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

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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 1980's 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, 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 questions. The first is, how responsive is illegal immigration to changes in U.S. and Mexican real 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 enforcement of the border 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 that attempt to enter the United States illegally. Instead, we observe the number of individuals that the U.S. government apprehends attempting to cross U.S. borders illegally and the resources that the U.S. government devotes to enforcing borders. Our approach is to examine illegal immigration indirectly by identifying the factors that determine border apprehensions. We examine the correlates of apprehensions using monthly data from the U.S. Immigration and Naturalization Service (INS) on total apprehensions at U.S. borders and the number of person hours the U.S. Border Patrol spends policing U.S. borders, and data on U.S. and Mexican wages and other variables. The empirical results provide evidence on how relative wages and border enforcement influence illegal attempts to enter the United States. Under plausible assumptions, the effects of U.S. and Mexican wages on apprehensions are a *lower bound* of the effects of wages on illegal attempts to cross the border. If the wage elasticities of apprehensions are large, the corresponding elasticities for attempts at illegal entry are also likely to be large. Similarly, by estimating the effect of enforcement on apprehensions we can examine the effectiveness of border enforcement as a policy to impede illegal immigration.

There is abundant literature on legal

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immigration, most of which examines who chooses to immigrate, how immigrants perform in the host economy, or how immigration impacts native workers (George J. Borjas, 1994; Rachel M. Friedberg and Jennifer Hunt, 1995). The literature on illegal immigration is comparatively small. Wilfred J. Ethier (1985, 1986) develops a theory of illegal immigration, in which a small country chooses how intensively to enforce its borders given an exogenous immigrant supply. The empirical literature includes case studies of Mexican communities that send illegal migrants to the United States, and estimates of the U.S. illegal-immigrant population.[1] A few papers use the same data source that we use. Frank D. Bean et al. (1990), using monthly INS data for 1977–1989, find that border apprehensions declined substantially following IRCA. Borjas et al. (1991), using annual INS data for 1967–1984, find that apprehensions by the U.S. Border Patrol are positively correlated with U.S. expenditure on border enforcement and U.S. real wages.

The contribution of our paper is twofold. First, we use monthly data on border apprehensions and enforcement from unpublished INS records for the period 1963–1996, which spans the entire modern period of illegal immigration from Mexico. Illegal immigration began to rise after the end of the Bracero Program (1942–1964), which permitted farm laborers from Mexico to work in U.S. agriculture on a temporary basis.[2] The sample period covers two major changes in U.S. immigration law, IRCA in 1986 and the Immigration Act of 1990, and most Mexican economic contractions during the postwar period, including the peso collapse of 1994. Second, in the empirical analysis we treat the decision of how intensively to enforce U.S. borders as endogenous. If the INS foresees that changing economic conditions will increase illegal attempts to enter the United States, it may expand border enforcement in response. We instrument for border enforcement using U.S. government expenditures on national defense and the timing of U.S. presidential, congressional, and gubernatorial elections.

The results of this paper have important implications for U.S. immigration policy and for U.S. policy towards Mexico. Both the North American Free Trade Agreement and the $40 billion loan package the U.S. government organized for Mexico in 1995 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 changes in U.S. and Mexican wages. Additionally, the INS devotes a large fraction of its enforcement resources to policing U.S. borders. An alternative policy for reducing illegal immigration is to monitor employers that are likely to hire illegal aliens. To assess the relative effectiveness of these policies, we need to know how responsive illegal immigration is to enforcement activities.

I. Migration Theory

Beginning with Larry A. Sjaastad (1962), economists view migration as an investment decision (Michael J. Greenwood, 1985; Oded Stark, 1991). An individual migrates if the expected discounted difference in the stream of income between the new and old location exceeds moving costs. Once the migration decision is taken, the individual moves with certainty. In the context of illegal immigration, individuals must circumvent destination-country authorities if they are to move abroad successfully. The expected probability of being apprehended at the border today and in the future influences the decision of whether or not to migrate.

Consider an individual in Mexico who is deciding whether or not to attempt to migrate to the United States illegally. The factors that influence the migration decision are the real wage in Mexico, W^{mx}, the real wage in the United States, W^{us}, the probability of being apprehended while attempting to cross the U.S.-Mexico border, P, and any information which is useful to predict future paths of these

[1] See Jorge Durand and Douglas S. Massey (1992) for a survey of the case study literature, and Robert Warren and Jeffrey S. Passel (1987) and Thomas J. Espenshade (1995) for estimates of the illegal-immigrant population.

[2] At its height in the 1950's, the Bracero Program admitted 400,000 Mexican laborers a year to work in U.S. agriculture (Kitty Calavita, 1992). Laborers were required to return to Mexico after completing their contract work.

variables, Ω. The direct costs of illegal immigration include foregone wages during migration, transport to the border, and securing safe passage across the border.[3] To the extent these costs vary across individuals, attempted illegal immigration will vary with the difference between expected future U.S. and Mexican earnings. The total number of individuals that attempt to migrate illegally at time t, M_t, can be expressed as,

$$(1) \qquad M_t = M(W_t^{mx}, W_t^{us}, P_t, \Omega_t, \Gamma_t)$$

where Γ_t is the distribution of individual characteristics that influence migration costs. If an individual crosses the border successfully, we assume that he expects to remain in the United States forever.[4] If an individual is apprehended at the border, he is deported to Mexico and may choose to attempt to cross the border illegally at a later date.[5]

While Mexican residents also have the option of attempting to migrate to the United States legally, the possibility of legal migration does not remove the incentive for illegal immigration. Under U.S. law, immediate family members of U.S. citizens qualify for legal entry without restrictions, but admission of other individuals is subject to quotas. For most individuals, obtaining legal entry takes several years or more (Espenshade, 1994). A Mexican resident who has applied for legal entry to the United States may choose to migrate illegally while the INS processes his application. If the individual is apprehended, he faces no repercussions from the INS as long as he agrees to leave the United States voluntarily.

Apprehensions at the border will be influenced by illegal attempts to cross the border and the probability that any individual migrant is apprehended. The apprehensions probability, P_t, is likely to be influenced by the level of effort U.S. authorities expend in enforcing the border, H_t, and total illegal attempts to cross the border, M_t. If all individuals face the same apprehensions probability,[6] apprehensions at the border, A_t, can be expressed by the following apprehensions function:

$$(2) \quad A_t = P(H_t, M_t) * M(W_t^{mx}, W_t^{us}, P_t, \Omega_t, \Gamma_t).$$

While we do not observe M_t or P_t, we do observe H_t and other variables that determine M_t. We use a reduced-form version of equation (2) as the basis for our empirical work.

II. Data

Table 1 defines the variables and shows summary statistics. Apprehensions and enforcement data are available from unpublished INS records, which show the number of individuals that the U.S. Border Patrol apprehends attempting to cross U.S. borders illegally and total person hours that the U.S. Border Patrol spends policing U.S. borders. An Appendix describes the INS data in detail. We assume that all illegal immigrants are Mexican residents. Over the period 1977–1996, 99.2 percent of apprehensions occurred at the U.S.-Mexico border. While the share of non-Mexicans in apprehensions has risen slightly over time, Mexican residents still account for the vast majority of those apprehended. Over the period 1988–1994, 96.1 percent of those apprehended by the Border Patrol were individuals of Mexican origin (INS, 1996).

[3] Smugglers, known as coyotes, transport illegal immigrants across the U.S.-Mexico border (Katherine M. Donato et al., 1992). Ted Conover (1987) cites anecdotal evidence that in the 1980's the cost of transport immediately across the border was $150. Keith W. Crane et al. (1990) report that among individuals apprehended by the INS in 1993 8.3 percent had used a coyote, compared to 5.0 percent in 1988 and 15.0 percent in 1976.

[4] While some illegal migrants are commuters—they work part of the year in Mexico and part in the United States—long-term illegal immigration appears to be increasingly the norm (Warren and Passel, 1987; Borjas et al. 1991; Wayne A. Cornelius, 1992).

[5] Individuals the INS apprehends that agree to be deported voluntarily are not processed by the U.S. justice system, spend a few days or less in custody before being returned to Mexico, and face no restrictions on their ability to enter the United States legally in the future. In 1994 voluntary departures accounted for 95.3 percent of all apprehensions (INS, 1996). Figures for previous years are similar.

[6] Using survey data from seven Mexican communities, Donato et al. (1992) find that the individual probability of being apprehended by the INS is not significantly correlated with observable individual characteristics, including age and previous border-crossing experience.

TABLE 1—VARIABLE DEFINITIONS, DATA SOURCES, AND SUMMARY STATISTICS

Variable	Definition	Mean (Standard deviation)
Apprehensions	Apprehensions by the U.S. Border Patrol of individuals attempting to cross U.S. borders illegally	42,890 (26,583)
Enforcement	Person hours spent by the U.S. Border Patrol policing U.S. borders	179,824 (67,209)
Mexican wage	Mexico average nominal hourly manufacturing wage/Mexico CPI	1.07 (0.18)
U.S. dollar wage	U.S. weighted-average nominal weekly earnings/U.S. CPI	402.52 (22.39)
U.S. peso wage	(U.S. weighted-average nominal weekly earnings* peso-dollar exchange rate)/Mexico CPI	10.84 (2.02)
IRCA	=1 if fiscal year is 1987 or later, when Immigration Reform and Control Act was implemented	0.35 (0.48)
Immigration Act 1990	=1 if fiscal year is 1992 or later, when Immigration Act of 1990 was implemented	0.21 (0.41)
Mexican admissions	U.S. legal admissions of Mexican individuals in previous fiscal year (INS)	136,803 (201,108)
Other admissions	U.S. legal admissions of non-Mexican individuals in previous fiscal year (INS)	504,114 (167,205)
U.S. unemployment	U.S. unemployment rate	6.43 (1.54)
Mexican minimum wage	Mexico minimum wage/Mexico CPI	0.16 (0.06)
U.S. minimum wage	U.S. federal minimum wage/U.S. CPI	4.53 (0.71)
Defense spending	U.S. government outlays for national defense (billions of U.S. dollars)	187.57 (92.35)
Presidential election	=1 if there is an upcoming U.S. presidential election in the current calendar year	0.25 (0.43)
Congressional election	=1 if there is an upcoming U.S. congressional election in the current calendar year	0.47 (0.50)
Gubernatorial election	=1 if there is an upcoming gubernatorial election in the state of Texas in the current calendar year	0.29 (0.46)

Notes: All variables are in levels. Observations for all variables are monthly (except for U.S. legal admissions and U.S. defense spending, which are annual) for the period January 1968 to August 1996.

Figures 1A and 1B show enforcement hours and (seasonally adjusted) apprehensions over the sample period. Apprehensions rise from an average of 2,400 per month in the 1960's to 70,100 per month in the 1990's. The series shows large spikes in 1983, 1986, and 1995, each of which follows a devaluation of the peso and a recession in Mexico. Apprehensions, and by implication illegal immigration, rise after the end of the Bracero Program in 1964, which provided temporary U.S. employment for hundreds of thousands of Mexican workers. Warren (1995) estimates that for 1982–1988 the average annual net inflow of illegal immigrants from Mexico was 165,000 individuals and that for 1988–1992 it was 149,000 individuals. Legal Mexican immigration in the United States has risen over time, but, with the exception of an amnesty to illegal aliens that IRCA granted, it remains at low levels. Prior to 1988, the number of legal Mexican admissions exceeded 75,000 individuals in only one year (INS, 1996).

Enforcement hours have grown erratically over time. From a mean level of 182,000 person hours per month for 1980–1986, enforcement rises to 368,000 person hours per month by 1996. The expansion in border enforcement is due largely to recent changes in U.S. immigration policy, which have increased the enforcement budget of the INS.

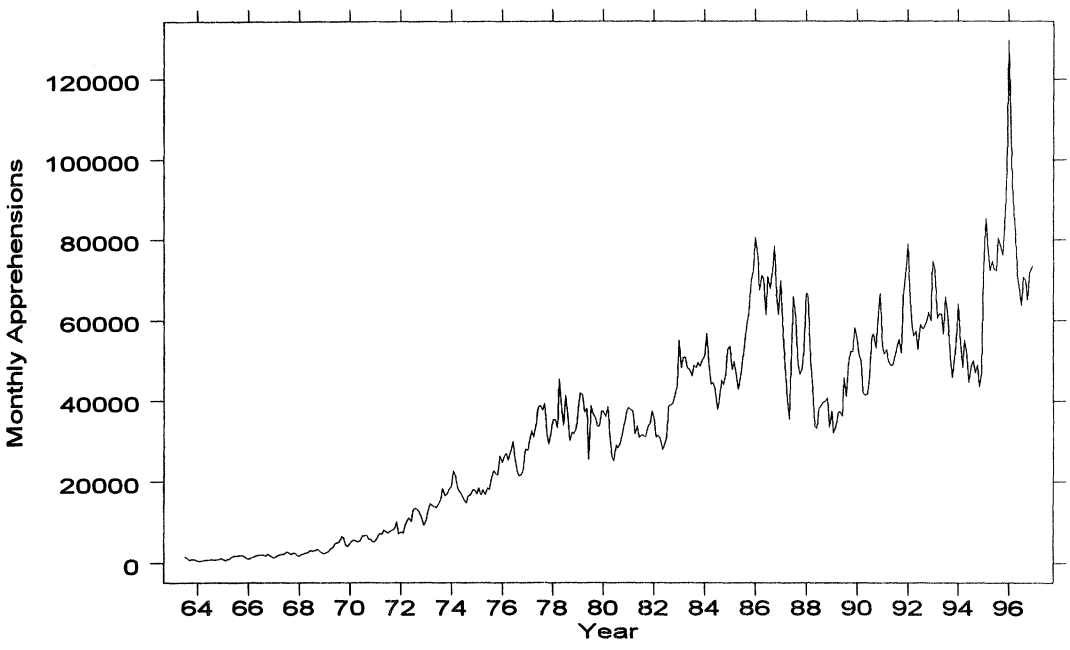

FIGURE 1A. APPREHENSIONS AT U.S.-MEXICO BORDER

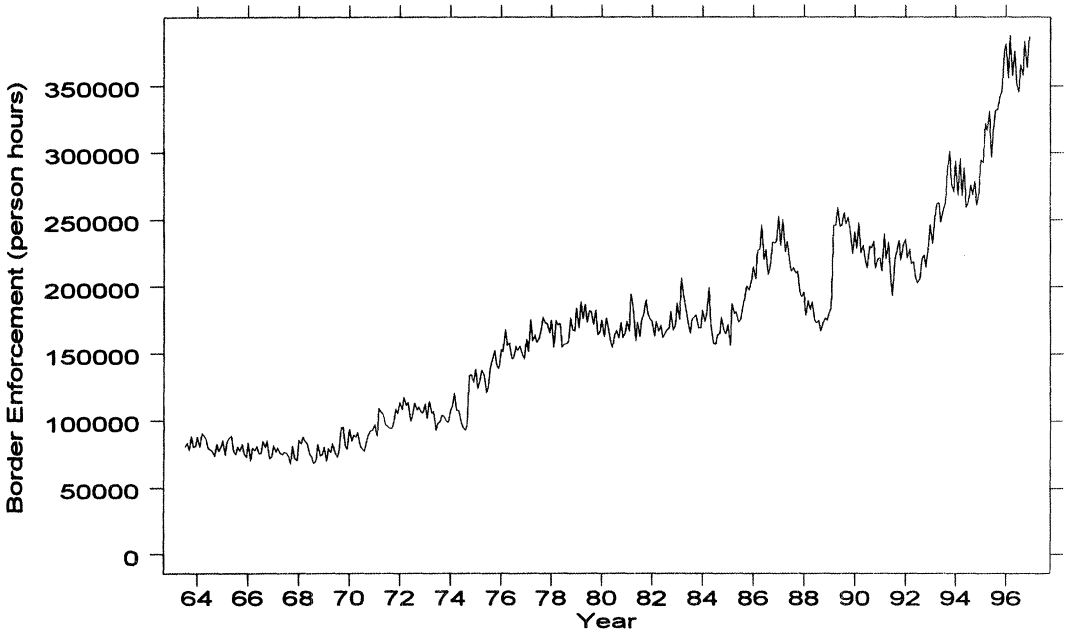

FIGURE 1B. ENFORCEMENT OF U.S.-MEXICO BORDER

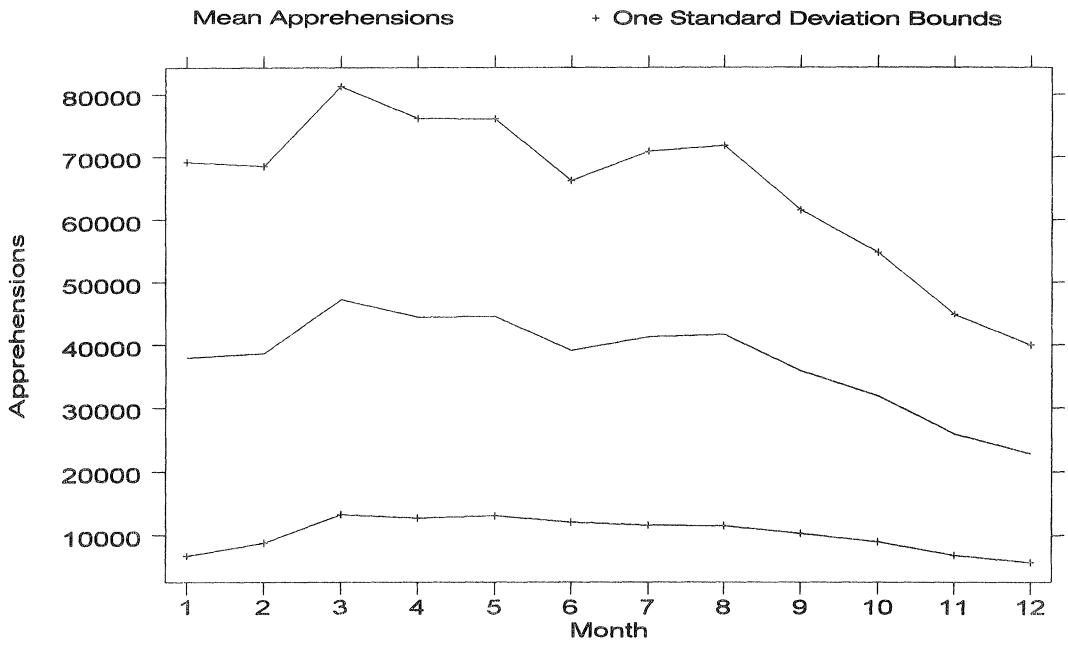

FIGURE 2A. SEASONALITY OF BORDER APPREHENSIONS

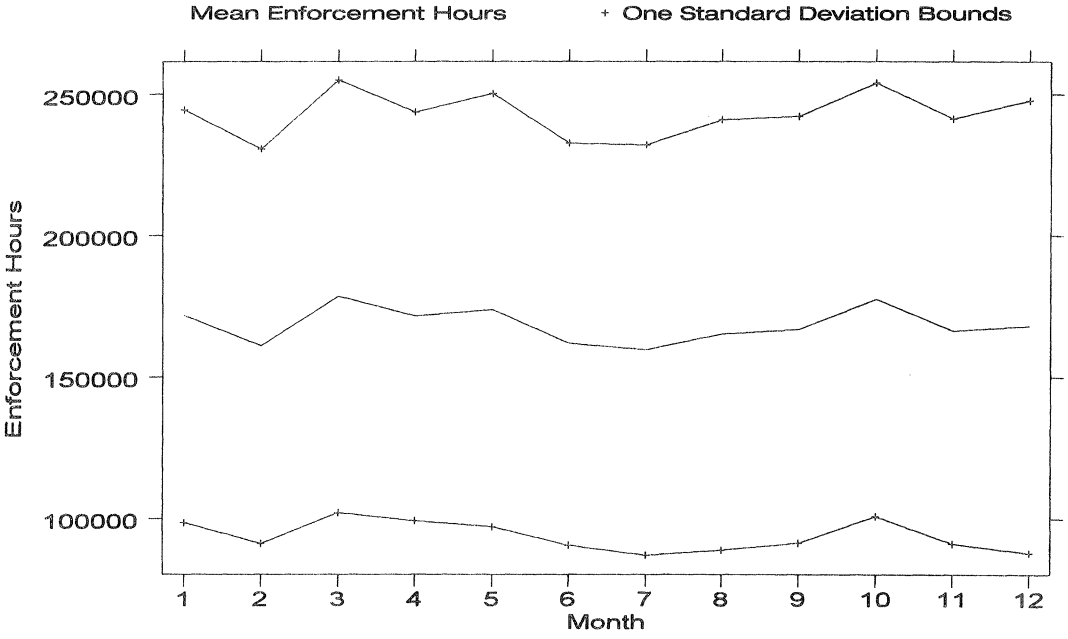

FIGURE 2B. SEASONALITY OF BORDER ENFORCEMENT

IRCA mandated an increase in U.S. Border Patrol activities, and the Bush and Clinton administrations have further raised expenditure on border enforcement.[7]

Apprehensions show a strong seasonal pattern. Figures 2A and 2B show monthly means for apprehensions and enforcement hours over the sample period. Apprehensions are stable from January through August, then decline by 40.0 percent between August and December. Border enforcement hours show no seasonal pattern. Several factors may contribute to seasonality in apprehensions. One is seasonality in U.S. agricultural labor demand. Some illegal immigrants are itinerant agricultural laborers, who work in U.S. agriculture during the spring and summer and return to Mexico to work for the rest of the year (Cornelius, 1992). The peak months for U.S. agricultural employment are May to September. One factor that may account for the end-of-year trough in apprehensions is that Mexican labor law mandates workers receive a year-end bonus, which is paid in December and can be a large fraction of annual earnings. Mexican workers planning to emigrate may be reluctant to leave their jobs late in the year. The concentration of religious holidays in December also discourages migrants from emigrating in the late fall.

Two measures of Mexican wages are available, a monthly index of the average nominal hourly wage of production labor in manufacturing, and the monthly average nominal minimum wage. Manufacturing wages are available from January 1968 onward. We deflate both series by the Mexican consumer price index (CPI). To our knowledge, no other monthly wage series are available for Mexico. One problem with the minimum wage series for our purposes is that between 1982 and 1996 the Mexican government allowed the minimum wage to fall by 74.0 percent in real terms.

An important issue is whether manufacturing wages are a relevant alternative wage for prospective migrants in Mexico. Education levels among Mexican migrants in the United States are similar to those for manufacturing workers in Mexico. Borjas (1994) reports that in 1990 average years of schooling for Mexican-born men residing in the United States was 7.6; for men employed in Mexican manufacturing in 1990 the figure was 8.1.[8] To pursue this issue, we estimate individual wage regressions using the Mexican National Urban Employment Survey, which has earnings data on a large cross section of individuals at a quarterly frequency for 1987–1995. We estimate a separate log-wage equation for each quarter, in which we include as regressors age, age squared, and dummy variables for years of education, the metropolitan area, and the 1-digit industry. The sample is males from 18 to 64 years of age who work at least 35 hours a week. Figures 3A and 3B plot the estimated coefficients on the industry dummies; the coefficients show the mean wage differential with respect to manufacturing for each industry in each quarter. While wages in manufacturing are below those in most industries, manufacturing wage differentials are stable over time with respect to all industries, except mining, which represents a small number of workers in the sample, and finance, insurance, and real estate, which has few workers who are likely to attempt illegal emigration. Given stable patterns of correlation between manufacturing wages and wages in other industries, we expect manufacturing wages to be a reasonable proxy for the alternative wage of prospective migrants.

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

[7] The INS enforcement budget increased by 83.9 percent in real terms between fiscal year 1985 and fiscal year 1995, compared to a 24.6-percent real increase in non-defense-related government spending over the same period.

[8] A large fraction of Mexican-born workers in the United States are employed in manufacturing. In 1980 45.0 percent of Mexican-born nonagricultural workers in the United States were in manufacturing; in 1990 the figure was 37.0 percent.

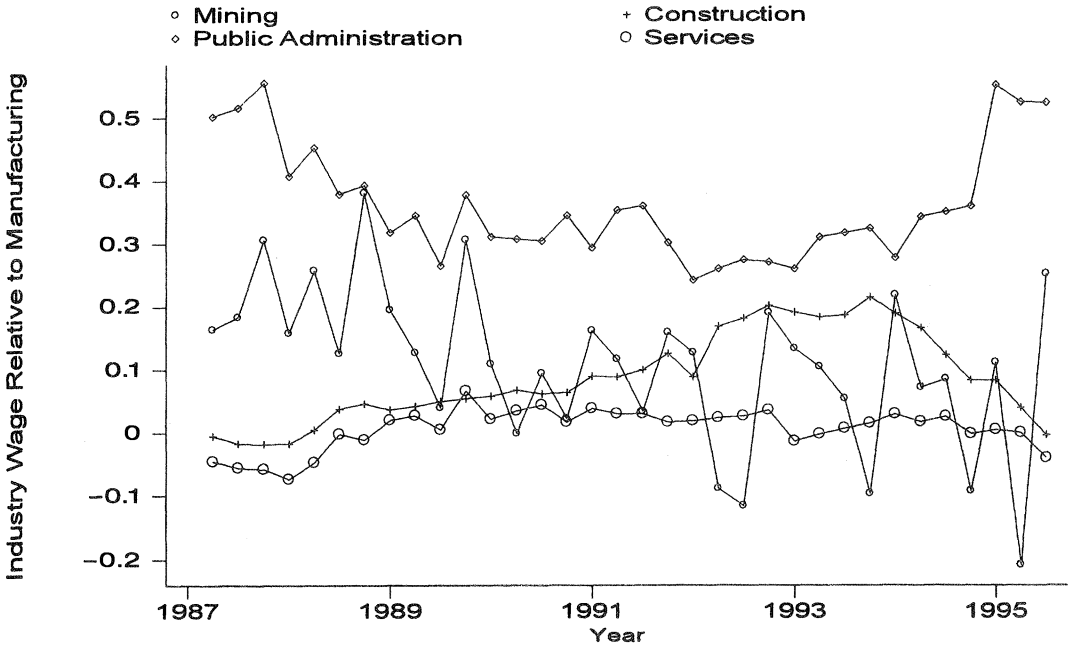

FIGURE 3A. MEXICO INTERINDUSTRY WAGE DIFFERENTIALS

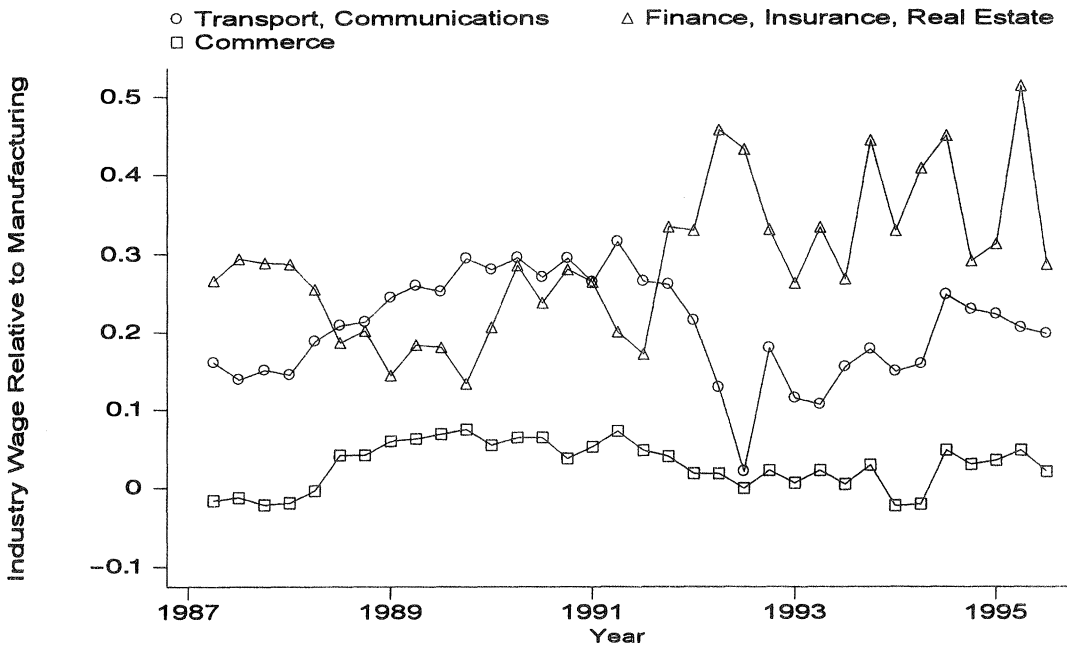

FIGURE 3B. MEXICO INTERINDUSTRY WAGE DIFFERENTIALS

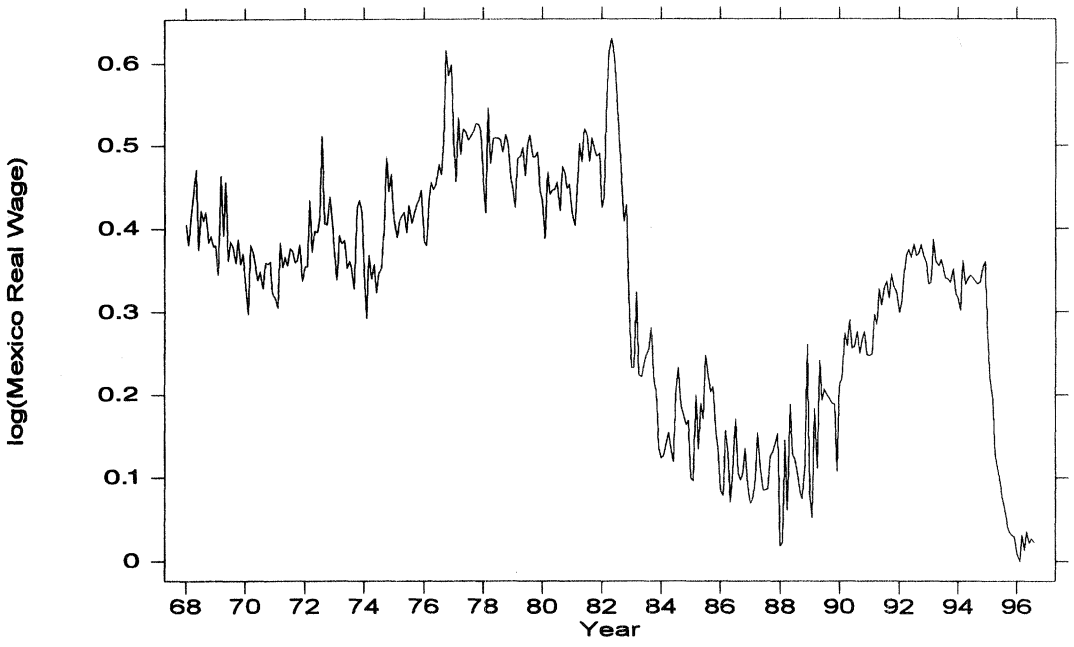

FIGURE 4A. MEXICO REAL WAGE

U.S. wage as weighted-average weekly earnings in these industries, using industry shares of nonagricultural Mexican-born workers as weights.[9] We also include the U.S. minimum wage and the U.S. unemployment rate as regressors.

One issue is how to deflate U.S. wages. Many Mexican-born individuals in the United States remit a portion of their earnings to Mexico (Durand, 1996). To the extent that migrants plan to support family members in Mexico, they may evaluate U.S. earnings in terms of peso purchasing power, rather than in terms of dollar purchasing power. We use two measures of the real U.S. wage, constant dollar wages (U.S. nominal weekly earnings/U.S. CPI) and constant peso wages (U.S. nominal weekly earnings*peso–dollar exchange rate/Mexico CPI).

Figures 4A–4C show log Mexican and U.S. real wages. The log scale is adjusted so that the lowest value each wage variable takes in any period is zero. Mexican real wages (Figure 4A) are highly volatile, with large drops following the onset of the country's debt crisis in 1982 and the peso collapse of 1994. Over the sample period there is a 61.0-percent difference between the highest and lowest value of the Mexican real wage. The U.S. real wage in constant dollar terms (Figure 4B) is relatively stable, showing a moderate decline following the 1973 and 1979 oil price shocks and a slow but steady decline during the 1980's. The U.S. real wage in constant peso terms (Figure 4C) shows the effects of relatively high rates of inflation in Mexico, punctuated by devaluations of the peso in 1976, 1982, 1987, and 1994.

To preview the estimation results for the apprehensions function, it is instructive to examine the raw correlations between border apprehensions and the main explanatory variables. Figures 5A–5D plot the change in log border apprehensions against the change in log border enforcement hours (Figure 5A), the change in the log

[9] To calculate the weights, we use employment data on Mexican-born individuals from the Public Use Microsample of the 1980 and 1990 *U.S. Census of Population*. We calculate weights as the average industry share of total Mexican-born employment in 1980 and 1990 (the weights are constant over the sample period). Monthly wage data for Hispanic individuals and for Mexican-Americans are available from the Bureau of Labor Statistics, but not until late in the sample period. These data are highly correlated with the wage series we construct.

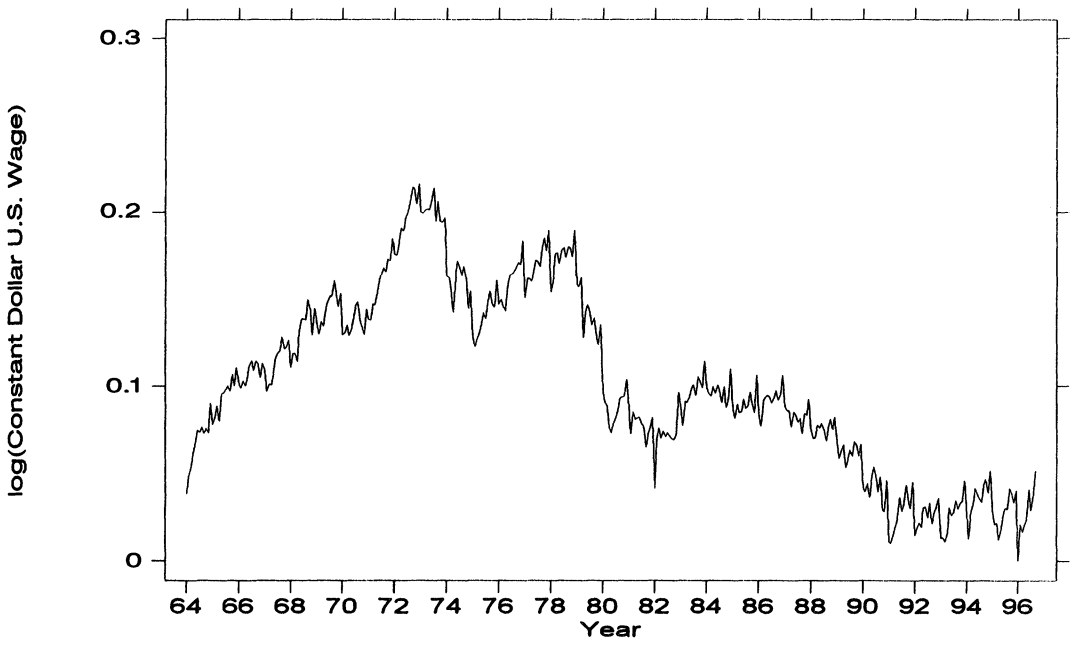

FIGURE 4B. CONSTANT DOLLAR U.S. WAGE

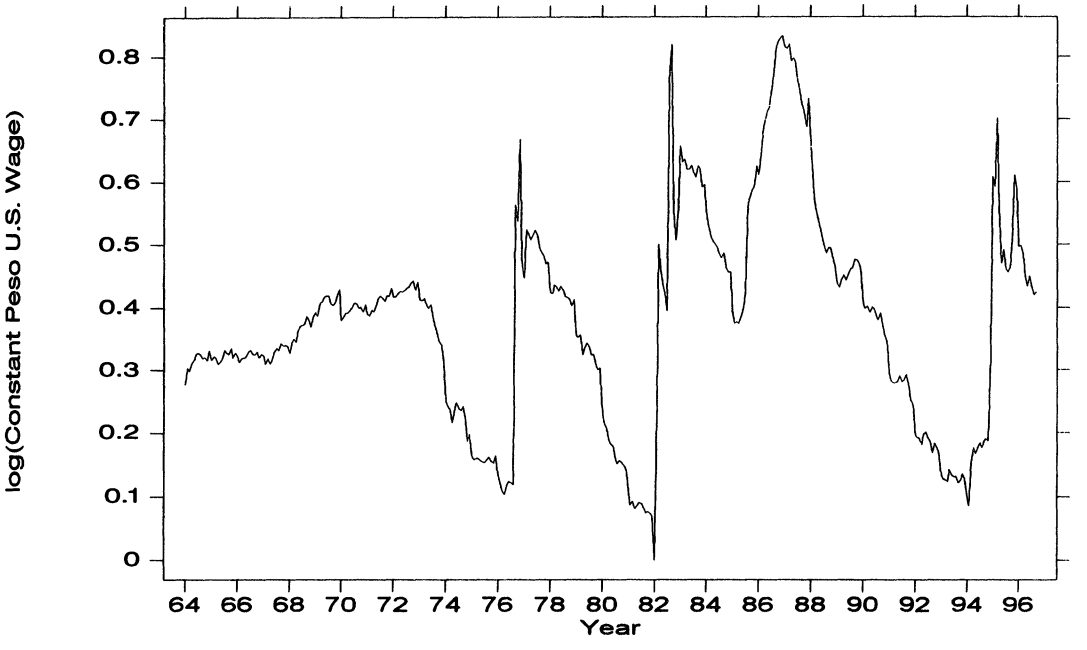

FIGURE 4C. CONSTANT PESO U.S. WAGE

Mexico real wage (Figure 5B), the change in the log constant dollar U.S. wage (Figure 5C), and the change in the log constant peso U.S. wage (Figure 5D).[10] In each graph, we show the regression line and report the regression coefficient and coefficient standard error associated with the regressor. As expected, there is a strong positive correlation between apprehensions and enforcement. This is consistent with the hypothesis that increases in enforcement are associated with increases in the number of illegal immigrants that are caught attempting to cross the border. There is a strong negative correlation between border apprehensions and the Mexico real wage, which suggests that periods of falling real wages in Mexico are associated with periods of increased attempted illegal immigration. There is a positive correlation between border apprehensions and either the constant dollar U.S. wage or the constant peso U.S. wage, which is consistent with the hypothesis that higher U.S. wages attract illegal immigrants to the United States, but both correlations are weaker in terms of statistical significance than that for Mexican wages. It appears that Mexican wages are a more reliable predictor of apprehensions than either measure of U.S. wages.[11] The estimation results we present in the next section confirm these findings.

III. Empirical Results

A. *Specification and Estimation Issues*

Following the apprehensions function in equation (2), we estimate log border apprehensions as a function of log border enforcement hours, the log Mexico real wage, the log U.S. real dollar wage, the log U.S. real peso wage, and a time trend.[12] To control for seasonality in apprehensions, we include monthly dummy variables in the estimation.

We control for other factors which may influence illegal immigration by including three sets of additional regressors. The first set includes the U.S. unemployment rate, which is a predictor of the likelihood that migrants will be able to find a job upon crossing the border, and the log Mexican and U.S. real minimum wages, which are additional measures of labor-market tightness.[13] The second set of regressors includes controls for U.S. immigration policy: a dummy variable for whether the fiscal year is 1987 or later, when IRCA was implemented, and a dummy variable for whether the fiscal year is 1992 or later, when the Immigration Act of 1990 was implemented. IRCA mandated an increase in resources to control illegal immigration, raised sanctions on employers that hire illegal aliens, and granted legal status to illegal aliens that had been in the United States continuously since 1982; the Immigration Act of 1990 established caps on legal immigration and altered the criterion for legal admission to favor immediate family members of U.S. citizens. The third set of regressors includes log legal admissions of non-Mexican individuals and log legal admissions of Mexican individuals. We use admissions from the previous fiscal year to control for the possibility that shocks to legal and illegal immigration may be correlated. Past legal immigration may signal the intensity with which the INS will enforce illegal immigration in the future. Legal immigration of Mexican individuals may also affect the incentive for future immigration from Mexico.

Several estimation issues call for attention. A first is that shocks to apprehensions may be serially correlated. Consider a shock which increases the number of Mexican residents who wish to enter the United States illegally. If residents of northern Mexico respond more quickly to the shock than do residents of southern Mexico, the shock will generate an increase

[10] We seasonally adjust each series by regressing the log change of a variable on monthly dummy variables. We use the residuals from these regressions to construct Figures 5A–5D.

[11] The scatterplot for the log change in the constant peso U.S. wage, Figure 5D, shows that the series has a number of outliers with large positive values. These outliers correspond to maxi-devaluations of the peso, each of which is evident in Figure 4D.

[12] The INS altered data collection and reporting procedures in 1977 and again in 1990. To control for the possible effects of definitional changes, we include dummy variables for whether the year is 1977 or later and for whether the year is 1990 or later and the interaction terms between these dummy variables and the time trend.

[13] We do not include the Mexican unemployment rate since data on the variable (and most other data on Mexican economic activity) are unavailable on a monthly basis until 1985.

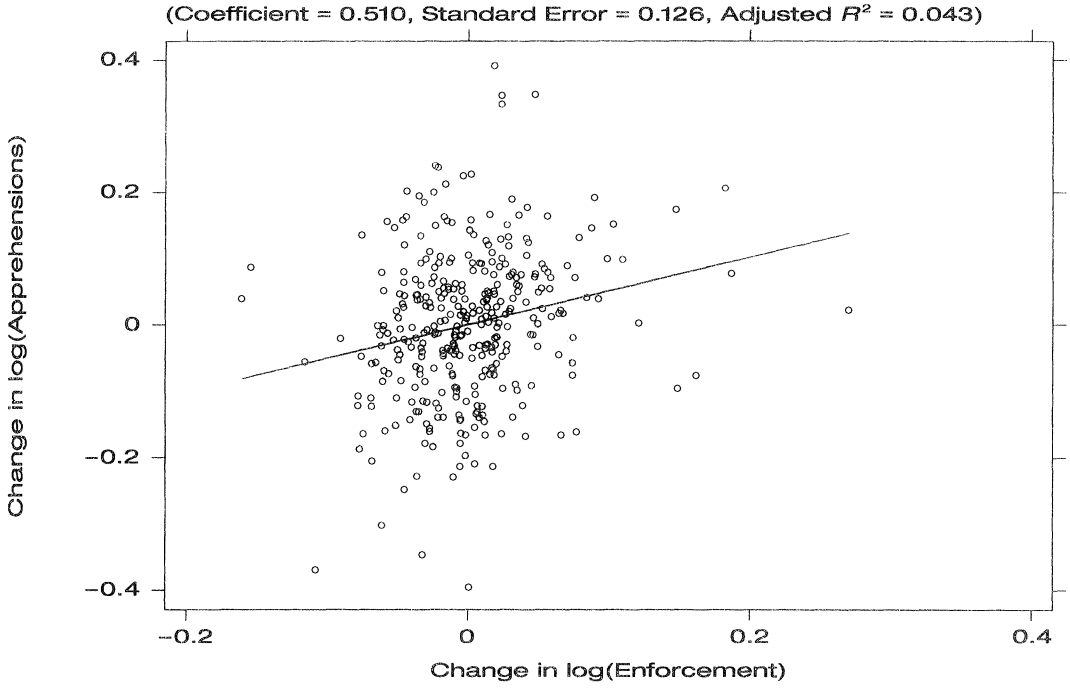

FIGURE 5A. BORDER APPREHENSIONS AND BORDER ENFORCEMENT

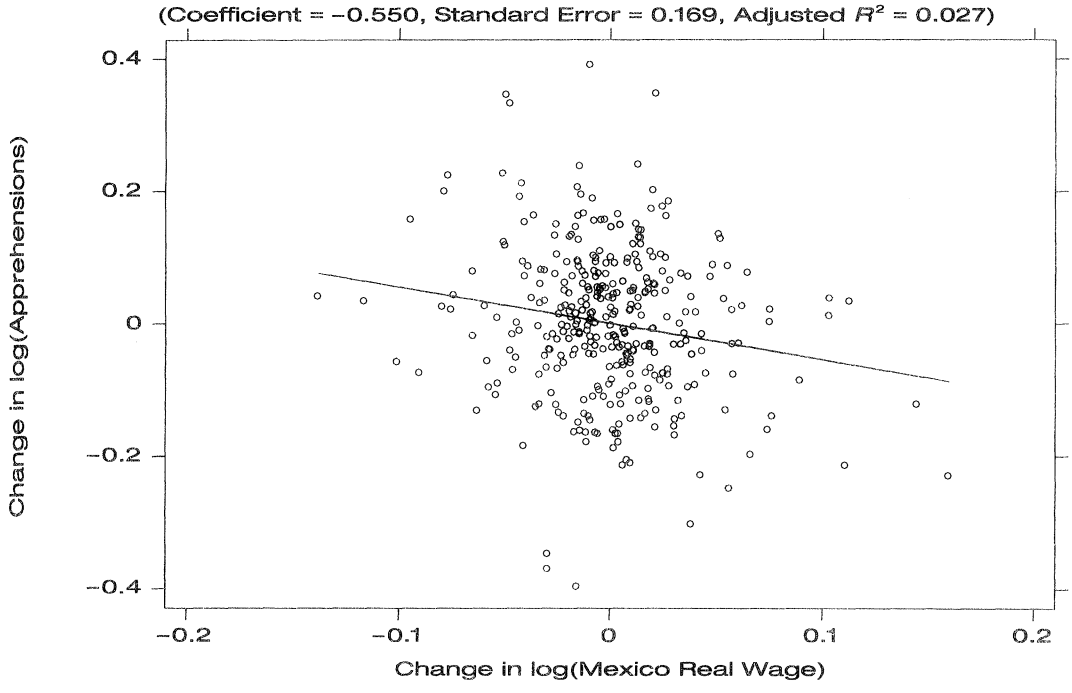

FIGURE 5B. BORDER APPREHENSIONS AND MEXICO REAL WAGE

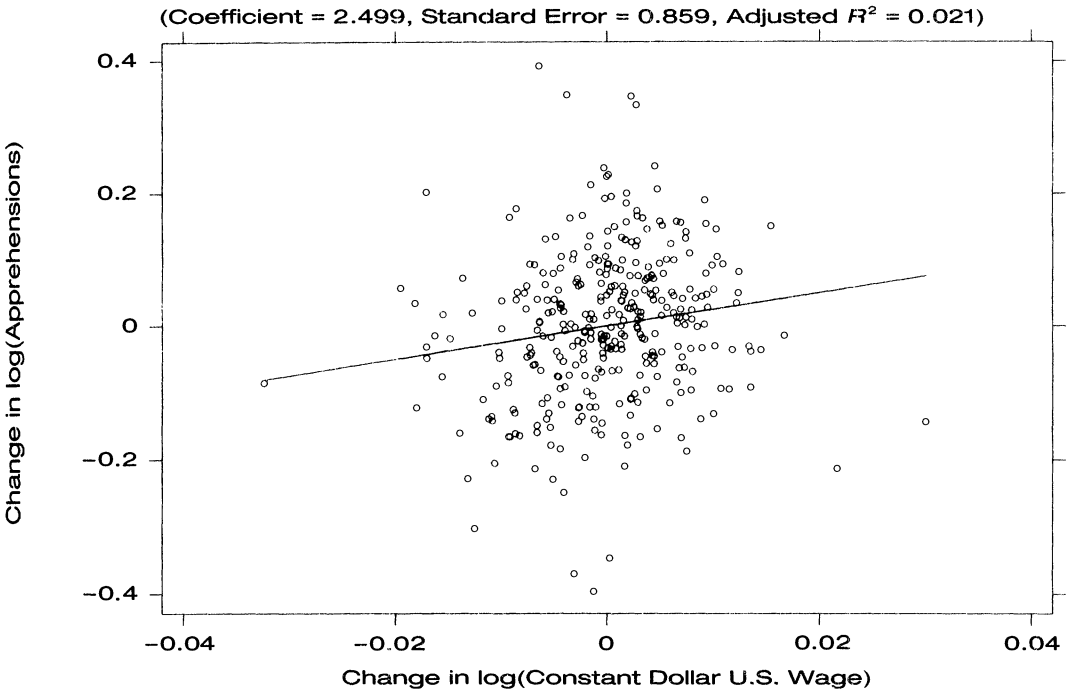

FIGURE 5C. BORDER APPREHENSIONS AND CONSTANT DOLLAR U.S. WAGE

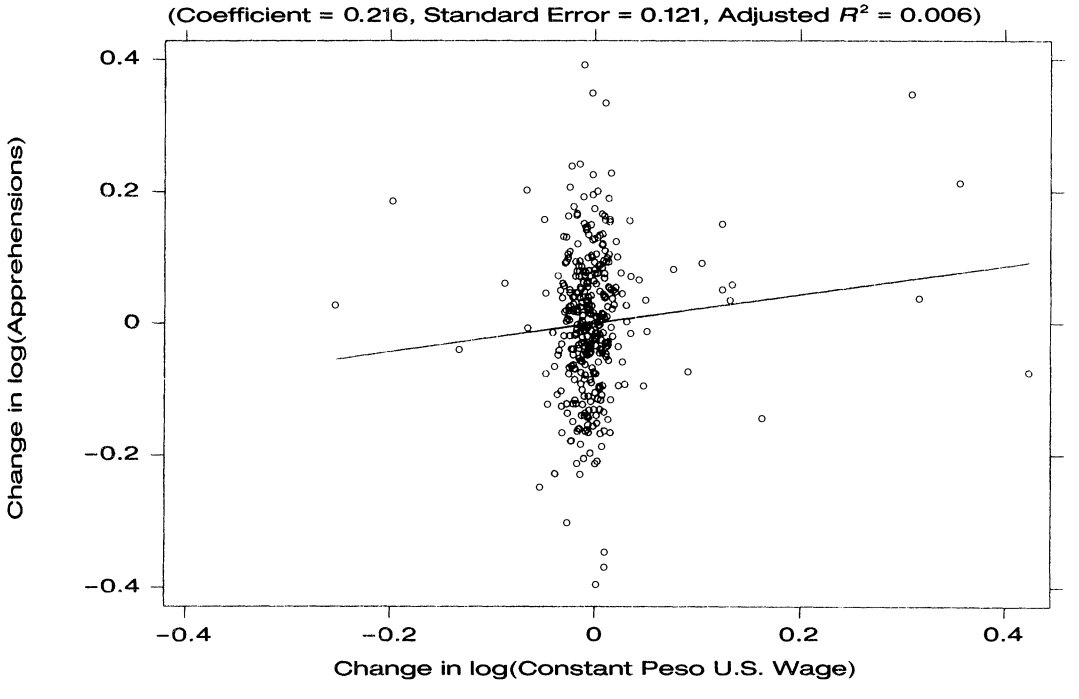

FIGURE 5D. BORDER APPREHENSIONS AND CONSTANT PESO U.S. WAGE

in attempted illegal immigration over several time periods. An additional source of persistence in apprehensions is that individuals who are apprehended by the U.S. Border Patrol at the U.S.-Mexico border 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 their actual residence, they may attempt to cross the border again in the near future, adding a dynamic component to the apprehensions process. To control for serial correlation in shocks to apprehensions, we estimate two specifications of the apprehensions function. In the first specification, we allow the disturbance term to follow a first-order autoregressive [AR(1)] process; in the second specification, we impose the assumption of a unit root in the disturbance term and estimate the apprehensions function in first differences.[14]

A second estimation issue 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 budget the U.S. Congress sets in the previous fiscal year, it may have some discretion in deploying its budgeted resources. The INS may choose to shift resources towards border enforcement in response to increases in attempts to cross the border or to changes in U.S. or Mexican economic conditions.

To control for the endogeneity of enforcement hours, we estimate the apprehensions function using instrumental-variables techniques. The instruments we use for enforcement hours are real U.S. government expenditures on national defense in the current fiscal year and a series of dummy variables that indicate whether a U.S. presidential election, a U.S. congressional election, or a Texas gubernatorial election will occur in the current calendar year. National defense is an activity that competes for resources with the INS. The current level of defense spending is an indicator of the political environment in the *previous* fiscal year when the U.S. Congress made budgetary allocations. In election years, politicians may manipulate the level or the allocation of public spending to improve their electoral prospects. The budgeted resources available to the INS may follow a political cycle, in which case the timing of elections will be correlated with border enforcement.[15] We also include as instruments current and lagged values of the exogenous regressors and long lags of enforcement hours and apprehensions.

B. *Estimation Results*

Table 2 reports estimation results, in which we allow the disturbance term to follow an AR(1) process. Theory provides little guidance on the appropriate number of lags to include on the regressors. We present specifications that obtain the lowest value of the Schwartz Bayesian Information Criterion. In all cases, this specification includes the contemporaneous values of the regressors only. The first two columns of Table 2 show regressions without dummy variables for IRCA and the Immigration Act of 1990; the second two columns include the variables. In columns (1b) and (2b), we estimate border apprehensions by instrumental variables (IV), following the procedure in Ray C. Fair (1970). The time period for the estimation is January, 1968 to August, 1996, the period for which we have Mexican wage data. There is strong evidence of serial correlation in the disturbances. The autocorrelation coefficient ranges in value from 0.68 to 0.78 and is very precisely estimated.

The estimated coefficient for a regressor can be interpreted as the long-run elasticity of border apprehensions with respect to that regressor. The elasticity of apprehensions with respect to border enforcement hours is positive, as expected, which suggests that the marginal product of enforcement is positive. The elasticity varies from 0.53 to 0.55 in AR(1) regressions and from 0.80 to 1.23 in IV-AR(1) regressions; in all regressions it is highly statistically significant. In the IV regression that includes dummy variables for U.S. immigra-

[14] We do not find evidence of nonstationarity in apprehensions. In augmented Dickey-Fuller tests for apprehensions and enforcement hours, we reject the null hypothesis of a unit root at the 10-percent significance level for both variables.

[15] Controlling for the exogenous regressors in the apprehensions function, we find that border enforcement hours are significantly lower in election years.

TABLE 2—AR(1) SPECIFICATION OF BORDER APPREHENSIONS, 1968–1996
(Asymptotic t-statistics in Parentheses)

Method	AR(1)	IV-AR(1)	AR(1)	IV-AR(1)
Variable	(1a)	(1b)	(2a)	(2b)
Enforcement	0.533	0.801	0.552	1.233
	(4.295)	(6.398)	(4.468)	(8.198)
Mexican real wage	−0.637	−0.705	−0.676	−0.862
	(−3.923)	(−4.290)	(−4.129)	(−5.042)
U.S. dollar wage	1.567	1.394	1.637	0.900
	(2.014)	(1.806)	(2.161)	(1.187)
U.S. peso wage	0.154	0.153	0.172	0.192
	(1.464)	(1.463)	(1.661)	(1.841)
IRCA	—	—	−0.118	−0.224
			(−1.379)	(−2.679)
Immigration Act 1990	—	—	0.117	0.223
			(1.167)	(2.212)
Mexican admissions	0.062	0.063	0.060	0.055
	(1.505)	(1.547)	(1.472)	(1.350)
Other admissions	−0.011	0.010	−0.065	−0.088
	(−0.064)	(0.055)	(−0.365)	(−0.488)
U.S. unemployment	0.198	0.170	0.157	−0.020
	(1.815)	1.593	(1.468)	−0.188
Mexican minimum wage	−0.046	−0.050	−0.048	−0.092
	(−0.332)	(−0.353)	(−0.340)	(−0.616)
U.S. minimum wage	−0.274	−0.241	−0.300	−0.257
	(−0.936)	(−0.826)	(−1.039)	(−0.871)
Time	0.203	0.188	0.206	0.185
	(8.554)	(8.305)	(9.253)	(8.492)
AR(1) coefficient	0.779	0.758	0.744	0.676
	(21.539)	(20.360)	(19.062)	(15.470)
Durbin-Watson statistic	1.818	1.804	1.813	1.784
Adjusted R^2	0.987	0.987	0.987	0.985
Observations	342	342	342	342

Notes: The time period is March 1968 to August 1996. All continuous variables are in logs. See Table 1 for variable definitions. Additional regressors (not shown) are monthly dummy variables, and dummy variables for whether the year is 1977 or later and for whether year is 1990 or later (see footnote 12) and the interaction of these dummies with the time trend. In columns (1b) and (2b) we instrument for Enforcement. The IV estimation procedure follows Fair (1970). Instruments are log real U.S. government expenditures on national defense in the current fiscal year; dummy variables for whether a U.S. presidential election, U.S. congressional election, or Texas gubernatorial election will occur in the current calendar year; current and lagged values of the exogenous regressors (U.S. and Mexican wages, monthly dummies, time trend, etc.); and lagged values of apprehensions and enforcement hours.

tion policy, the magnitude of the elasticity suggests that there may be increasing returns to scale in border enforcement.

There is a negative and statistically significant correlation between border apprehensions and the current Mexican real wage. This finding is consistent with the hypothesis that a decline in Mexican wages relative to U.S. wages contributes to an increase in attempted illegal immigration in the United States from Mexico. The elasticity of apprehensions with respect to the Mexican wage ranges from −0.64 to −0.86 and is statistically significant in all cases. The large negative elasticities we estimate for Mexican wages suggest that apprehensions are highly sensitive to changes in Mexican wages. This result is surprising in light of previous literature on migration, which tends to find that pull factors, which in this case are U.S. wages, matter more than push factors, which in this case are Mexican wages (e.g., R. Paul Shaw, 1986).

Both the constant dollar U.S. wage and the constant peso U.S. wage are positively correlated with apprehensions. The elasticity of

apprehensions with respect to the constant dollar U.S. wage ranges in value from 0.90 to 1.64 and is statistically significant at the 5.0-percent level in two regressions. The elasticity of apprehensions with respect to the constant peso U.S. wage ranges in value from 0.15 to 0.19 and is statistically significant at the 10-percent level in two regressions. The positive correlation between constant peso U.S. wages and apprehensions suggests that prospective migrants evaluate U.S. earnings in peso terms. This finding is consistent with case studies on illegal immigration (Durand, 1996), which suggest that Mexican immigrants remit a portion of their earnings to family members in Mexico.

The contemporaneous correlation between apprehensions and U.S. and Mexican wages suggests that the effect of wages on apprehensions is immediate: when U.S. and Mexican wages change, apprehensions respond within the current month. The rapid response in illegal immigration to innovations in wages is one indication that U.S. and Mexican labor markets are tightly linked. Through illegal immigration, shocks to Mexican (U.S.) wages affect the stock of workers in the United States (Mexico). We also find much larger effects of U.S. and Mexican wages on apprehensions than have previous studies (Bean et al., 1990). This may be due to the fact we examine a longer time period than earlier literature (1968–1996 versus 1977–1989); our sample period includes multiple cycles of boom and bust in the Mexican economy.

In terms of the additional regressors, we find some evidence that apprehensions respond to changes in U.S. immigration policy. The dummy variable for IRCA indicates that apprehensions fell by 12.0 to 22.0 percent following the passage of the legislation in 1986. The IRCA dummy is statistically significant in one regression. This finding is consistent with the hypothesis that there was a reduction in illegal attempts to cross the U.S.-Mexico border following IRCA. Bean et al. (1990) obtain similar results for the period 1977–1989. The dummy variable for the passage of the Immigration Act of 1990 is positive and in both regressions it is of sufficient magnitude to negate the IRCA effect. We fail to reject the null hypothesis that the sum of the coefficients on the two dummy variables is zero at any level of significance. We interpret this result to mean that the decline in apprehensions following IRCA was temporary, not that the Immigration Act of 1990 somehow increased illegal immigration.[16]

To pursue the issue of how U.S. immigration policy influences illegal immigration, we examine whether legal admissions are correlated with apprehensions. The elasticity of apprehensions with respect to lagged log legal admissions of Mexican individuals is positive, though statistically insignificant, in all regressions. This is weakly consistent with the hypothesis that legal immigration today contributes to illegal attempts to enter the United States in the future. One channel through which this may occur is that U.S. immigration policy favors family members of legal residents. Once a Mexican resident obtains legal status, his or her family members may come to United States illegally in the expectation that they will be granted legal entry. A second channel is network effects. Borjas (1992, 1995) finds that human-capital accumulation in one generation is positively correlated with human capital accumulated in the previous generation by individuals of the same ethnic group. If ethnicity has external effects, legal immigration from a country today may increase immigration from that country in the future. Legal admissions of non-Mexicans do not appear to influence apprehensions; the correlation between the variable and apprehensions is essentially zero in all regressions.

The other additional regressors are weakly correlated with apprehensions. The U.S. unemployment rate is negatively correlated with apprehensions in one regression and, surprisingly, positively correlated with apprehensions in three regressions, but it is imprecisely estimated in all cases. The log real U.S. minimum wage and the log real Mexican minimum wage are both negatively correlated with apprehensions and imprecisely estimated in all regressions. While the negative correlation for the U.S. minimum wage is counterintuitive—we expect the demand for illegal labor to be high when the minimum wage is high—it may be spurious. The real U.S. minimum wage falls by 55.4

[16] In unreported results, we examine whether there was a structural break in the regression equation after the passage of IRCA. We fail to reject the null hypothesis that the coefficients on enforcement hours, U.S. and Mexican wages, and other regressors are stable over time.

TABLE 3—FIRST-DIFFERENCE SPECIFICATION OF BORDER APPREHENSIONS, 1968–1996
(Asymptotic t-statistics in Parentheses)

Method	OLS	IV	OLS	IV
Variable	(1a)	(1b)	(2a)	(2b)
Enforcement	0.544	1.273	0.544	1.292
	(4.262)	(2.724)	(4.245)	(2.716)
Mexican real wage	−0.590	−0.769	−0.590	−0.777
	(−3.387)	(−3.603)	(−3.368)	(−3.584)
U.S. dollar wage	1.631	1.074	1.629	1.057
	(1.856)	(1.091)	(1.847)	(1.066)
U.S. peso wage	0.164	0.198	0.162	0.201
	(1.341)	(1.525)	(1.319)	(1.525)
IRCA	—	—	−0.004	0.003
			(−0.128)	(0.094)
Immigration Act 1990	—	—	0.009	0.013
			(0.242)	(0.348)
Mexican admissions	0.064	0.061	0.064	0.062
	(1.274)	(1.162)	(1.282)	(1.164)
Other admissions	−0.116	−0.129	−0.119	−0.136
	(−0.584)	(−0.620)	(−0.596)	(−0.647)
U.S. unemployment	0.140	0.068	0.137	0.064
	(1.049)	(0.467)	(1.027)	(0.431)
Mexican minimum wage	−0.030	0.027	−0.031	0.027
	(−0.222)	(0.187)	(−0.228)	(0.187)
U.S. minimum wage	−0.436	−0.371	−0.441	−0.378
	(−1.343)	(−1.081)	(−1.350)	(−1.094)
Time	−0.004	−0.006	−0.004	−0.006
	(−1.030)	(−1.217)	(−1.025)	(−1.215)
Durbin-Watson statistic	2.003	2.057	2.004	2.059
Adjusted R^2	0.767	0.743	0.766	0.740
Observations	342	342	342	342

Notes: The time period is March 1968 to August 1996. All continuous variables are in log first differences. In columns (1b) and (2b) we instrument for Enforcement. See Table 1 for variable definitions and Table 2 for the set of instruments included in IV regressions.

percent over the sample period, with a steady decline in the 1980's when Mexico experienced several severe contractions.

To check the sensitivity of our results, we estimate a simpler but more restrictive version of the apprehensions function in which we assume that the disturbance term has a unit root. The resulting specification is the apprehensions function in first-differenced form, which we estimate by ordinary least squares (OLS) and IV, using the same set of instruments as in Table 2. Table 3 reports the results. Coefficient estimates are nearly identical to those in Table 2. One slight difference is that the elasticity of apprehensions with respect to enforcement is now greater than one in both IV regressions, which is again consistent with increasing returns in border enforcement.

In unreported results we experiment with additional regressors and with additional specifications of the apprehensions function. We find no statistically significant (or economically significant) correlation between apprehensions and other measures of economic activity in the United States (industrial production, nonagricultural employment and average weekly hours, California and Texas unemployment rates), other measures of economic activity in Mexico (total imports), or other seasonal factors (U.S. unemployment rate for agricultural labor, monthly precipitation, and average temperatures in California, Florida, and Texas). The inclusion of these variables has little impact on the results that we report in Tables 2–3. IV results are robust to the exclusion of individual variables from the set of instruments. We also examine whether the regression parameters are stable across the four seasons of the year; we fail to reject the null hypothesis that the regression parameters are stable over time.

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 elasticity of apprehensions with respect to the Mexican real wage, W^{mx}. From the apprehensions function in (2), $A_t = P_t * M_t$ (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,

$$(3) \qquad \frac{\partial \ln A}{\partial \ln W^{mx}} = \left(1 + \frac{\partial \ln P}{\partial \ln M}\right) * \frac{\partial \ln M}{\partial \ln W^{mx}}.$$

The term of interest is $\partial \ln M / \partial \ln W^{mx}$, the elasticity of illegal attempts to cross the border with respect to the Mexican real wage. Elasticities for U.S. wages are analogous.

Suppose that $\partial \ln P / \partial \ln M \leq 0$, or that the probability an individual migrant is apprehended is decreasing in total illegal attempts to cross the border. This assumption is not very restrictive, as it is difficult to imagine conditions under which, for constant enforcement, more attempts to cross the border increase the likelihood that an individual migrant is caught. If it is also true that $-1 \leq \partial \ln P / \partial \ln M$, then $\partial \ln A / \partial \ln W^{mx}$ is a lower bound for $\partial \ln M / \partial \ln W^{mx}$. A justification for assuming that $-1 \leq \partial \ln P / \partial \ln M$ is that the coefficient we estimate, $\partial \ln A / \partial \ln W^{mx}$, is negative and we expect $\partial \ln M / \partial \ln W^{mx}$ to be negative, given that intuition suggests that reductions in the Mexican real wage should raise the incentive to migrate. As long as $-1 \leq \partial \ln P / \partial \ln M \leq 0$, the results in Table 2 suggest that a 10-percent decrease in the Mexican real wage gives rise to *at least* a 6.4- to 8.7-percent increase in attempted illegal immigration.[17]

A similar argument applies to the interpretation of the enforcement elasticity of apprehensions. From equation (2), the elasticity of apprehensions with respect to enforcement that we estimate, $\partial \ln A / \partial \ln H$, can be decomposed as,

$$(4) \qquad \frac{\partial \ln A}{\partial \ln H} = \frac{\partial \ln P}{\partial \ln H} + \left(1 + \frac{\partial \ln P}{\partial \ln M}\right) * \frac{\partial \ln M}{\partial \ln H}.$$

The term, $\partial \ln P / \partial \ln H$, is the elasticity of the apprehensions probability with respect to enforcement, which is the *direct effect* of enforcement on apprehensions. The term, $\partial \ln M / \partial \ln H$, is the elasticity of illegal attempts to cross the border with respect to border enforcement, which is the *deterrent effect* of border enforcement on illegal immigration. Enforcement impedes illegal immigration in two ways: by capturing those that attempt to cross the border and by deterring those that would attempt to cross the border at a lower level of enforcement. From previous discussion, we expect $-1 \leq \partial \ln P / \partial \ln M \leq 0$. The existence of a deterrent effect would imply that $\partial \ln M / \partial \ln H \leq 0$, which would make the second right-hand-side term in (4) negative and imply $\partial \ln P / \partial \ln H \geq \partial \ln A / \partial \ln H$. To the extent a deterrent effect exists, we underestimate the direct effect of enforcement. Given IV estimates of $\partial \ln A / \partial \ln H$ in Tables 2 and 3, which are greater than 1, a 1-percent increase in border enforcement would give rise to at least a 1-percent increase in the apprehensions probability. Our findings thus suggest that the effectiveness of border enforcement may rise with the level of enforcement.

IV. Concluding Remarks

This paper uses data on apprehensions by the U.S. Border Patrol at U.S. borders to examine illegal immigration from Mexico in the United States. We find a negative correlation between the Mexican real wage and border apprehensions and a positive correlation between U.S. real wages and border apprehensions. The elasticity of border apprehensions with respect to the Mexican real wage is -0.64 to -0.86, which is consistent with the hypothesis that attempted illegal immigration is highly sensitive to changes in Mexican wages. The purchasing power of U.S. wages in pesos, as well as

[17] We assume implicitly that wages do not affect P_t, the apprehensions probability. This assumption may be violated if wage levels influence the composition of individuals that attempt to cross the border. Case study evidence (see footnote 6) suggests that the composition of border crossers does not affect the apprehensions probability (Donato et al., 1992).

their purchasing power in dollars, matters for border apprehensions. This suggests that, consistent with case study evidence, prospective migrants expect to maintain links with Mexico, through return migration or through supporting family members at home. We also find that the elasticity of border apprehensions with respect to border enforcement is positive, with instrumental variables results indicating that there may be increasing returns to scale in border enforcement.

The importance of U.S. and Mexican wages for border apprehensions suggests that factors that reduce the U.S.-Mexico wage gap would also reduce illegal Mexican immigration. These findings offer support for claims 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 wages on border apprehensions that we find suggests that it is a key factor in the illegal migration decision.

One striking feature of the effect of U.S. and Mexican wages on apprehensions is that it is immediate: a reduction in the Mexican real wage or an increase in U.S. real wages leads to an increase in apprehensions in the current month. This suggests that U.S. and Mexican labor markets are tightly linked. Mexican residents respond to occasional steep declines in relative Mexican wages, which are associated primarily with exchange-rate crises, by seeking safe haven in the United States. This finding has implications beyond Mexico, for it suggests that labor markets in developing countries respond to shocks far more quickly than previous research indicates. Macroeconomic instability may thus condition the nature of labor-market integration between neighboring countries.

Data Appendix: Border Apprehensions and Border Enforcement Hours

All data on border apprehensions and enforcement hours 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 U.S. interior. 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. Since linewatch apprehensions occur at an international border, we know the moment in time when those apprehended attempt to enter the United States, allowing us to match these data to economic conditions in the United States and Mexico. Non-linewatch apprehensions occur at U.S. Border Patrol traffic checkpoints, raids on businesses, and interior patrols (Bean et al., 1990). We have no way of knowing when individuals apprehended by Border Patrol officers on non-linewatch duty first entered the country. Also, a consistent series on non-linewatch enforcement hours exist only for fiscal years 1977 forward. Over the period 1977–1996, linewatch apprehensions account for 61.2 percent 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 A1 reports sample means and sample correlations for the two series over the period for which they overlap, 1977 to 1996.

Over the period 1977–1996, 99.2 percent of linewatch apprehensions and 91.6 percent of linewatch enforcement hours occur at the U.S.-Mexico border. The two linewatch apprehensions series and the two linewatch enforcement hour series are nearly perfectly correlated. While it is possible that the two linewatch series deviate more sharply over the earlier period 1964–1976, for which we cannot make a

TABLE A1—INS APPREHENSIONS DATA, 1977–1996

	Mean	Standard error	Correlation	*N*
Linewatch apprehensions				
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

comparison, we believe this to be unlikely. The Statistics Division of the INS reports that since the early 1950's 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 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, which are also very similar to those in Tables 2 and 3.

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