	U.S. unemployment rate.	1.91 (0.18)
lnHRUS	Average weekly hours worked by U.S. nonagricultural laborers.	3.55 (0.02)

ln indicates the natural log. Observations for all variables are monthly for the period December 1976 to August, 1995.

Table 2: Estimation Results for Border Apprehensions
(asymptotic t-statistics in parentheses)

Method	OLS	GMM	OLS	GMM
Variable	(1a)	(1b)	(2a)	(2b)
lnA_{t-1}	0.585	0.743	0.647	0.768
	(6.987)	(5.883)	(7.808)	(6.056)
lnA_{t-2}	-0.080	-0.057	-0.046	0.007
	(-1.049)	(-0.455)	(-0.590)	(0.058)
lnA^{I}_{t-1}	0.114	0.299	0.064	0.233
	(1.754)	(2.916)	(0.962)	(2.141)
lnA^{I}_{t-2}	-0.089	-0.218	-0.074	-0.184
	(-1.439)	(-2.189)	(-1.174)	(-1.853)
lnH_t	0.757	0.890	0.732	0.778
	(4.560)	(3.459)	(4.319)	(2.712)
lnH_{t-1}	-0.300	-0.567	-0.350	-0.601
	(-1.739)	(-2.284)	(-2.005)	(-2.281)
$lnRW_t$	0.528	0.299	--	--
	(4.717)	(3.213)		
) $lnRW_t$	0.327	0.112	--	--
	(1.840)	(0.410)		
PDV_t	--	--	0.005	0.003
			(3.667)	(2.122)
) PDV_t	--	--	0.006	0.012
			(2.284)	(2.996)
$PESO_{t-1}$	0.075	0.081	0.082	0.065
	(2.340)	(3.537)	(2.423)	(2.689)
Time	0.002	-0.002	0.007	0.0004
	(0.492)	(-0.522)	(1.472)	(0.070)
<u>Long run Elasticities</u>				
$\partial lnA/\partial lnH$	0.923	1.030	0.958	0.785
	(4.810)	(3.472)	(3.903)	(1.996)
$\partial lnA/\partial lnH$	1.068	0.953	0.013	0.011
	(5.270)	(3.656)	(3.641)	(2.099)

Table 2: Continued

	(1a)	(1b)	(2a)	(2b)
<u>Marginal Product of Enforcement</u>				
$\partial A/\partial H$	0.282 (0.434)	0.300 (0.268)	0.316 (0.340)	0.235 (0.236)
Durbin's h statistic	-0.743	--	-1.292	--
χ^2 [dof] test of over-identifying restrictions (P-value)	--	32.47 [32] (0.444)	--	32.35 [35] (0.597)
Adjusted R^2	0.932	0.919	0.929	0.918
Observations	223	219	223	219

<u>Notes</u>:

See Table 1 for variable definitions. Additional regressor (not shown) are monthly dummy variables and fiscal year dummy variables for years after 1986 (When IRCA was implemented). Durbin's h statistic is the t-value on the first lag of the residual in a regression of the residual on its first lag and the explanatory variables. The value of $\partial A/\partial H$ is calculated at mean values for the explanatory variables. Standard errors for estimated long-run elasticities are calculated using the delta method.

GMM results are robust to heteroskedasticity and first-order serial correlation in the errors. The test of overidentifying restrictions tests the null hypothesis that the instruments are uncorrelated with the errors against the alternative hypothesis that at least one of the instruments is correlated with the errors (with degrees of freedom equal to the number of instruments minus the number of regressors). Instruments in GMM estimation are the fourth to sixth lags of the regressors, the projected INS budget for the current fiscal year, and the fourth to sixth lags of log employment and log average weekly hours in U.S. nonagricultural industries, and the fourth to sixth lags of log Mexican imports.

Table 3: Estimation Results for Alternative U.S. Wage Measures
(asymptotic t-statistics in parentheses)

Method	OLS	GMM
Variable	(1)	(2)
lnA_{t-1}	0.568	0.725
	(6.774)	(5.101)
lnA_{t-2}	-0.080	-0.060
	(-1.075)	(-0.467)
lnA^{I}_{t-1}	0.122	0.234
	(1.882)	(2.185)
lnA^{I}_{t-2}	-0.118	-0.284
	(-1.945)	(-3.135)
lnH_t	0.752	1.034
	(4.672)	(2.986)
$lnWMX_t$	-0.451	-0.250
	(-3.459)	(-2.472)
) $lnWMX_t$	-0.374	-0.168
	(-2.037)	(-0.517)
$lnWUS1_{t-1}$	0.310	1.071
	(0.466)	(2.631)
) $lnWUS1_t$	-2.934	-1.300
	(-1.518)	(-0.461)
$lnWUS2_t$	0.183	0.107
	(2.564)	(1.957)
) $lnWUS2_t$	0.198	0.299
	(1.436)	(2.073)
$PESO_{t1}$	0.032	0.043
	(0.907)	(1.644)
Time	0.003	0.015
	(0.245)	(2.208)

Table 3: Continued

	(1)	(2)
Long-Run Elasticities		
$\partial lnA/\partial lnH$	0.847	1.223
	(4.696)	(3.708)
$\partial lnA/\partial lnWMX$	-0.881	-0.745
	(-3.705)	(-2.824)
$\partial lnA/\partial lnWUS1$	0.605	3.190
	(0.460)	(1.871)
$\partial lnA/\partial lnWUS2$	0.357	0.318
	(2.675)	(2.244)
Marginal Product of Enforcement		
$\partial A/\partial H$	0.251	0.329
	(0.462)	(0.187)
Durbin's h statistic	-1.053	--
χ^2 [dof] test of over-identifying restrictions (P-value)	--	27.34 [28] (0.500)
Adjusted R^2	0.937	0.926
Observations	223	219

See Table 1 for variable definitions and notes to table 2 for a description of reported results.

Table 4: Extended Estimation Results

(asymptotic t-statistics in parentheses)

Method	OLS	GMM	OLS	GMM
Variable	(1a)	(1b)	(2a)	(2b)
<u>Long run Elasticities</u>				
$\partial lnA/\partial lnH$	0.831	1.038	0.857	1.478
	(4.462)	(3.720)	(4.793)	(2.444)
$\partial lnA/\partial lnWMX$	-0.813	-0.509	-0.804	-0.588
	(-3.292)	(-1.668)	(-3.266)	(-1.346)
$\partial lnA/\partial lnWUS1$	-0.478	1.362	0.039	1.861
	(-0.300)	(0.808)	(0.027)	(0.603)
$\partial lnA/\partial lnWUS2$	0.443	0.466	0.382	0.410
	(2.587)	(1.640)	(2.742)	(1.775)
$\partial lnA/\partial lnUNUS$	-0.134	-0.177	--	--
	(-0.861)	(-0.749)		
$\partial lnA/\partial lnHRUS$	--	--	2.423	8.132
			(0.725)	(1.548)
$PESO_{t-1}$	0.035	0.036	0.035	0.066
	(0.967)	(1.001)	(1.006)	(1.984)
Durbin's h statistic	-0.753	--	-1.047	--
χ^2 [dof] test of over-Identifying restrictions (P-value)	--	29.17 [26] (0.575)	--	24.02 [26] (0.304)
Adjusted R^2	0.937	0.928	0.938	0.916
Observations	223	219	223	219

The explanatory variables for the regressions in Table 4 include those from the corresponding regressions in Table 3, plus either the current value and first lag of the log U.S. unemployment rate (*lnUNUS*) or the current value of first lag of log average weekly hours worked by U.S. nonagricultural laborers (*lnHRUS*). See Table 1 for variable definitions and notes to Table 2 for further description of reported results.