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Northern Triangle Undocumented Migration to the United States

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ABSTRACT: Undocumented migration from the Northern Triangle countries (El Salvador, Guatemala and Honduras) to the United States has been steadily increasing over the past 30 years, accelerating at times. The paper investigates what factors could explain this fact, by estimating an investment decision model, using annual data over 1990-2019. Economic labor market conditions (real wages and unemployment rates, especially in the U.S.) play a major role in explaining undocumented migration. Less explored drivers of undocumented migration tied to living conditions at home also explain well undocumented migration (natural disasters, coffee production, higher temperatures, and homicide rates). Tighter border enforcement measures act as a deterrent, and perceptions regarding changes of these measures could also drive up undocumented migration at times. Policies that address the root causes of migration at home, including with the U.S. help, are essential in reducing the difference between perceived benefits and expected costs of migration.

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WORKING PAPERS

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Glossary

CBP – U.S. Customs and Border Protection

CMS – Center for Migration Studies

DACA – Deferred Action for Childhood Arrivals

DHS – U.S. Department of Homeland Security

ECLAC – Economic Commission for Latin America and the Caribbean

FAOSTAT – Statistics Department of the Food and Agriculture Organization of the United Nations

IDA – Institute for Defense Analyses

ILO – International Labor Organization of the United Nations

IRCA – Immigration Reform and Control Act

NT – Northern Triangle

UNODC – United Nations Office on Drugs and Crime

USDA – U.S. Department of Agriculture

I. Introduction

Over time a steady influx of migrants from the Northern Triangle countries (NT: El Salvador, Guatemala, and Honduras) have settled in the United States, mostly undocumented. Out of the 3 million migrants of NT origin living in the U.S in 2019, more than half were undocumented, representing the second largest demographic group of undocumented migrants in the U.S. (Center for Migration Studies, 2022). The main mode of arrival is undocumented entry across the U.S. Southwest border, and during 2014-19 migrants from the NT countries represented the largest group arriving undocumented at the U.S. Southwest border.

This steady increase in the population of undocumented NT migrants to the U.S. occurred against the backdrop of tighter U.S. immigration policy and enforcement measures. Between 1990 and 2019 the U.S. border enforcement tightened substantially, including due to: (i) an increase in the number of border agents (which increased by nearly 400 percent), (ii) greater coverage of the border wall barrier (which increased by over 240 percent, to 654 miles), and (iii) expanded coverage of versatile border surveillance equipment. At the same time, undocumented migration from the NT countries increased almost four-fold, from half million in 1990 to 1.8 million by 2019.

Understanding the factors that drive undocumented migration has important policy implications for NT countries, as well as broadly for other countries which are experiencing increased emigration. Understanding migration more broadly has macro-critical implications for the economy, as migrants send remittances home, and emigration reduces the domestic labor supply, and thereby could lower economic growth.[1] Media has documented well the human costs of the perilous journey to reach the U.S. for an undocumented migrant, especially from the NT countries. Most importantly, these articles—based on individual interviews—as well as U.S. Customs and Border Protection (CBP) Border Patrol reports present anecdotal evidence of various factors driving undocumented migration from the NT countries, citing frequently among other causes high crime, especially gang related, loss of livelihood due to low commodity prices, droughts, and frequent natural disaster events. The Migration Policy Institute shows in 2022 based on survey data that economic conditions—wages/incomes, unemployment, and job prospects—represent the vast majority of the motivating factors for the decision to migrate. Amid slowly emerging empirical studies on specific factors, a more rigorous analysis estimating the role of all drivers of migration is needed, filing a gap in literature.[2]

This paper disentangles the role of various drivers in explaining the increasing undocumented migration from the NT countries to the U.S. To gauge undocumented migration—an unobserved variable—we use data on the U.S. border apprehensions, similar to Hanson and Spilimbergo (1999).[3] To assess the role of various factors we employ explanatory variables consistent with an investment decision theory model, with migrants assessing if the quantifiable benefits from undocumented migration are higher than its costs. As such, along with the traditional economic factors (wages in the host compared to home country, and unemployment rates, in the NT and the U.S., as in Hanson and Spilimbergo, 1999) we also control for the role of the probability of being apprehended (measured by the U.S. border enforcement). Moreover, we also control for

[1] Remittances flows exceeded 20 percent in El Salvador and Honduras, and are very sizeable in Guatemala, thereby appreciating the exchange rates and complicating macroeconomic policies.

[2] Haliday (2006) showed how agricultural shocks induced liquidity constraints drive migration in El Salvador.

[3] Hanson (2006) reviews studies and methodologies used for estimating stocks and flows of undocumented migrants.

non-traditional factors of migration, including changes in coffee production, changes in temperature, homicide rates, and natural disaster events. We also account for sudden spells of undocumented migration.

Our findings have important policy implications. We find that undocumented migration of people of NT country of origin are well explained by both traditional factors—such as indicators of income (real wages or GDP per capita) and indirect measure of probability being apprehended—as well as non-traditional factors. We find that, as survey data suggest, economic considerations (real wages and unemployment rates, especially in the U.S). play an important role in driving undocumented migration. Most importantly, our results suggest that border enforcement measures act as a deterrent for undocumented migration. However, we also find that large and sudden increases in border apprehensions are at times linked to favorable changes in the perception of probability of being apprehended. The results are robust to various specifications, estimation methods, and to different measures of income, probability of apprehension, decline in livelihoods due to coffee production and changes in temperature, as well as to additional explanatory variables. Changes at home should be centered around providing conditions for sustained inclusive growth, to create enough jobs, and advancing economic transformation to ensure higher wages as well as livelihood resilience to climate change and natural disasters, along with reducing crime.

This paper is organized as follows. In Section II, we present the model and in section III we describe the data used (and some styled facts about this data). The empirical analysis is presented in Section IV. Section V presents the concluding remarks, outlook, and policy implications.

II. Model

Our empirical analysis uses the investment decision theory and border apprehensions data. According to the investment decision theory, an individual decides to migrate when expected discounted difference in the stream of income between the new and old location exceeds the moving costs (see Sjaastad, 1962). Furthermore, for a migrant who decides to migrate undocumented, the decision also depends on the difference between the perceived probability of being apprehended today, as well as in the future. Empirical application of the investment decision theory into analysis of undocumented migration is challenging, as both the arrival of undocumented migrants and the probability of apprehension are not directly observed variables.[4] Similar to Hanson and Spilimbergo (1999), we used the number of border apprehensions as an indirect indicator of undocumented migration.[5] Annex I presents the theoretical underpinnings of the model, and Annex II details why border apprehensions is the best measure of flows of undocumented migration.

We start with the reduced form model of Hanson and Spilimbergo (1999). In this specification, border apprehensions are modeled as a function of factors of the potential stream of income in the U.S., factors of the forsaken stream of income in the country of the origin, and indicators of migrants' perceptions of contemporaneous and future probabilities of being apprehended. Potential stream of income is associated with

[4] For conceptual model see Annex I.

[5] Border apprehensions are widely used in studies to estimate the attempts and entries of undocumented migrants (DHS, 2017; Fazel-Zarandi et al., 2018). Since these estimates of attempts and entries are consistently proportional to the number of apprehensions, and since the undetected entries across the border make up the main channel of arrival for undocumented migrants from the NT countries, the evolution of border apprehensions represents well the evolution of undocumented migration from these countries. We believe that in the case of NT-born undocumented migration this indicator is subject to negligible measurement error. For discussion on the use of border apprehensions to measure undocumented migration see Annex II.

gains in real income following a move to the U.S., while forsaken stream of income is associated with the real income the migrant could have earned if (s)he stayed in the country of origin. As gains in real income materialize only if the migrant finds a job, or the real income is forsaken only if the migrant has a job, the decision to emigrate would also depend on the unemployment rate in both U.S. and the country of origin. Contemporaneous and future probabilities of being apprehended, while not directly observed, could be indirectly gauged by border enforcement measures and changes in the U.S. immigration policy, including legal admissions and legalization of undocumented migrants.[6]

We extend this model with additional drivers of undocumented migration from NT countries. First, we added variables affecting the livelihoods in NT countries, which were also cited by apprehended migrants as reasons to migrate, including crime rate, coffee production, natural disaster events, and climate change.[7] Second, we further expanded the set of variables to capture indirectly the impact of probability of apprehension, by controlling for the recidivism rate of deportations on border apprehensions. Third, we control for perceptions in the change of U.S. migration policy. In the two recent episodes of migration waves, the first wave occurred in FY2012-FY2014, following the announcement of the Deferred Action for Childhood Arrivals (DACA), and the second wave which peaked in FY2019, in anticipation of announced changes in the U.S. immigration policy.[8] [9]

The baseline model explaining the annual border apprehensions of NT-born migrants at the U.S. Southwest border is represented by the following regression specification, with home and host factors:

$$A_{NT,t} = \alpha_0 + \alpha_1 W_{US,t} + \alpha_2 U_{US,t} + \alpha_3 W_{NT,t} + \alpha_4 U_{NT,t} + \alpha_5 BA_{US,t} + \alpha_6 LA_{NT,t} + \alpha_7 Deport_{NT,t} + \alpha_8 Wave1_{NT,t} + \alpha_9 Wave2_{NT,t} + \alpha_{10} Coffee_{NT,t} + \alpha_{11} Homicide_{NT,t} + \alpha_{12} Temp_{NT,t} + \alpha_{13} Disaster_{NT,t} + \alpha_{14} Trend_t + v_{NT} + \varepsilon_{NT,t} \quad (1)$$

Potential stream of income in the U.S. (including possibility of earning such an income):

- $W_{US,t}$ is the median real wage for Hispanics in the U.S.;
- $U_{US,t}$ is the U.S. Hispanic unemployment rate;

Forsaken stream of income in the NT countries:

- $W_{NT,t}$ is the average real wage in the NT country;
- $U_{NT,t}$ is the unemployment rate in the NT country;

Probability of being apprehended:

- $BA_{US,t}$ is the number of border enforcement agents at the U.S. Southwest border;
- $Deport_{NT,t}$ is the number of deportations of undocumented migrants of NT country origin from the U.S.;

Perceptions of changes in the U.S. migration policy:

- $Wave1_{NT,t}$ is an immigration wave 1 in FY2012-FY2014, a dummy variable;
- $Wave2_{NT,t}$ is an immigration wave 2 in FY2019, a dummy variable;
- $LA_{NT,t}$ is the number of legal admissions from the NT country to the U.S.;

[6] Hanson and Spilimbergo (1999) also controlled for additional events that indirectly impacted migrants' perceptions of probability being apprehended, namely the event following the Immigration Reform and Control Act (IRCA) of 1986 and the Immigration Act of 1990. In our study, since these events occurred prior to our sample starting timeline, we did not control for them.

[7] Climate change has a distinct effect on rural poverty and livelihoods derived from coffee, since in the drought corridor of Central America, from Panama to Mexico, 50-100 percent of crops were affected by historic episodes of droughts.

[8] In the U.S., Fiscal Year (FY) runs from October of the previous year to September of the current year, 12 months. Deportations can also be thought of as an indicator of recidivism rate of attempts to entry U.S. border undetected

[9] Immigration policy and rules of implementing it have changed starting with FY2017.

Other NT-specific factors:

- $Coffee_{NT,t}$ is coffee production in the NT country;
- $Homicide_{NT,t}$ is the homicide rate per 100,000 people in the NT country;
- $Temp_{NT,t}$ is the two-year average deviation of temperature in March-August from historical trend (1951-1980) in the NT country;
- $Disaster_{NT,t}$ is a dummy variable to control for natural disaster event in the NT country;
- $Trend_t$ is a time trend; and
- v_{NT} is country fixed effect and $\varepsilon_{NT,t}$ is an error term.

All variables have been transformed in natural logarithm.

III. Data and Stylized Facts

Apprehensions of citizens of NT origin at the U.S. Southwest border (the main port of entry in the U.S.) has steadily increased over the past 40 years, accelerating at times. In the 1990s and early 2000s three episodes of natural disasters stand out for the region: the volcano eruption in Guatemala, the Mitch Hurricane in 1998 with severe impact in Honduras, 2001 earthquakes in El Salvador, followed by devastating floods. More recently, a prolonged drought in the region affected agricultural production, including coffee production, adversely impacting the livelihoods of many NT citizens. Following these episodes, one could observe an increase in undocumented migration (as measured by apprehensions at U.S. Southwest border).

There are a few recent periods in which apprehensions of NT citizens increased rapidly which cannot be explained by natural disasters. These episodes were observed during 2003-2005, 2012-2014, and 2017-2019. In FY2005, a total of 112,000 citizens of NT countries were apprehended at the U.S. Southwest border. Since FY2005 border apprehensions of NT citizens plateaued at 40,000 people per year on average until September 2017. After October 2017 U.S. Southwest border apprehensions of NT citizens increased 170 percent until September 2019 (reaching a record high of 608,000 people in FY2019). To put things into perspective, apprehensions reached 2.6 percent of home population for Honduras in 2019. While this relatively recent spike is part of a larger phenomenon, data shows that apprehensions of NT citizens have increased against the background of declining total apprehensions of all citizens at the U.S. border since 2000[10] (see Figure 1).

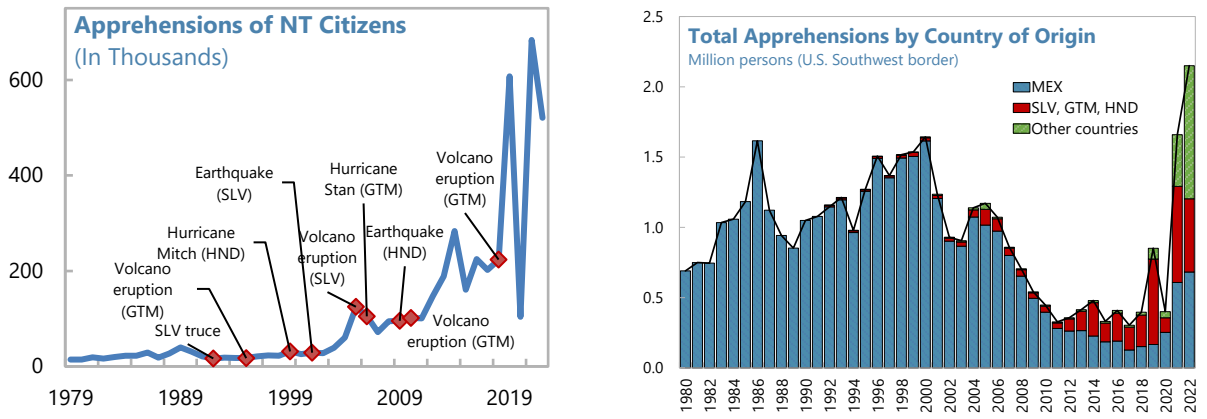
However, since the COVID-19 pandemic, apprehensions of NT citizens moderated. There was a sharp decrease in border apprehensions in FY2020—due to travel restrictions and lockdowns. While apprehensions of NT citizens rebounded in 2021, they remained well below FY2019 levels (left chart).[11] Most importantly, while the NT citizens represented the highest number of apprehended people during 2014-19, since FY2021 they represent the third largest group, below the number of apprehensions of citizens of Mexico (which was the case historically) and other countries (including Haiti, Cuba, and Nicaragua).[12]

[10] In FY2019 year, NT citizens made up 62 percent of all US Southwest border apprehensions, up from 1 percent in FY1994.

[11] Once adjusted for Title 42 expulsions.

[12] The current level of apprehensions of Mexican citizens is low in historical perspective. However, the total apprehensions of all citizens have now reached a historical peak.

Figure 1. Evolution of Apprehensions at U.S. Southwest Border 1/



Source: DHS, U.S. CBP, and authors' calculations.
1/ In U.S. fiscal year runs from October of the previous year to September of the current year, 12 months. Nationwide apprehensions includes apprehensions at all US borders. Includes Title 8 apprehensions and Title 42 apprehensions and immediate expulsions.

The data was collected from public sources as follows. For U.S. Hispanic wages and unemployment rate we used data from Haver Analytics. For the home country wages, we used real average wages reported by the Economic Commission for Latin America and the Caribbean (ECLAC) and unemployment rate as reported by the UN International Labor Organization of the United Nations (ILO) database. Homicide rates for each of the NT countries are reported by the World Bank. Coffee production by country is reported by the International Coffee Organization. Data on temperature deviations were taken from the UN Statistics Department of the Food and Agriculture Organization of the United Nations (FAOSTAT) Temperature Change database. We used data from the EM-DAT International Disaster Database, to distinguish years with natural disaster events. We constructed a dummy variable, which is set to 1 for earthquakes in El Salvador in 2001, Honduras in 2009, volcano eruptions in El Salvador in 2005, in Guatemala in 1995, 2010, and 2018; and 0 otherwise. We used U.S. CBP's data on annual border apprehensions of citizens of Northern Triangle countries – El Salvador, Guatemala, and Honduras. We used U.S. Department of Homeland Security (DHS) annual statistical reports to collect data on legal admissions and deportations.

The sample used is 1994-2019, given the availability of data, and the different structural breaks after 2019. As was documented in several official and media reports, the post-pandemic increase of apprehensions is in some part due to Title 42 expediated expulsions, which have a high recidivism rate. Moreover, during this period apprehensions at the U.S. Southwest border were primarily under Title 8. Annex III presents the data and stylized facts in more detail.

IV. Estimation Strategy and Results

The empirical strategy controls for several estimation issues. First, to account for the presence of serial autocorrelation, as shocks to the border apprehensions tend to linger, we estimate the model for the panel of three countries—El Salvador, Guatemala, and Honduras—using the Feasible Generalized Least Squares method with serial autocorrelation in panels. Second, to address potential identification issue—as border

enforcement measures could be simultaneously determined with border apprehensions—we estimate the baseline specification in the robustness section also: (i) without border enforcements measures; (ii) using the instrumental variables regression approach; and (iii) using the residual approach.

The baseline specification explains well the evolution of border apprehensions of NT undocumented migrants. Results are shown in Table 1:

- *Potential stream of income:* U.S. real wage and job opportunities play a very important role in explaining border apprehensions. The elasticity with respect to the U.S. Hispanic real median wage is positive and large, which means that migration attempts are highly sensitive to changes in the median real wages for U.S. Hispanics. Labor demand and job opportunities in the U.S. are significant drivers of undocumented immigration as well. The elasticity with respect to the U.S. Hispanic unemployment rate is negative and significant and large, showing that as employment conditions deteriorate apprehensions also moderate. Those two explanatory coefficients are the second and third highest coefficients of the regression.

- *Forsaken stream of income* factors also explain well border apprehensions. The elasticity with respect to home country real wage is negative and significant. Its magnitude is smaller than that with respect to the U.S. Hispanic real median wage, which means that home earnings have a smaller effect in deterring undocumented immigration than the pull factors. The elasticity with respect to the home country unemployment rate is positive, significant, and large, with the absolute value greater than that for the U.S. Hispanic unemployment rate (in fact it is the highest coefficient), meaning that home country labor market conditions and job opportunities play the biggest role in driving undocumented migration.[13] This latter result is consistent with Migration Policy Institute, 2022, and other sources (e.g. local articles), documenting that one of the most important causes of migration is driven by the fact that the number of jobs created in NT countries every year is much lower than the number of entrants in the labor market.

Table 1: Determinants of evolution of border apprehensions of NT citizens (FY1994-FY2019)

Constant	5.383 (8.369)
US: Hispanics real median wage	5.241*** (1.693)
US: Hispanics unemployment rate	-6.101** (2.388)
NT: Real average wage	-1.438*** (0.236)
NT: Unemployment rate	16.160*** (5.230)
US: Southwest border agents	-2.264*** (0.485)
US: Legal admissions of NT citizens to the U.S.	0.013 (0.230)
US: Deportations of NT citizens from the U.S.	0.554*** (0.092)
NT: Immigration wave 1, FY2012-FY2014 (D)	0.831*** (0.095)
NT: Immigration wave 2, FY2019 (D)	0.729*** (0.145)
NT: Coffee production	-0.417*** (0.104)
NT: Homicide rate per 100,000	0.277** (0.117)
NT: Temperature (deviation March-August, 2-year average)	0.197* (0.103)
NT: Natural disaster event (D)	0.144** (0.063)
Time trend	1.569*** (0.418)
Number of observations	78

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01
All variables are in natural log form. The regression model was estimated using Feasible Generalized Least Squares method with serial autocorrelation in panels.

- *Indirect measures of probability of being apprehended* also contributed to the evolution of border apprehensions. Border enforcement, measured by the number of border agents, is significant and negatively associated with apprehensions. Higher border enforcement measures increase the probability of apprehension, which in turn deters attempts of migration and thus may leads to lower border

[13] While the NT countries have a high informality rate, and therefore this presents a data challenge, we used survey-based measures, which are capturing total unemployment, thereby giving a reasonable cause of migration.

apprehensions.[14] Legal admissions are found to have no effect on border apprehensions, and by extension on attempts of undocumented migration.[15] Deportations have a significant and positive effect on border apprehensions. Once a deportation occurs, the deported migrant perceived probability of being apprehended in the future increases. Hence, the migrant might attempt to migrate soon after deportation, rather than waiting or giving up. The result is consistent with anecdotal evidence as well as calculations by the DHS and other of the recidivism rate, as well as the coyote costs of helping migrants cross the border (with a paid sum including multiple attempts). For more stylized facts of border enforcement and the probability of being apprehended, see Annex II.

- *Perception of changes in the U.S. migration policy* are important in explaining evolution of border apprehensions. The migration wave dummies have positive coefficients and significant. The first immigration wave followed the DACA announcement in 2012. The result is consistent with media reports that many apprehended NT migrants perceived these announcements as favorable, resulting in an influx of caravans of families and unaccompanied children attempting to migrate undocumented. The second immigration wave was observed in 2019 and was triggered by the U.S. government tightening border enforcement measures, and anti-immigration political rhetoric, causing a change in the migrants' perceptions of incoming tightening of the U.S. migration policy, and in turn might have determined some migrants to move forward their decision to migrate, or to decide to migrate, before the costs of migration would be too high/prohibitory.[16]

- *NT-specific and non-income factors* are important drivers of border apprehensions. Elasticity with respect to coffee production is negative and significant, suggesting that greater production of this cash crop provides disincentive for undocumented migration attempts. Elasticity with respect to homicides is positive and significant, suggesting that higher crime pushes out undocumented migration. We also find that elasticity with respect to temperature deviation is positive (and significant at 10 percent), suggesting warmer temperatures played role in explaining evolution of undocumented migration. Natural disaster events coefficient is positive (and significant at 5 percent) highlighting the role such events play in explaining undocumented migration. In the years of such events 14 percent of border apprehensions could be attributed to these events, on average.

Our baseline specification has a good fit and explains well the evolution of border apprehensions, and the results are robust. Fitted values of the baseline specification complies well with the actual data of border apprehensions, suggesting the model performs well in a goodness of fit test (see left chart). Annex IV presents country-specific results. Annex V presents unit root and cointegration tests. The results are robust to various specifications, estimation methods, different measures of variables of interest (of border apprehensions, income, probability of apprehension, decline in livelihoods due to coffee production and changes in temperature), as well as different sample sizes or number of explanatory variables used. Annex VI summarizes the most important sets of additional results (replacing real wages with real GDP per capita, various measure of undocumented migration, use of stock of immigrant population as network effect, instrumental variables, and residuals enforcements estimations). A much larger set of results is available by request from the authors.

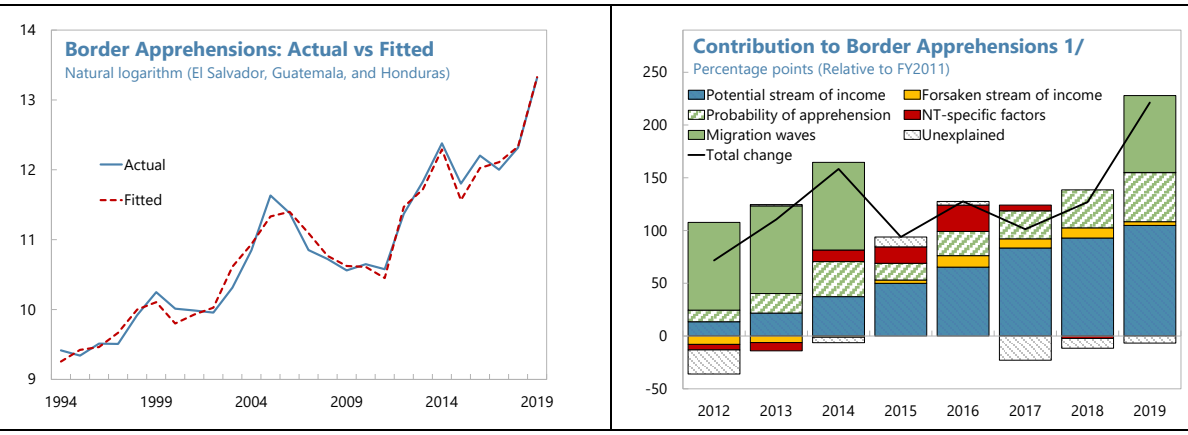
[14] Hanson and Spilimbergo (1999) estimated elasticity with respect to border agents is positive. For detailed discussion of these findings see Annex VII. It is important to note that for the sample, the number of border agents is allocated for all migrants, which might explain the difference in results, since prior to 1999 the vast majority of apprehensions were of Mexican citizens.

[15] We expected that higher legal admissions would lead to more migrants choosing legal migration channels and therefore resulting in lower number of attempts of undocumented migration, and lower border apprehensions.

[16] In the same period coyote fees have increased, a clear measure of cost of migration, see Annex II.

To better understand the results, and what role they play over time, we illustrate the contribution of various group of factors, to the increase in border apprehensions in FY2019 compared to FY2011. We used the model estimates to examine the recent evolution in border apprehensions, in the period FY2012-FY2019. The right chart shows the contribution of each group of factors as a change in the corresponding variable relative to FY2011, times its elasticity. In the chart we aggregated results for overall the NT region and across identified the groups of variables.

Figure 2. Fitness of Estimated Model



Source: Staff estimates based on baseline model in Table 1. See data section for sources.
1/ Chart shows contribution to detrended series of border apprehensions for an average NT country.

The results suggest that the potential stream of income was one of the main drivers of border apprehensions in the past decade, and played an increasing role. The chart shows the increasing contribution of the U.S. labor market conditions related factors (blue bar). Indeed, data shows that since FY2011, the U.S. Hispanic real median wages continuously increased, and the U.S. Hispanic unemployment rate continuously declined.[17] Together these two factors of potential stream of income explained 100 percentage point increase in border apprehensions in FY2019 relative to FY2011 (out of the 230 percent increase).

The perceptions of changing migration policy mattered in driving temporary surges in undocumented migration from the NT countries to the U.S. For example, the first immigration wave in FY2012-FY2014 accounted for an additional 83 percent of apprehensions, compared to FY2011, by far the largest contributing factor of the surge in migration at the time. The second wave accounted for an additional 73 percent of apprehensions in FY2019.

Changes in the probability of being apprehended also explained the recent trends in undocumented migration. The change in the indirect measures of probability being apprehended contributed to 46 percentage points increase in border apprehensions in FY2019 relative to FY2011.[18] Annex VII discusses in more detail border enforcement measures and their role.

[17] By FY2019, the U.S. Hispanic real median wage increased by 12 percentage points relative to the level observed in FY2011, and the U.S. Hispanic unemployment rate declined by 6.6 percentage points in the same period of time.

[18] The number of border agents continuously declined (as apprehensions also declined in a historical perspective; 10 percentage points by FY2019, and deportations continuously increased by 40 percentage points in the same period.

The role of NT-specific factors and the forsaken stream of income factors in border apprehensions of NT migrants varied among time and across countries, but overall played a lower role. The chart shows that during FY2014-FY2017, the NT-specific factors (red bar) played on aggregate a limited role in explaining the increased apprehensions. Looking in further detail, at the country level (see Annex IV) we observe that indeed for El Salvador, the high and rising homicide rate at the time and the decline in coffee production played the most important role in explaining apprehensions. In Guatemala and Honduras, the NT-specific factors were more favorable—as coffee production increased and homicides declined—and contributed negatively to the border apprehensions. The forsaken stream of income indicators (yellow bar) contributed positively to apprehensions in 2016-2019, with large heterogeneity. The positive developments in El Salvador during this period—increase in real wages—contributing negatively to border apprehensions, while the opposite is true for the other countries, especially Guatemala and Honduras.

Climate change and natural disaster events explained significant share of border apprehensions of the NT undocumented migrants. The average May-August temperature deviation from the historical values, accelerated since 2015, and averaged around 30 percent, annually. Our model results suggest that warmer temperatures resulted in additional 6 percent of border apprehensions since FY2015. Natural disaster events occurred in Honduras in 2016 and 2018, and in Guatemala in 2019, which our model suggest contributed to additional 14 percent of border apprehensions.

V. Concluding Remarks, Outlook, and Policy Implications

This paper disentangles the role of various drivers of undocumented migration from the NT countries to the U.S., which has increased steadily over time. To gauge undocumented migration—an unobserved variable—we use data on the U.S. border apprehensions, similar to Hanson and Spilimbergo (1999). To assess the role of various factors we employ explanatory variables consistent with an investment decision theory model, with migrants assessing if benefits from undocumented migration are higher than its costs. As such, along with the traditional economic factors, we also control for the role of the probability of being apprehended, sudden spells of undocumented migration, and non-traditional factors of migration. We find that undocumented migration of people of NT country of origin to the U.S. is well explained by traditional factors—such as indicators of income (real wages or GDP per capita, especially in the U.S.). The results are consistent with anecdotal evidence, and MPI survey data that suggest that the economic considerations (real wages and unemployment rates) play the largest role in driving undocumented migration. Most importantly, our results suggest that border enforcement measures act as a deterrent, but large and sudden increases in border apprehensions are at times linked to favorable changes in the perception of probability of being apprehended. We also find that nontraditional factors (increase in temperature, decline in coffee production, increase in homicides rates and natural disasters) also play an important role in driving up undocumented migration, sometimes the most important role in explaining an increase in a given country, and year. The results are robust to various specifications, estimation methods, and different measures and variables used.

Migration factors are expected to persist, given rising challenges from climate change, but mostly depending on the relative economic developments in the U.S. economy versus the NT countries. Climate change experts expect temperatures to continue rising, which would continue to adversely affect the

traditional livelihoods in the NT countries. The medium-term outlook for the U.S. economy remains favorable, supporting positive developments in the labor market conditions. The medium-term outlook for the NT countries remains subject to downside risks, as tighter global financial conditions will curb private sector investments. Addressing structural challenges at home to ensure competitive wages and equitable and inclusive growth, as well as improving security conditions, remain key priorities. These factors—uncertainty in the forsaken stream of income and NT-specific factors—would continue motivating undocumented migration. For example, a 10 percent increase in home country real wages would decrease undocumented migration by 14 percentage points. While a one standard deviation increase in temperature equivalent of 1.7 degrees, would increase undocumented migration by 10 percentage points.

Against this backdrop, the immigration wave events are expected to be frequent, especially when there is a change in border enforcement or immigration policy. Deportations are expected to continue, and border enforcement measures continue to tighten, which coupled with speculations of further tightening in the migration process and changes in migration policy, may fuel episodic immigration waves.

Policy response should aim at lifting up economic conditions in NT countries, help traditional producers adapt to climate change, and enhance security measures. Improving economic conditions at home that ensure higher real wages and low unemployment and creating more and better paid jobs would disincentivize undocumented migration from the region. Diversifying income opportunities for the coffee producers—especially in El Salvador—, while investing in climate-change resilient agricultural production would benefit migration-prone population and discourage attempts at undocumented migration. Preserving and further enhancing security measure to tackle crime in the NT countries would also be instrumental in stoving off attempts for undocumented migration. Furthermore, broadening ways of legal migration for NT migration, including in seasonal and temporary jobs, may also contribute at regulating flows, especially if conditions at home improve. Therefore, continued dialogue and efforts to help address the root causes of migration in NT countries should continue with the U.S., as already done with the USAID and other development partners.

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Annex I. Investment Decision Theory of Undocumented Migration

Migration can be viewed as an investment decision; an individual *i* assesses whether the expected benefits between the new ($V_{US,t+1}$) and old location ($V_{NT,t+1}$), discounted to present value (by ρ) exceed current wage ($w_{NT,t}$) and perceived migration costs (C_t). Once the decision is taken, the individual moves with certainty (see Sjaastad, 1962). In the context of undocumented migration, the decision to migrate also depends on the expected probability of being apprehended at the border today and in the future (PA_t). Formally, an individual's investment decision to migrate can be written as the following indicator function:

$$I_{i,t} = \begin{array}{l} 1\ (migrate)\ if\ \ w_{NT,i,t} + C_{it} < \frac{1-PA_t}{1+\rho}\left(V_{US,i,t+1} - V_{NT,i,t+1}\right) \\ 0\ (not\ migrate)\ otherwise \end{array} \quad (1.1)$$

To the extent that the individuals' decision to migrate vary, we can aggregate the decision of all individuals attempting to migrate undocumented, $M_{NT,t}$, as a function of expected future U.S. earnings $W_{US,t}$, home earnings $W_{NT,t}$, probability of apprehension PA_t, along with any other information to predict future paths of these variables $\Omega_{NT,t}$, and personal characteristics $\Gamma_{NT,t}$.

$$M_{NT,t} = M(W_{US,t}, W_{NT,t}, PA_t, \Omega_{NT,t}, \Gamma_{NT,t}) \quad (1.2)$$

Apprehensions at the border will be influenced by the number of illegal attempts to cross the border and the probability that any individual migrant is apprehended. The apprehensions probability, PA_t, is likely to be influenced by the level of effort U.S. authorities expend in enforcing the border, $BA_{US,t}$, and total attempts to cross the border undocumented, $M_{NT,t}$. As all individuals face the same apprehensions probability, apprehensions at the border, $A_{NT,t}$, can be expressed by the following apprehensions function

$$A_{NT,t} = P\left(BA_{US,t},\ M_{NT,t}\right) * M(W_{US,t}, W_{NT,t}, PA_t, \Omega_{NT,t}, \Gamma_{NT,t}) \quad (1.3)$$

However, we do not observe directly the probability of apprehension and the total number of attempts, and therefore we will be using a reduced form to analyze border apprehensions (1.4). Border apprehensions are defined by the level of border enforcement efforts measured by border agents, $BA_{US,t}$, US real minimum wage $W_{US,t}$, home country real minimum wage $W_{NT,t}$, number of legal admissions to the US $LA_{NT,t}$, and the US unemployment rate of Hispanics $U_{US,t}$.

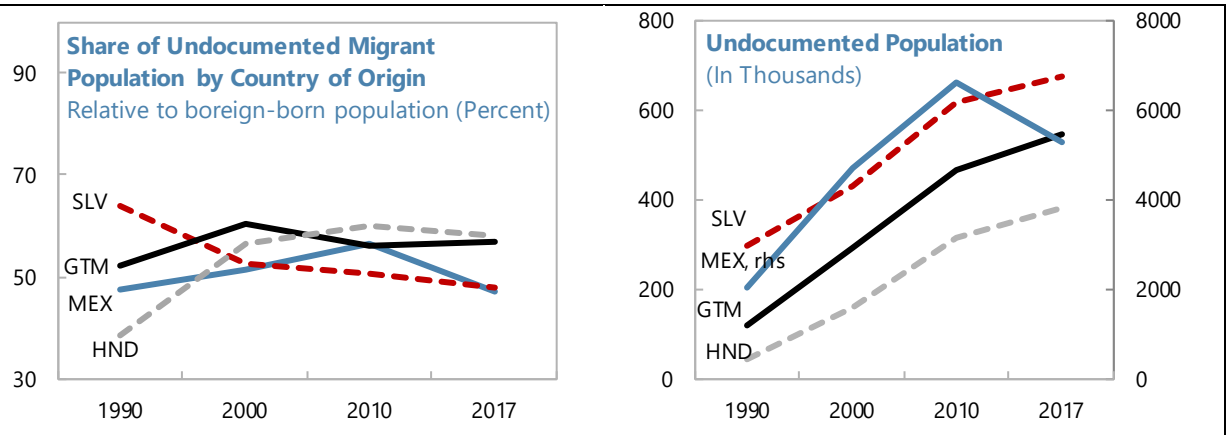
$$A_{NT,t} = \gamma_1 BA_{US,t} + \gamma_2 W_{US,t} + \gamma_3 W_{NT,t} + \gamma_4 LA_{NT,t} + \gamma_5 U_{US,t} + \varepsilon_{NT,t} \quad (1.4)$$

We further extend the baseline specification (1.4) to control for variables that are important to the NT migration. Anecdotal evidence from media articles on NT migration, and official CBP reports cite NT migrants identifying factors to leave their country as high crime, loss of livelihood due to decline in coffee production and droughts, and frequent natural disaster events. We add variables such as homicide rates, international coffee prices, temperatures, and disaster events. The extended baseline specification is shown in equation (1) in the main text of the working paper.

Annex II. Border Apprehensions and Undocumented Migration

The undocumented NT-born population grew at faster rates than other groups, becoming the second largest group of undocumented population in the US. By FY2017 from a total of 10.6 million undocumented migrants living in the US, the NT-born undocumented migrants represent a sixth of that total stock. This trend occurred while the undocumented population from Mexico—representing the vast majority of total undocumented population in the U.S., about half—declined considerably (since 2010, right chart). Moreover, all other nations combined, despite some having the largest home populations and a rapidly increasing undocumented population (e.g. India), represent only a third of the stock of undocumented migrants.

While the magnitudes differ, the trends are broadly similar for all the NT countries. The stock of Honduras-born undocumented population in the U.S. increased nine times, to 380,000 in FY2017, the stock of Guatemala-born increased nearly five times, to 550,000, and for El Salvador increased slightly more than twice, to 670,000, respectively. The migrants from Honduras and Guatemala came primarily as undocumented in this period; their share in the total foreign-born population increased to 60 percent, while the share of undocumented migrants from El Salvador declined from about two thirds to less than half (left chart).



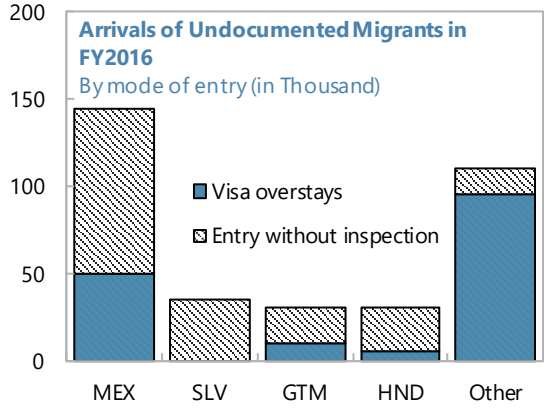
Sources: DHS for 1990 and 2000, Center for Migration Studies (CMS) for 2010 and 2017.

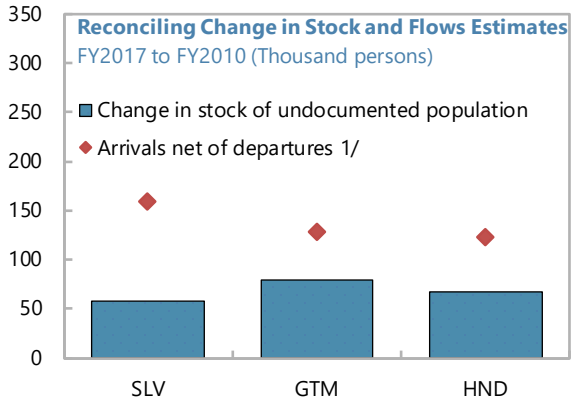
For undocumented migrants from NT countries the main mode of arrival is undocumented entry across the border, which is estimated using the observed number of apprehensions and the estimate of the rate/probability of apprehension (see chart).[1][2] The estimated number of entries of undocumented NT migrants taken together with estimated departures of undocumented migrants, correlate with the change in the population of undocumented migration as reported by the U.S. census surveys.

[1] Number of undocumented entries equals total attempts net of apprehensions.

[2] The other mode of arrival of undocumented migrants is visa overstay, which for NT migrants is estimated to be significantly smaller than that for other nationals (See Chart).

The methods used to estimate number of entries, control for deterrents, turn-banks, and recidivism rate. The main goal of the studies is to derive the rate of apprehension, which is used to gauge the effectiveness of border enforcement measures. Various studies report that an estimated rate of apprehension remained stable at 40-50 percent of attempts up until FY2011 and increased since FY2011 to 70 percent. The increment was due to the shift in demographics of the apprehended migrants, with stronger waves of family units and unaccompanied children attempting to cross the border.

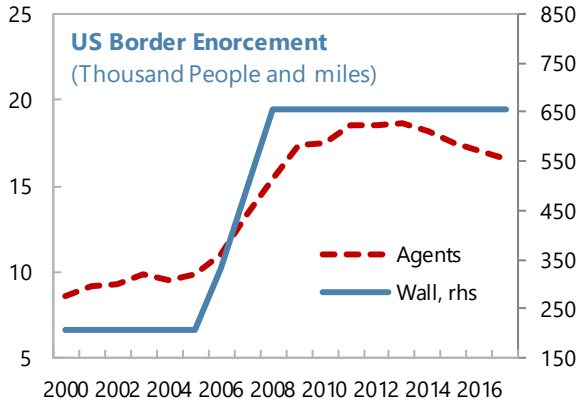




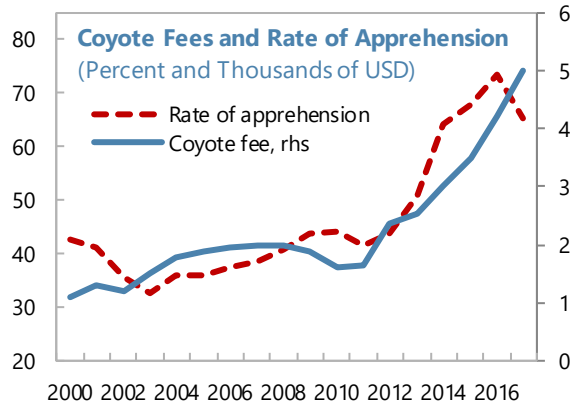
Sources: CMS (2019), Fazel-Zarandi et al. (2018), DHS and authors calculations.
1/ Arrivals are defined as the sum of visa overstays and estimated entries (border apprehensions divided by rate of apprehensions). Departures are defined as officially reported removals.

However, the rate of apprehension increased modestly amidst tighter enforcement measures. Since 1990s, the US Border Patrol budget increased by more than 1,000 percent, from US$400 million in FY1994 to US$4,696 million in FY2019. Larger budget allowed to hire more agents, whose number increased by more than 300 percent, from 3.7 thousand in FY1994 to 16.6 thousand in FY2019. The budget also allowed for expanding the wall construction from 203 miles in FY1994 to 654 miles in FY2019. In addition, since FY2011 the US authorities extended a deployment of accessible surveillance technology at the border, including drones, mobile cameras, and sensor alarm systems.

To circumvent tighter border enforcement NT migrants relied on coyote smugglers. The large part of the 2,000 mile US-Mexico border is natural barrier and remains unguarded by officials due to the difficult terrain. As a result of these recent measures, the area of potential border-crossings narrowed, effectively decreasing the probability of successful entry. To maximize the odds of a successful entry, the NT migrants turn to coyote smugglers, who actively use technology in response to the technological change on the border enforcement. Reflecting an interplay of higher demand for coyote services and supply constraints due to the difficulty crossing the border, the coyote fees increased, and even sharply following the second episode of high NT immigration of 2012-2014.



Sources: U.S. CBP and authors' calculations.



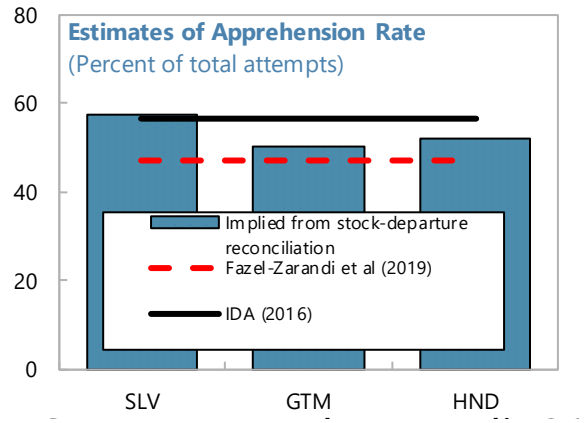
Sources: IDA, DHS and authors' calculations.

Uncertainty around the estimate of rate of apprehension

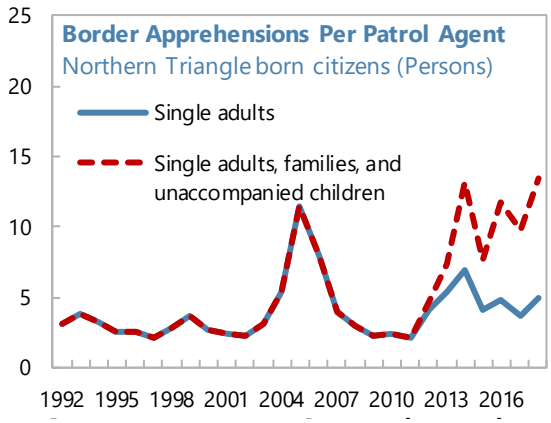
The uncertainty around the estimate of rate of apprehension arise from several issues: (i) sampling skewed to Mexican citizens, which had fewer attempts since FY2012 (Bailey et al., 2016 and Fazel-Zarandi et al, 2018); (ii) ignoring significant change in the demographic composition of apprehended since FY2012, due to the influx of NT families and unaccompanied children (Bailey et al., 2016 and Fazel-Zarandi et al, 2018)[3]; and (iii) choice of mathematical optimization model (Cornwell et al., 2010; Wein et al. 2007).

However, the uncertainty around the estimates of rate of apprehension is small. We compared the two prominent estimates of rates of apprehension with derived rate of apprehension from the census data and departure data, which is defined as the ratio of apprehensions relative to the sum of apprehensions and net change of stock of undocumented population plus removals. As the charts illustrate, these derived rates of apprehensions for individual NT countries differ marginally from the partial rate of apprehension calculated for all migrant apprehensions at Southwest border (Fazel-Zarandi, 2018) and the estimates based on Mexican apprehensions (Bailey et al., 2016). Similarly, we see little evidence of increased rate of apprehensions when we look at border apprehensions of NT-born migrants per patrol agent, which were stable, except for two periods, in FY2003-FY2005 and in FY2012-FY2018.

[3] Families and unaccompanied children are reportedly seeking to being apprehended since their ultimate goal is to apply for asylum. Therefore, for this group of migrants, rate of apprehension could be as high as 100 percent.



Sources: Fazel-Zarandi (2019), Bailey et al. (2016), and authors' calculations.



Sources: DHS and author's calculations.

Despite the uncertainty around the rate of apprehensions, border apprehensions are the best proxy for the gross arrival of undocumented NT-born migrants. Border apprehensions are widely used in studies to estimate the attempts and entries of undocumented migrants of citizens of Mexico and NT-countries origin. (DHS, 2017; Fazel-Zarandi, 2018) Since these estimates of attempts and entries are consistently proportional to number of apprehensions, and since the undetected entries across the border make up the main channel of arrival for undocumented migrants from the NT countries, the evolution of border apprehensions represents well the evolution of undocumented migration from these countries.

Annex III. Evolution of the Factors Driving Migration

Economic factors for undocumented migration to the U.S. increased amidst disparities in the wage growth and unemployment vis-à-vis the same variables in the Northern Triangle. Adjusted for the national CPI, real average wages in private sector of Honduras declined by 30 percentage points, from an index of 100 percent in 1991 to 70 percent in 2018. In Guatemala, after peaking in 2004, real average wages halved by 2019.[4] In El Salvador real average wages in private sector remained relatively unchanged during the period of 1991-2018. While in the U.S., the median real wage of Hispanics, by 2019 increased by 18 percentage points relative to 1991. Against this backdrop, unemployment rate increased markedly in Honduras, somewhat increased in Guatemala, and persistently decreased in El Salvador. Meanwhile, the US Hispanics unemployment rate declined to 5 percent in 2007, after which it peaked at 12.5 percent in 2010, and rapidly declined since then, mimicking the US business cyclical developments.

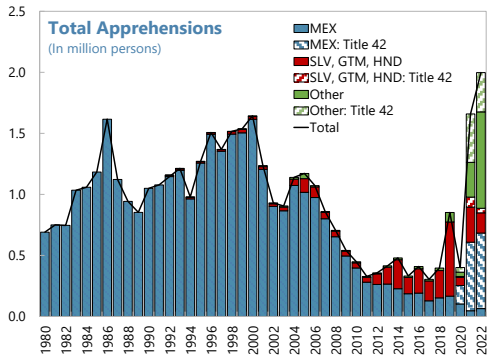
Disparities in the labor market developments were exacerbated by stagnant economic growth and increase in the relative cost of living. Ratio of NT countries GDP per capita to the US GDP per capita in constant PPP dollars, declined from 1991 to 2005. In the short period of 2005-2008, economic growth of the NT countries accelerated, on the back of massive capital flows. Following the GFC and its adjustment, the economic growth was stagnant, which resulted in unchanged ratio of income in Guatemala and Honduras. However, in El Salvador income convergence continued, albeit at low rate, which resulted in slow growth of the ratio of income per capita relative to the US. At the same time, the cost of living in NT countries, relative to the US, has increased substantially in Guatemala and Honduras, and to a lesser extent in El Salvador.

Organized crime led to high homicide rates and endangered the safety of livelihoods of NT citizens. Disproportionately high share of male victims in the NT countries (and especially in El Salvador) is due to the presence of organized crime (Sviatschi, 2020; UNODC, 2019). After El Salvador's civil war ended in a peace agreement in 1992, the Immigration and Naturalization Service increased deportation of Salvadoran gang members through the Violent Gang Task Force, which focused on deporting undocumented immigrants with criminal records (DeCesare 1998). The flow of deported criminals resulted in the sudden increase in homicide rates in El Salvador in the early 1990s (Sviatschi, 2020). From 1999 to 2011, albeit lower than before, the homicide rate remained high at 62 homicides per 100,000 people. A temporary truce between gangs in 2012 helped to reduce homicide rates, which nonetheless expired in 2014, resulting in the sudden increase in homicide rates. In Guatemala and Honduras, in addition to the gang violence, drug trafficking has also contributed significantly to the increase in homicide rates. Raise of the Mexican cartels in the late 1990s resulted in the pivotal change in the transportation route from the Caribbean to the NT corridor. In the 2000s, the homicide rates in Honduras mirrored the homicide rates in Mexico. Similarly, the homicide rates in Guatemala mirrored the homicide rates in Dominican Republic.

Setbacks in production and international prices compromised livelihoods relying on coffee crop. International coffee prices crashed from the high of 185 cents per pound in 1997 to 60 cents per pound in 2002 and resulted in decline of coffee production in all NT countries in the same period, as producers cut on their investment costs (USDA, 2004). Despite the recovery in the international coffee prices from 2002 to 2010,

[4] In Guatemala private sector wages were adjusted for the price level of the cost of living, instead of CPI.

the coffee production continued to decline in El Salvador and remained stable in Guatemala. Increase in coffee production in Honduras was due to the increase in the scale of production on the back of an estimated 10 thousand farmers switching from other crops to coffee. In 2012, the international coffee prices collapsed again and impacted coffee production in all NT countries. In addition, a large outbreak of coffee leaf rust in 2011-2012 further affected production. As a result of these developments, many farmers sold their plots and migrated.

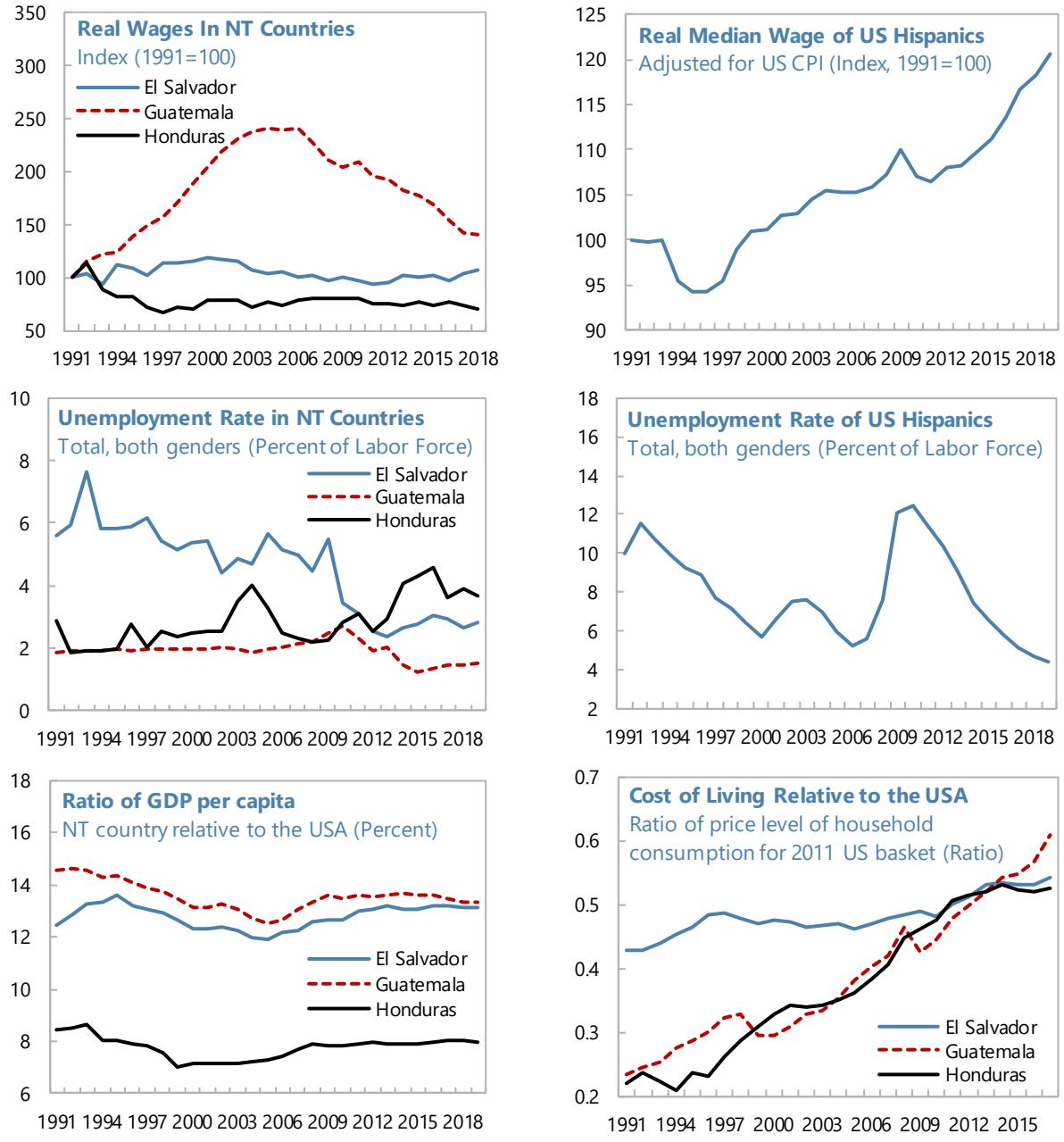


Raising temperatures further exacerbated the hardships from coffee production fallout, especially since 2012. In 1991-2000, the seasonal temperatures in March-May period, the dry season in the NT region, were 0.7 degrees of Celsius above the historical period of 1951-1980 (FAO, 2020). The average temperatures continued to increase in the following years; in 2001-2010 and 2011-2018 the average March-May temperatures were 0.71 degrees and 0.83 degrees of Celsius above the historical records, respectively. Temperature increases in the NT countries were well above those observed in the sample of warm countries with an annual average temperature above 20 degrees Celsius. In addition, rainfall in the NT countries became volatile and droughts were more frequent. According to a 2017 United Nations World Food Program study, repeated droughts since 2014 have destroyed crops and resulted in “levels of food insecurity [that] have not been previously seen in the Central American Dry Corridor”, encompassing 58% of El Salvador, south Honduras, and southeast Guatemala. In 2016, the United Nations’ Food and Agriculture Organization estimated that at least 1.6 million people in Central America faced constant food insecurity because of climate change. In 2017, a survey of Central American migrant families conducted by the World Food Program found that nearly half had left their country because of a lack of food.

Frequent and devastating natural disasters in the NT countries pushed many families to migrate. In the last 30 years, there were 186 natural disaster events in the NT countries, causing 21.5 thousand deaths, and affecting livelihoods of 21 million people. The deadliest period was in 1996-2000, during which 15.6 thousand people died in a total of 25 natural disaster events. Hurricane Mitch in October 1998 was the deadliest natural disaster, which killed nearly 15 thousand people and impacted more than 2 million people in Honduras with estimated damage of US$ 2 billion (16 percent of GDP). Following the hurricane, many Hondurans attempted to enter the US; border apprehensions of Hondurans in FY1999 (which starts on October 1998) doubled to 16 thousand people from 7.8 thousand people in FY1998. The second deadliest disaster was hurricane Stan in 2005, which killed 1.5 thousand people in Guatemala and caused damages of US$ 1 billion (1 percent of GDP). The third deadliest disaster was a 2001 earthquake in El Salvador, which killed 844 people, affecting 1.3 million people, and causing damage of US$ 1.5 billion (12 percent of GDP). Following both events, the border apprehensions of Salvadorans and Guatemalans increased.

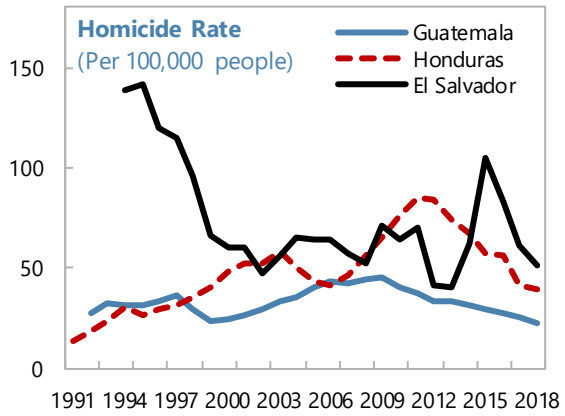
Changes in the migration policy are reflected in the text chart, showing the changes in status of apprehensions starting with 2020.

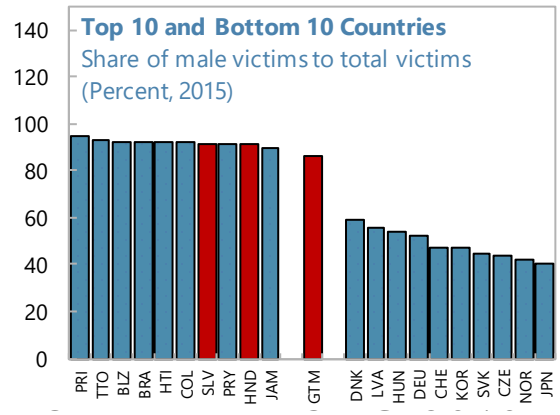
Figure III.1: Economic Factors Driving Undocumented Migration

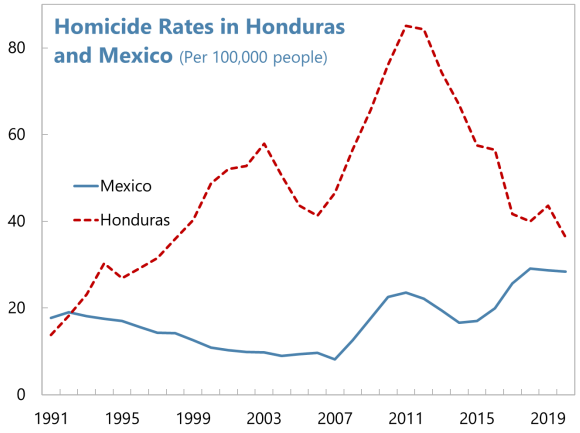


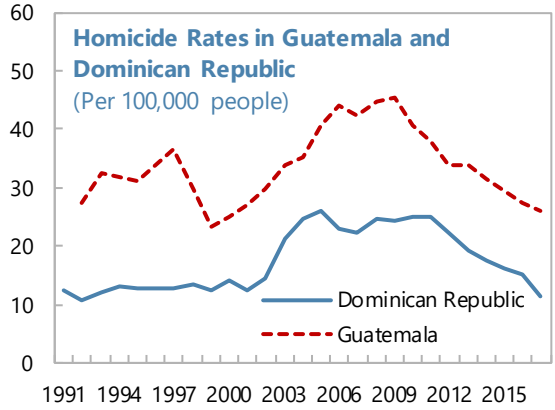
Sources: ILO, national authorities, US Bureau of Labor Statistics (BLS), IMF WEO Database, Penn World Tables version 9, and authors' calculations.

Figure III.2: Homicide Rate



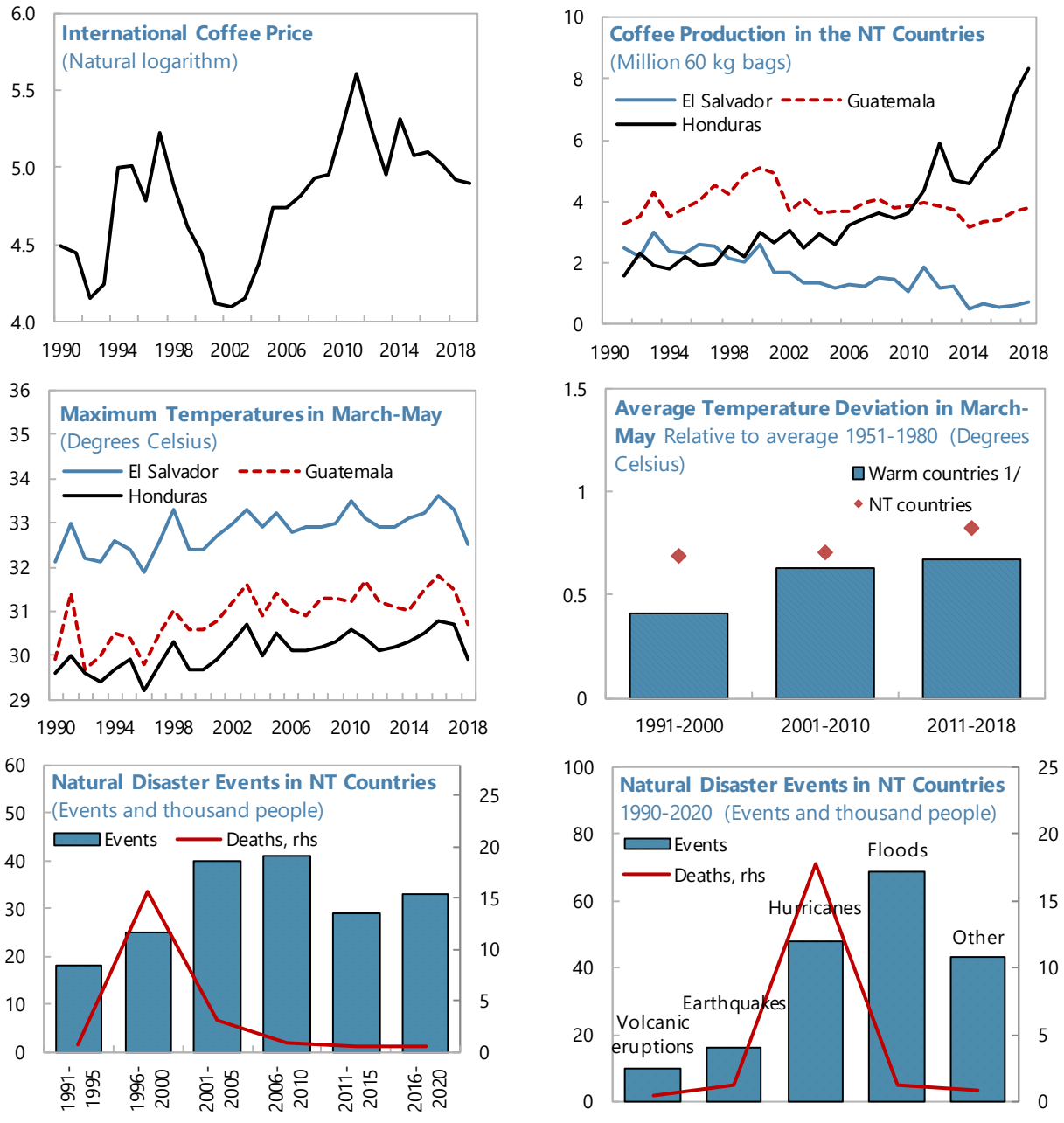






Sources: World Development Indicators (World Bank), United Nations Office on Drugs and Crime (2019), and authors' calculations.

Figure III.3: Socioeconomic Factors Driving Migration

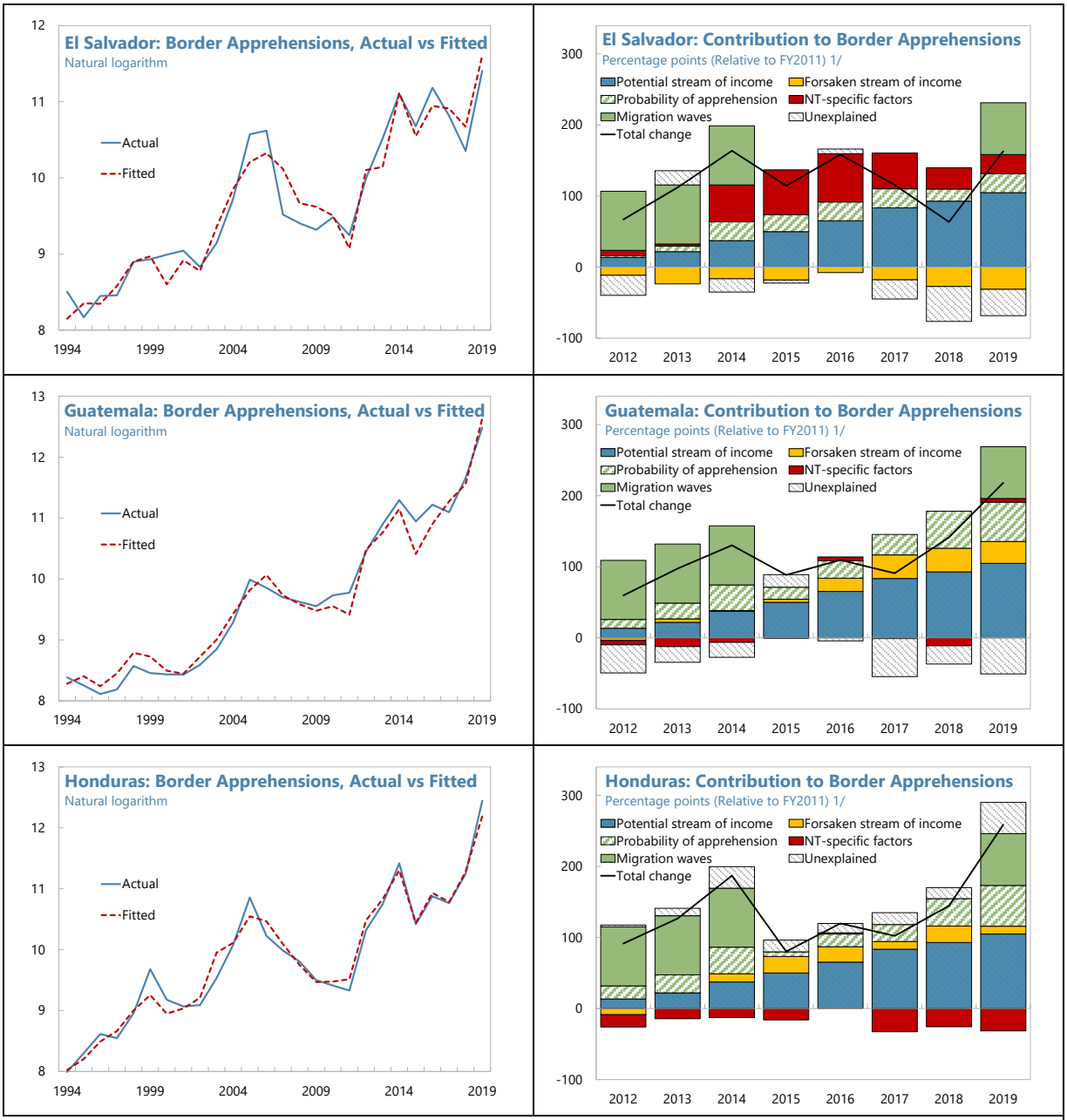


Sources: IMF WEO database, International Coffee Organization, Climatic Research Unit (University of East Anglia), FAO Climate Change Database, EM-DAT, CRED / UC Louvain, and authors' calculations.

1/ Based on a sample of countries with annual average temperatures > 20 degrees Celsius.

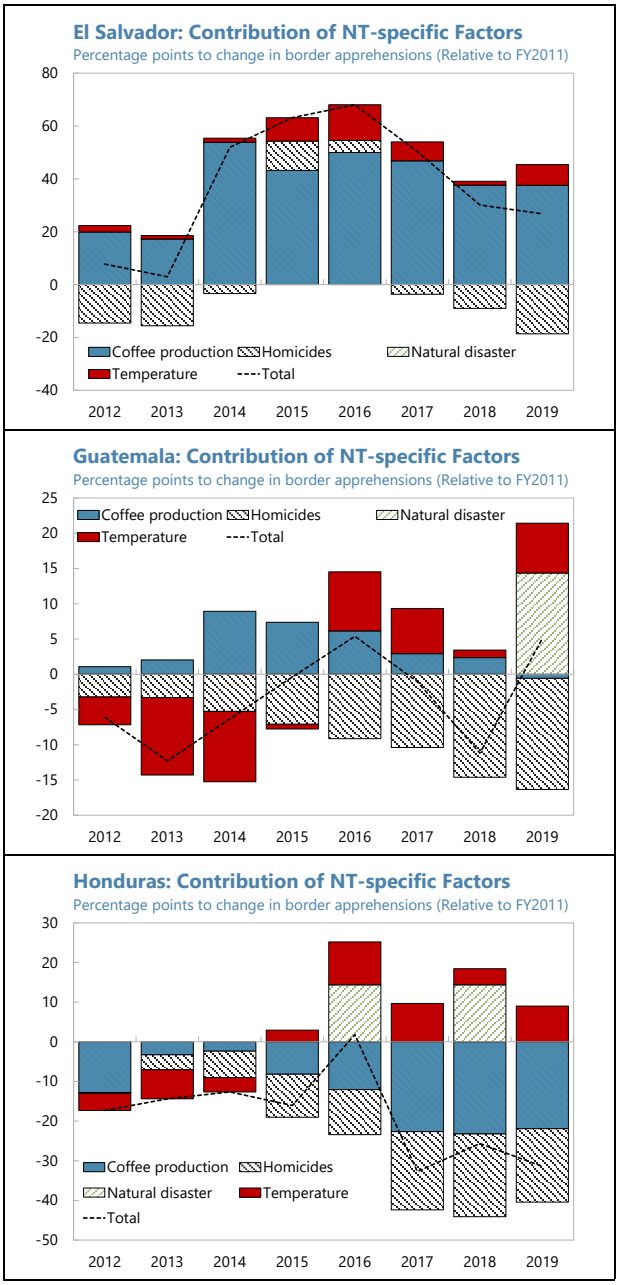
Annex IV. Country Results

Figure IV.1. Country Specific Results: Goodness of Fit and Role of Various Factors Explaining the Increase in Migration in FY2019 compared to FY2011



Source: Staff estimates based on baseline model in Table 1. See data section for sources.
1/ Charts show contribution to detrended series of border apprehensions.

Figure IV. 2. Country Specific Nontraditional Factors



Source: Staff estimates based on baseline model in Table 1. See data section for sources.

1/ Charts show contribution to detrended series of border apprehensions.

Annex V. Unit Root and Cointegration Tests

Table V.1. Unit Root Test

	El Salvador		Guatemala		Honduras	
	Level	Difference	Level	Difference	Level	Difference
Border apprehensions	-2.78	-4.43***	-1.43	-3.81**	-2.33	-4.56***
Border agents	0.05	-3.59**	0.05	-3.59**	0.05	-3.59**
Legal admissions	-1.43	-2.37	-2.29	-5.44***	-2.92	-3.78**
U.S. Hispanics real median wage	-2.20	-4.11***	-2.20	-4.11***	-2.20	-4.11***
NT real wage	-2.33	-7.07***	-1.64	-3.30*	-2.76	-7.45***
NT unemployment rate	-3.90**	-7.21***	-1.53	-3.94**	-3.14*	-5.34***
U.S. Hispanics unemployment rate	-2.58	-5.28***	-2.58	-5.28***	-2.58	-5.28***
NT coffee production	-3.89**	-8.70***	-3.24*	-6.43***	-4.12***	-9.13***
NT homicide rate	-2.24	-3.93**	-0.65	-3.65**	-1.90	-3.38**
NT temperature deviation	-4.32***	-6.22***	-3.74**	-5.45***	-4.10***	-6.01***
NT deportations	-1.01	-3.91***	-1.31	-4.51***	-1.55	-4.44***
Border apprehensions per caipta	-2.79	-4.43***	-1.40	-3.82**	-2.30	-4.56***
Border agents per capita	0.02	-3.61**	0.02	-3.61**	0.02	-3.61**
Legal admissions per capita	-1.40	-2.39	-2.22	-5.41***	-2.86	-3.78**
Deportations per capita	-1.00	-3.90***	-1.34	-4.52***	-1.61	-4.44***

Note: Unit root test is performed on regression with trend of the following form $y_t = c + \delta t + \phi y_{t-1} + \varepsilon_t$

Table reports Augmented Dickey Fuller test statistics for unit roots in levels and the first differences.
*** Indicates rejection of the null hypothesis of unit roots at 1 percent; ** at 5 percent; and * at 10 percent.

Table V.2. Cointegration Test between Border Apprehensions and Various Indicators

	El Salvador	Guatemala	Honduras
Border agents	-3.04**	-3.09**	-2.66*
Legal admissions	-2.99**	-1.69	-2.52
U.S. Hispanics real median wage	-2.91**	-1.82	-2.68*
NT real wage	-2.89**	-2.34	-2.63*
NT unemployment rate	-2.95**	-2.32	-2.64*
U.S. Hispanics unemployment rate	-3.44***	-1.88	-3.75***
NT coffee production	-3.54***	-1.58	-2.26
NT homicide rate	-2.88**	-1.98	-2.81*
NT temperature deviation	-3.22**	-1.68	-2.80*
NT deportations	-2.93**	-2.18	-2.32

Note: Table reports ADF test statistics on unit roots in the residuals of OLS regressions.
*** Indicates rejection of the null hypothesis of unit roots at 1 percent; ** at 5 percent; and * at 10 percent.

Annex VI. Robustness Tests

For testing the robustness of our empirical strategy, stemming from the potential identification problem of simultaneous identification of border apprehensions and border agents, we estimated the following specifications:

1. Baseline specification with and without variable for border agents (Table VI.1, columns 1 and 2)
2. Baseline specification for border apprehensions per capita of population of country of origin, and defining border agents as per capita of the U.S. population (Table VI.1, columns 3 and 4)
3. The same specifications as in Table VI.1 with real GDP per capita in the U.S. and the NT country, instead of real wage variables (Table VI.2)
4. IV regression of specifications (1) and (3) in Table VI, instrumenting for lagged values of border agents and total apprehensions in Southwest border (Table VI.3, columns 1 and 2)
5. Residual enforcement regression of specifications (1) and (3) in Table VI, with border agents defined as excess (or residual) of border agents beyond the structural equation of border agents as a function of last period value of border agents and border apprehensions of Mexican citizens. (Table VI.3, columns 3 and 4)
6. Specification that controls for pre-existing network of immigrant population (Table VI.4)

Across these different specifications, the estimates for baseline specification coefficients are preserved. Moreover, the coefficient for legal admissions was estimated as negative, as expected, and statistically significant in specification VI.1.4 and VI.3.4.

Table VI.1. Determinants of Evolution of Border Apprehensions of NT Citizens (FY1994 - FY2019)

	Dependent variable:			
	Border apperhensions		Border apperhensions per capita	
	(1)	(2)	(3)	(4)
Constant	-40.942	-63.163**	-54.727**	-62.459**
	(26.190)	(28.730)	(24.715)	(27.552)
US: Hispanics real median wage	5.241***	7.789***	4.554***	7.580***
	(1.693)	(1.832)	(1.600)	(1.655)
US: Hispanics unemployment rate	-6.101**	-14.250***	-7.099***	-14.645***
	(2.388)	(1.917)	(2.272)	(1.821)
NT: Real average wage	-1.438***	-1.384***	-1.330***	-1.319***
	(0.236)	(0.296)	(0.211)	(0.265)
NT: Unemployment rate	16.160***	24.009***	18.124***	24.127***
	(5.230)	(5.453)	(4.959)	(5.218)
US: Southwest border agents	-2.264***		-2.073***	
	(0.485)		(0.461)	
US: Legal admissions of NT citizens to the U.S.	0.013	-0.224	-0.159	-0.449*
	(0.230)	(0.268)	(0.227)	(0.258)
US: Deportations of NT citizens from the U.S.	0.554***	0.401***	0.478***	0.322***
	(0.092)	(0.095)	(0.096)	(0.098)
NT: Immigration wave 1, FY2012-FY2014 (D)	0.831***	0.826***	0.808***	0.821***
	(0.095)	(0.105)	(0.092)	(0.101)
NT: Immigration wave 2, FY2019 (D)	0.729***	0.799***	0.723***	0.789***
	(0.145)	(0.157)	(0.140)	(0.152)
NT: Coffee production	-0.417***	-0.493***	-0.469***	-0.552***
	(0.104)	(0.116)	(0.099)	(0.107)
NT: Homicide rate per 100,000	0.277**	0.247*	0.235**	0.223*
	(0.117)	(0.136)	(0.113)	(0.129)
NT: Temperature (deviation March-August, 2-year average)	0.197*	0.323***	0.190*	0.305***
	(0.103)	(0.109)	(0.100)	(0.106)
NT: Natural disaster event (D)	0.144**	0.123*	0.133**	0.115*
	(0.063)	(0.069)	(0.061)	(0.067)
Number of observations	78	78	78	78

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01
All variables are in natural log form. The regression model was estimated using Feasible Generalized Least Squares method with serial autocorrelation in panels.

Table VI.2. Determinants of Evolution of Border Apprehensions of NT Citizens (FY1994 - FY2019)

	Dependent variable:			
	Border apperhensions		Border apperhensions per capita	
	(1)	(2)	(3)	(4)
Constant	-145.237**	-213.233**	-141.786**	-208.903**
	(55.319)	(53.938)	(53.211)	(50.901)
US: Real GDP per capita	7.974**	11.789***	7.700**	11.906***
	(3.247)	(3.184)	(3.209)	(3.043)
US: Hispanics unemployment rate	0.775	-3.577	-0.754	-4.188
	(3.284)	(3.252)	(3.112)	(3.122)
NT: Real GDP per capita	0.760	0.854	0.046	0.478
	(1.056)	(1.049)	(0.992)	(0.967)
NT: Unemployment rate	15.990**	23.817***	16.318***	23.801***
	(6.565)	(6.396)	(6.260)	(6.009)
US: Southwest border agents	-2.080***		-1.974***	
	(0.621)		(0.611)	
US: Legal admissions of NT citizens to the U.S.	0.050	-0.083	-0.098	-0.276
	(0.234)	(0.248)	(0.237)	(0.247)
US: Deportations of NT citizens from the U.S.	0.342**	0.091	0.299**	0.045
	(0.143)	(0.126)	(0.142)	(0.119)
NT: Immigration wave 1, FY2012-FY2014 (D)	0.847***	0.881***	0.831***	0.864***
	(0.116)	(0.118)	(0.112)	(0.113)
NT: Immigration wave 2, FY2019 (D)	0.742***	0.796***	0.737***	0.787***
	(0.152)	(0.159)	(0.148)	(0.155)
NT: Coffee production	-0.440***	-0.518***	-0.466***	-0.574***
	(0.120)	(0.124)	(0.118)	(0.118)
NT: Homicide rate per 100,000	0.271**	0.249*	0.212	0.174
	(0.138)	(0.140)	(0.131)	(0.132)
NT: Temperature (deviation March-August, 2-year average)	0.270**	0.410***	0.269**	0.399***
	(0.114)	(0.112)	(0.111)	(0.110)
NT: Natural disaster event (D)	0.062	0.029	0.056	0.022
	(0.066)	(0.070)	(0.065)	(0.069)
Number of observations	78	78	78	78

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01
All variables are in natural log form. The regression model was estimated using Feasible Generalized Least Squares method with serial autocorrelation in panels.

Table VI.3. Instrumental Variable and Residual Enforcement Regressions (FY1994 - FY2019)

	IV regression		Residual approach regression	
	Border apperhensions	Border apperhensions per capita	Border apperhensions	Border apperhensions per capita
	(1)	(2)	(3)	(4)
Constant	-65.459**	-60.633**	-43.771	-45.919*
	(28.321)	(25.721)	(26.738)	(25.579)
US: Hispanics real median wage	6.438***	5.713***	6.545***	6.343***
	(1.989)	(1.856)	(1.672)	(1.508)
US: Hispanics unemployment rate	-10.039***	-11.037***	-13.015***	-13.439***
	(2.616)	(2.367)	(1.750)	(1.660)
NT: Real average wage	-1.453***	-1.365***	-1.655***	-1.591***
	(0.176)	(0.177)	(0.242)	(0.227)
NT: Unemployment rate	23.098***	22.121***	19.636***	20.438***
	(5.672)	(5.337)	(5.214)	(4.958)
US: Southwest border agents	-1.192*	-1.018*	-2.891***	-2.726***
	(0.666)	(0.599)	(0.660)	(0.643)
US: Legal admissions of NT citizens to the U.S.	-0.101	-0.279	-0.233	-0.434**
	(0.196)	(0.206)	(0.234)	(0.221)
US: Deportations of NT citizens from the U.S.	0.487***	0.384***	0.652***	0.545***
	(0.099)	(0.108)	(0.107)	(0.111)
NT: Immigration wave 1, FY2012-FY2014 (D)	0.921***	0.868***	0.709***	0.717***
	(0.086)	(0.078)	(0.105)	(0.100)
NT: Immigration wave 2, FY2019 (D)	0.732***	0.742***	0.834***	0.832***
	(0.149)	(0.156)	(0.147)	(0.143)
NT: Coffee production	-0.524***	-0.546***	-0.409***	-0.460***
	(0.102)	(0.094)	(0.107)	(0.101)
NT: Homicide rate per 100,000	0.295**	0.268**	0.259**	0.245**
	(0.118)	(0.108)	(0.122)	(0.115)
NT: Temperature (deviation March-August, 2-year average)	0.313***	0.283***	0.260**	0.248**
	(0.113)	(0.100)	(0.101)	(0.098)
NT: Natural disaster event (D)	0.181***	0.168**	0.097	0.095
	(0.067)	(0.065)	(0.064)	(0.062)
Number of observations	78	78	78	78
R-square	0.959	0.959		
Underidentification test	27.934	25.544		
Weak identification test	33.491	37.712		
Hansen J-statistic	1.725	0.263		

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01

Table VI.4. Pre-existing Network and Border Apprehensions (FY1994 - FY2019)

	Dependent variable:			
	Border apperhensions		Border apperhensions per capita	
	(1)	(2)	(3)	(4)
Constant	-61.995**	-55.901*	-68.599***	-59.726**
	(25.056)	(29.117)	(25.127)	(27.494)
US: Hispanics real median wage	4.077**	5.112**	7.246***	7.061***
	(1.739)	(2.017)	(1.571)	(1.687)
US: Hispanics unemployment rate	-9.775***	-14.662***	-12.144***	-14.644***
	(1.832)	(1.972)	(1.891)	(1.866)
NT: Real average wage	-1.243***	-1.426***	-1.321***	-1.341***
	(0.190)	(0.280)	(0.239)	(0.265)
NT: Unemployment rate	19.363***	23.941***	21.893***	24.094***
	(5.193)	(5.615)	(4.905)	(5.298)
US: Southwest border agents	-1.288***		-0.879***	
	(0.254)		(0.291)	
US: Legal admissions of NT citizens to the U.S.	-0.028	-0.283	-0.316	-0.462*
	(0.237)	(0.258)	(0.251)	(0.254)
US: Deportations of NT citizens from the U.S.	0.461***	0.244**	0.459***	0.288***
	(0.095)	(0.100)	(0.096)	(0.090)
NT: Immigration wave 1, FY2012-FY2014 (D)	0.775***	0.819***	0.819***	0.818***
	(0.093)	(0.108)	(0.093)	(0.102)
NT: Immigration wave 2, FY2019 (D)	0.735***	0.886***	0.744***	0.810***
	(0.144)	(0.157)	(0.148)	(0.154)
NT: Coffee production	-0.685***	-0.559***	-0.554***	-0.552***
	(0.106)	(0.121)	(0.101)	(0.109)
NT: Homicide rate per 100,000	0.090	0.241*	0.198	0.227*
	(0.124)	(0.138)	(0.121)	(0.131)
NT: Temperature (deviation March-August, 2-year average)	0.207**	0.298***	0.235**	0.301***
	(0.099)	(0.109)	(0.104)	(0.106)
NT: Natural disaster event (D)	0.102	0.124*	0.114*	0.118*
	(0.063)	(0.068)	(0.064)	(0.066)
NT: Immigrant population in U.S. (t-1)	1.949***	0.717	1.082*	-0.006
	(0.445)	(0.454)	(0.610)	(0.513)
Number of observations	78	78	78	78

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01
All variables are in natural log form. The regression model was estimated using Feasible Generalized Least Squares method with serial autocorrelation in panels.

Annex VII. Discussion on the Role of Border Enforcement Measures

The elasticity with respect to border enforcement in equation 1.3 in Annex I—after taking into account simultaneous identification of border enforcement and apprehensions—can be expressed in the following way:

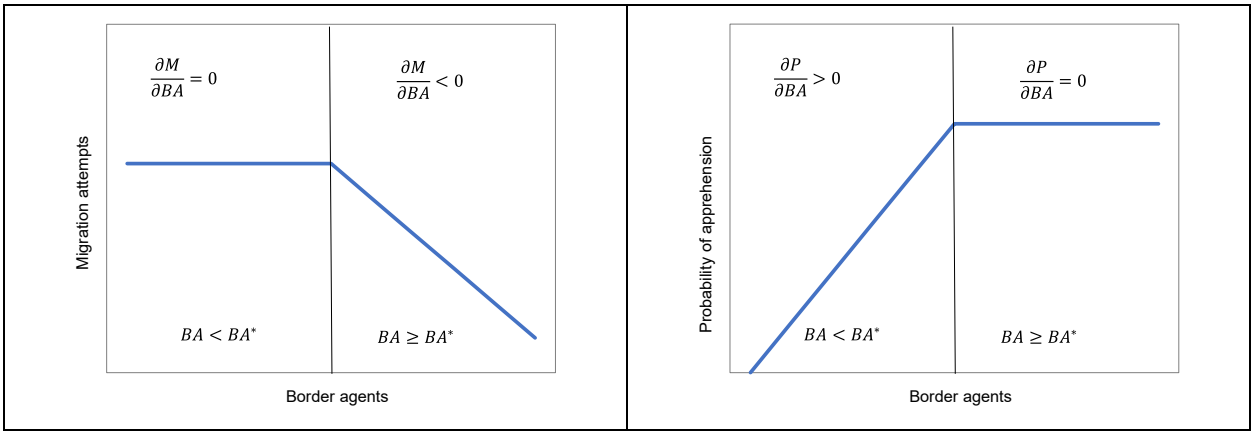
$$\frac{\partial A}{\partial BA} = \frac{\partial P}{\partial BA} + (1 + \frac{\partial P}{\partial M})\frac{\partial M}{\partial BA} \quad (2)$$

The term, $\frac{\partial P}{\partial BA} \geq 0$, is the elasticity of probability of apprehension with respect to the border agents—a direct effect of enforcement measures on apprehensions—which is increasing alongside border enforcement measures (agents). The term, $\frac{\partial M}{\partial BA} \leq 0$, is the elasticity of migration attempts with respect to the border agents—an indirect effect of enforcement measures on apprehensions—which acts as deterrent and is decreasing alongside border enforcement measures (agents). The term, $\frac{\partial P}{\partial M} \leq 0$, is the elasticity of probability of apprehension with respect to attempts—a direct effect of attempts on apprehensions—is decreasing alongside number of attempts.

In Hanson and Spilimbergo (1999), $\frac{\partial A}{\partial BA} > 0$, which was argued as a lower bound of the true marginal product of enforcement, as they are likely to underestimate the marginal product of enforcement and overestimate the marginal cost of enforcement. One interpretation of Hanson and Spilimbergo is that deterrent effect, $\frac{\partial M}{\partial BA}$, may not exist or too small to be offset by direct effect of probability of apprehension, $\frac{\partial P}{\partial BA}$.

The elasticity of apprehension with respect to border agent in our model is negative, which support the evidence of a strong deterrent effect. To reconcile these two opposite findings, we can argue that there is nonlinearity in the estimate of elasticity, with inflection point subject to the border enforcement measures distance to its equilibrium point, BA^*.

For border enforcement measures below equilibrium level, $BA < BA^*$, we can see that $\frac{\partial P}{\partial BA} > 0$ and $\frac{\partial M}{\partial BA} = 0$, which would render results of Hanson and Spilimbergo, $\frac{\partial A}{\partial BA} > 0$. However, when border enforcement measures are at or beyond its equilibrium level, $BA \geq BA^*$, we can see that $\frac{\partial P}{\partial BA} = 0$ and $\frac{\partial M}{\partial BA} < 0$, with result in $\frac{\partial A}{\partial BA} < 0$.



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