Managing the Impact of Climate Change on Migration: Evidence from Mexico*

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Abstract

This paper uses state-level migration flow data between Mexico and the U.S. from 1999 to 2011 to investigate the migration response to climate shocks and the mitigating impact of an agricultural cash-transfer program (PROCAMPO) and a disaster fund (Fonden). Our results suggest that droughts increase undocumented migration. Fonden amounts are found to mitigate the effect of climate shocks by lowering the undocumented migration response to precipitation anomalies. Similarly an increase in the share of PROCAMPO funds to the *ejido* sector decreases undocumented migration after a shock. By contrast, we find no robust evidence of a mitigating impact on documented migration.

Keywords : International migration ; Climate change ; Public policies; Weather variability; Natural disasters ; Mexico-U.S. migration

JEL classification : F22, Q54; Q18 ; 015; J61

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1 Introduction

Among the many consequences of climate change on economic activity, its impact on human mobility is a key issue. According to the UNHCR, individuals are today twice more likely to be forced to migrate due to environmental disasters than in 1970. The Internal Displacement Monitoring Centre estimates to 17.5 million the number of people displaced by weather-related disasters in 2014. However, these figures only capture the most visible part of climate-induced migration. Gradual and sustained shifts in rainfall and temperatures also contribute to drive migration, in particular through their impact on agricultural yields (Schlenker and Roberts, 2009; Feng et al., 2012). The impact of climate change on migration is found to be higher in developing countries that are ex-ante more vulnerable (Beine and Parsons, 2015; Coniglio and Pesce, 2015), which can be partly explained by the limited capacity of governments to fund public policies helping households to cope with climatic shocks. In the rapidly growing body of literature concerned by the impact of climate change on migration, the mitigating role of public policies, though critical, has remained largely unexplored.

Taking advantage of a unique panel database on yearly Mexico-US migrant flows at the Mexican state level from 1999 to 2011, this paper investigates the impact of climatic factors on migration and the mitigating impact of two public programs, the cash-transfer agricultural program PROCAMPO, and the disaster fund Fonden. Following Chort and De La Rupelle (2016), the migration flow database is constructed based on individual data from the Survey of Migration at the Northern Border of Mexico (*Encuesta sobre Migración en la Frontera Norte de México* or EMIF Norte). Information on Mexican states of origin and survey weights are used to obtain yearly migration outflows from each Mexican state. In spite of the unusual design of the EMIF aimed at capturing transit migrants, the data collected, once aggregated, have been found to be fairly representative of Mexico-US migrant flows (Rendall et al., 2009)[1]. Three unique features and major

[1] See also Chort and De La Rupelle (2016) for a detailed discussion of the advantages and drawbacks

advantages of the migration flow data constructed from the EMIF are the availability of a 13 year panel, the fine level of regional disaggregation, and the possibility to analyze documented and undocumented flows separately. The longitudinal dimension of our data allows us to control for all time-invariant specific characteristics of Mexican states of origin and year effects common to all Mexican states by using origin and year fixed-effects, and to deal with serial and spatial correlation issues following Hsiang (2010). Migration flow data are merged to satellite and land data on precipitations and temperatures and information on hurricanes coming from the US National Oceanic and Atmospheric Administration. Finally, we combine migration and climate data with information on state-level payments of two governmental programs, the PROCAMPO program run by the Mexican Ministry of Agriculture (SAGARPA), and the disaster fund Fonden. The two programs, though of very different nature, are of particular relevance as PROCAMPO is the largest agricultural program funded by the Mexican federal government and consists in direct payments to agricultural producers on a per-hectare basis made twice a year, while Fonden is a disaster fund aimed at providing insurance to localities hit by a natural disaster. The specificities of each program imply that they may have a different mitigating impact. Sadoulet et al. (2001) find an income multiplier of 1.5-2.6 for the poorest category of PROCAMPO beneficiaries, which suggests that the transfers received under the program contribute to alleviating households' liquidity constraints. As such, PROCAMPO payments may affect the capacity of households to manage the effect of climatic shocks and influence migration decisions. The evaluation of the economic impact of the Fonden fund provided by de Janvry et al. (2016) shows a positive and sustained effect of the program on local economic activity and employment, suggesting that Fonden may affect migration responses to climatic shocks through different channels. The different mechanisms through which those two programs may impact migration after climate shocks are discussed in the following section.

Among the main results of our empirical analysis, we provide evidence of a positive

of using the EMIF data to construct migration flow aggregates.

impact of lower than average rainfall during the dry season on migration flows from Mexico to the US, supporting the assumption of drought driven migration and consistent with previous research on Mexico (Munshi, 2003; Pugatch and Yang, 2011; Chort, 2014; Chort and De La Rupelle, 2016). Being here able to separate documented and undocumented flow, we show that the latter finding is specific to undocumented flows: drought at origin increases the flows of undocumented Mexicans immigrants to the United-States. Moreover, we find evidence of an heterogenous impact of climatic shocks on undocumented migrant flows. Sizeable and significant effects are observed only for the most agricultural states which are ex-ante the most vulnerable, consistent with Beine and Parsons (2015) and Coniglio and Pesce (2015). Regarding the role of public policies, we find a mitigating impact of Fonden on the undocumented migration response to drought. Similarly, an increase in the share of PROCAMPO funds received by the *ejido* sector is found to decrease the undocumented migration response to rainfall anomalies. By contrast, we find no robust evidence of a mitigating impact of the two programs on documented migrant flows.

This article provides a bridge between the macroeconomic and microeconomic literature on the impact of climate on migration, as it focuses on a single country but explores the regional dynamics of climate-induced migrations by exploiting a panel of state level migration flows over a 13 year period. Our approach is fully in line with the macroeconomic literature on climate-induced migration initiated by Beine and Parsons (2015). We contribute to this strand of research by showing that climate shocks have heterogeneous impacts on migration not only depending on the season of the shock or the ex-ante vulnerability of locations of origin (Beine and Parsons, 2015; Coniglio and Pesce, 2015), but also on the type of migration, documented or undocumented.

In addition, our paper contributes to the literature investigating the impact of public policies on migration. In the Mexican context, early evaluations of the PROGRESA anti-poverty program suggest that conditional cash-transfers reduce migration to the U.S. (Stecklov et al., 2005). By contrast, focusing on labor migration only, Angelucci (2015) finds that entitlement to the new version of the PROGRESA program (*Oportunidades*) increases migration, suggestive of the existence of credit constraints and consistent with Rubalcava and Teruel (2006). These conflicting findings indicate that the same program may have heterogenous impacts on different migrant flows. Consistent with this intuition, our results suggest that the two programs that we study have different impacts on documented and undocumented flows.

2 Context and theoretical mechanisms

2.1 Climate and migration in Mexico

Studying the consequences of weather variability on migration in the Mexican context is particularly interesting for three reasons. First Mexico sits astride the Tropic of Cancer and has a large diversity of climatic characteristics, although almost all parts of the country are subject to hurricanes and tropical storms in summer and autumn[2]. Second, the economy of Mexican rural areas largely depends on agricultural activities[3]. Third, Mexico has a long history of migration to the United States, suggesting that moving has long been a way for Mexican households to cope with adverse economic shocks.

Climate projections for Mexico converge towards a 2.5 to 4°C increase in temperatures and a decrease in precipitations by 2100 (Gosling et al., 2011), while extreme phenomena such as hurricanes are expected to be more frequent and violent (Emanuel, 2013; Mendelsohn et al., 2012). Although climate change is a long term phenomenon, focusing on the recent period is of relevance given the dramatic acceleration of global warming in the last two decades and the observed higher frequency of natural disasters such as hurricanes or floods.

[2]The most recent destructive episodes in Mexico were due to Hurricane Ingrid and Manuel in September 2013, with an estimated number of directly affected people of one million and over 190 deaths, and Hurricane Norbert in 2008 striking the North Western states of Mexico and causing 25 deaths and millions of damages.

[3]Although the share of agriculture in the Mexican GDP is low (3.5% in 2010-2014) agricultural employment represents 13 % of total employment and 21% of the population live in rural areas (World Development Indicators, The World Bank).

In the context of Mexico, a number of previous papers have incidentally stressed the role of climatic events on migration (Munshi (2003), Pugatch and Yang (2011), Chort (2014), Chort and De La Rupelle (2016)). However, to date, few empirical studies have specifically focused on the impact of environmental factors on Mexican migration. Exceptions are Feng et al. (2010), who estimate the impact of decreases in crop yields due to climate change on migration, based on state level data for the periods 1995-2000 and 2000-2005. Saldaña-Zorrilla and Sandberg (2009) use data from the 1990 and 2000 Mexican censuses and focus on the impact of natural disasters on international migration. Nawrotzki et al. (2013) investigate the role of drought on migration based on the 2000 Mexican census[4]. The contribution of our paper to this literature is twofold. First, we complement existing evidence on climate induced Mexico-US migration by exploiting longitudinal yearly data on a relatively long period and by analyzing separately documented and undocumented flows. Second and most importantly, while previous studies exclusively focused on the effect of climate shocks, we investigate and compare the potential mitigating impact of different public policies.

2.2 The PROCAMPO and Fonden programs

We focus in this paper on two major programs, an agricultural cash-transfer program, PROCAMPO, and a disaster fund, Fonden. The PROCAMPO program is the vastest agricultural program in Mexico, initially launched in 1993 to mitigate the impact of the North American Free Trade Agreement (NAFTA) on Mexican producers by substituting direct cash payments to price support. Initially, eligibility was limited to plots planted in one of the nine identified basic crops (corn, beans, wheat, rice, sorghum, soybeans, cotton, safflower and barley) in the three year period preceding the implementation of the program. The program went through several reforms, the first one being the extension of the program to plots planted in any legal crop, as well as areas with livestock or under

[4] All these issues are also conceptually discussed in Cohen et al. (2013) but without econometric validation, while Eakin (2005) uses ethnographic data to analyze the vulnerability of rural households to climatic hazards.

forestry exploitation (autumn-winter cycle 1995-96). Two pro-poor reforms were carried out, in 2002 and 2009, the 2002 reform increasing in particular the amount per hectare received by small producers, and the 2009 modification establishing a maximum amount of one hundred thousand pesos per beneficiary and agricultural cycle (Fox and Haight, 2010). Eligible producers receive cash transfers on a per-hectare basis twice a year, for each growing season. In an early evaluation of the program, Sadoulet et al. (2001) find a high multiplier for PROCAMPO transfers, consistent with the existence of liquidity constraints and suggesting that received amounts are massively invested by producers in agricultural inputs. While average payments in real terms tend to decline over the period, the different pro-poor reforms contributed to maintain the level of transfers to small producers (less than 5 ha) to around MXN 600 in constant 1994 prices. Although PROCAMPO benefits are totally unrelated to climate events, this program is interesting as it is directed at agriculture, which is expected to be particularly affected by climate shocks. The coverage of the program is high, as the number of beneficiaries of PROCAMPO was 2,471,802 in 2010, representing 63% of agricultural production units. Beneficiaries of PROCAMPO are highly heterogenous, in particular due to the existence of the *ejido* sector that resulted from the 1910 revolution. As households in the *ejido* sector are on average poorer and have significantly contributed to migration to the US (Janvry et al., 1997), we choose to focus on the state-level share of transfers under PROCAMPO that are received by producers in the *ejido* sector.

The second program, Fonden, is a disaster fund created in 1996 and operational only since 2000, aimed at providing emergency relief funds and financial support to municipalities hit by a natural disaster to fund reconstruction of federal and local government assets (World Bank, 2012; de Janvry et al., 2016). Following an adverse shock, the procedure is launched with a declaration of a natural disaster and is subject to the decision of a damage assessment committee. The list of natural events qualifying for the program is not closed and includes in particular the following hydro-meteorological events: severe hail, hurricane, river flooding, rain flooding, severe rain, severe snow, severe drought, tropical storm, tornado. Since the start of the program, an average of 30 declarations of natural disasters has been registered each year. An evaluation of the impact of the program on economic recovery is provided by de Janvry et al. (2016) who find a positive and sustained effect of Fonden on economic activity, associated with a large increase in employment in the construction sector. After a natural disaster, funds are delivered quickly (within days for emergency funds, to weeks or months for reconstruction funds). For this reason, in the following discussion and in the empirical analysis, we investigate the mitigating impact of the two programs (Fonden and PROCAMPO) on contemporaneous climate shocks.

Importantly, state-level funds received under both programs are unlikely to be directly correlated with ex-ante migration trends or, in the case of Fonden, anticipated by prospective migrants. Indeed, entitlement to PROCAMPO is only based on agricultural land use and Fonden is explicitly targeted at natural disasters that are unpredictable and exogenous to migration decisions.

2.3 Theoretical mechanisms

We discuss in this section the impact of two different types of public programs on climate-induced migration, an unconditional cash-transfer program, and a disaster fund, to mimic the characteristics of the two programs, PROCAMPO and Fonden, presented above[5].

We assume that individuals live two periods, and decide to migrate at the end of the first period. In period 1, their only source of - home (H) - income is agriculture (a), and they earn a wage $w_{Ha,i,1} = \beta_{Ha,1} x_i$ with x_i a measure of individual skills and $\beta_{Ha,1}$ the returns to skills in the agricultural sector. Their utility depends additively on their wage, and on local amenities $A_{H,1}$. Utility of individual i in period 1 is given by:

$$u_{i,1} = w_{Ha,i,1} + A_{H,1} \tag{1}$$

[5]Strictly speaking, the cash-transfers under PROCAMPO are not unconditional, but what matters in our study is that entitlement to the program is not affected by the migration of one household member provided that part of the household stays and maintains an agricultural activity.

In period 2, their utility depends on whether they decide to migrate and, in the absence of any climatic shock, writes:

$$u_{i,2} = (1 - M_i)[w_{Ha,i,2} + A_{H,2}] + M_i[w_{F,i,2} + A_{F,2} - C] \tag{2}$$

where $w_{F,i,2}$ is the foreign wage ($w_{F,i,2} = \beta_{F,2}x_i$), depending on individual skills x_i and the returns to skills abroad $\beta_{F,2}$. $A_{F,2}$ are amenities at destination, and $M_i = 0, 1$ is a choice dummy with $M_i = 1$ if individual i decides to migrate, and $M_i = 0$ if she decides to stay. Migration is assumed to be costly, with an up-front cost C. If individuals cannot borrow, they are able to migrate only if migration costs are not higher than their saving capacity. Migration is thus subject to the following feasibility constraint:

$$C \leq w_{Ha,i,1} \tag{3}$$

Under the above assumptions, the maximization problem is the following: individual i decides to migrate if $w_{F,i,2} + A_{F,2} - C \geq w_{Ha,i,2} + A_{H,2}$ provided that constraint 3 is satisfied. Such a liquidity or credit constraint implies the existence of a pool of individuals willing to migrate but who are forced to stay for lack of sufficiently high income.

We now introduce climate shocks and public policies in the model. For simplicity, we assume that climate shocks occur in period 1 only. While Cattaneo and Peri (2016) focus exclusively on the productivity channel in their model, we assume that shocks can affect both amenities, through the destruction of infrastructures for example, and wage at origin, by lowering agricultural productivity. For simplicity, we further assume that the effect of the shock is homogenous across skill levels. In the event of a negative shock, period 1 utility writes:

$$u_{i,1} = \gamma_1 w_{Ha,i,1} + \delta_1 A_{H,1} \tag{4}$$

with $0 \leq \gamma_1 \leq 1$ and $0 \leq \delta_1 \leq 1$.

In period 2, in the absence of public policies, utility of agent i writes:

$$u_{i,2} = (1 - M_i)[\gamma_2 w_{Ha,i,2} + \delta_2 A_{H,2}] + M_i[w_{F,i,2} + A_{F,2} - C] \tag{5}$$

with $\gamma_1 \leq \gamma_2 \leq 1$ and $\delta_1 \leq \delta_2 \leq 1$, as we assume both a persistence of the impact of shocks occurred in period 1 and an attenuation between period 1 and 2. Shocks are assumed not to affect outcomes at destination.

Individual i decides to migrate if and only if:

$$w_{F,i,2} + A_{F,2} - C > \gamma_2 w_{Ha,i,2} + \delta_2 A_{H,2} \tag{6}$$

and

$$\gamma_1 w_{Ha,i,1} \geq C \tag{7}$$

In the absence of public policies, a negative climatic shock can affect migration decisions through several channels: first, through its direct impact on amenities. By lowering the value of local amenities, and thus the home utility, a negative climatic shock will increase migration. Second, a negative climate shock will have an indirect negative impact on agricultural wages in period 2, which will reinforce the amenity channel. However, a third effect goes in the opposite direction: through its impact on agricultural wages in period 1, a negative climatic shock will reduce individual ability to fund migration costs and will tend to lower migration. The resulting total impact of a negative climate shock on migration is indeterminate and depends in particular on the nature and intensity of the shock which will affect the relative importance of the γ and δ parameters at each period, and on the degree of persistence of the impact over the two periods.

However, more than the impact of a shock on migration, what is of interest for us is the potentially mitigating effect of public policies. We focus on two types of programs, an unconditional agricultural cash transfer program, and a disaster fund. The cash transfer program provides an amount T at the end of each period. We assume that T can be received even when migrating, which amounts to considering an unconditional cash-transfer. Indeed, the operational rules and characteristics of PROCAMPO make it comparable to an unconditional cash-transfer program since provided that the migrant leaves at least one member of the household and that an agricultural activity is maintained, she retains her entitlement to the benefits of the program. Amounts received at the end of period 1 can be either invested so as to mitigate the negative impact of climate shocks on agricultural wage in period 2 or used to fund migration in the second period.

The cash-transfer program thus affects individuals' maximization program in the following way. Individual i decides to migrate at the end of the first period provided that:

$$w_{F,i,2} + A_{F,2} - C + T > \gamma_2(\alpha_i T) w_{Ha,i,2} + \delta_2 A_{H,2} + T \tag{8}$$

and

$$\gamma_1 w_{Ha,i,1} + (1 - \alpha_i)T \geq C \tag{9}$$

with $0 \leq \alpha_i \leq 1$ the share of the amount received by individual i that is invested in agriculture. $\gamma_2(.)$ is assumed to be an increasing function of αT ($\gamma_2' > 0$), meaning that the recovery rate of agricultural productivity is increasing with the share of the first-period transfer that is invested in agriculture. As the transfer is assumed to be unconditional, the second-period transfer T appears on both sides of the inequality in Equation 8. The impact of the program on migration will depend on the use that is made of the payment T. If T is mostly invested in agricultural production (if α_i is close to one), we expect the program to have a mitigating impact: following a negative shock, the program will help agricultural wage to recover and increase the utility of staying. If T is mainly used to fund migration and provided that individual migration was liquidity constrained, then the program will increase migration, consistent with the assumptions made by Angelucci

(2012). However, empirical evidence suggests that PROCAMPO transfers in the first years of the program were predominantly invested by producers in agricultural inputs (Sadoulet et al., 2001). The overall impact of the program on migration decisions in the event of a negative climate shock is thus indeterminate.

The disaster fund operates through different channels. Funds are transferred to localities that suffered from a negative climate shock at the end of period 1. Based on empirical evidence provided by de Janvry et al. (2016), we assume that the transfers received first allow to reconstruct infrastructures, which we translate in the model by the fact that amenities have fully recovered in period 2. Second, the transfers generate a boom in the non-agricultural sector, due to the demand for labor created by reconstruction needs. We model this effect by introducing a second income source in period 2 which can be cumulated with agricultural income. In that case, the second period utility writes:

$$u_{i,2} = (1 - M_i)[\gamma_2 w_{Ha,i,2} + w_{Hna,i,2} + A_{H,2}] + M_i[w_{F,i,2} + A_{F,2} - C] \tag{10}$$

We thus expect the disaster fund to provide incentives to stay by increasing the value of the home option, through its effect on amenities and on income, and thus to have a mitigating impact on migration.

In sum, while the effect of the unconditional agricultural cash-transfer program on migration in response to a negative climate shock is indeterminate, the disaster fund is found to have an unambiguous mitigating effect. Given the characteristics of the two programs studied here, we expect the impact of PROCAMPO on climate-induced migration to depend on the use that is made of cash-transfers received, while Fonden is likely to reduce migration in response to an adverse climatic shock.

3 Data

3.1 Migration flows

Following Chort and De La Rupelle (2016), the migration flow data used in this paper are constructed from the EMIF surveys (Encuesta sobre Migración en la Frontera Norte de México)[6], collected annually since 1993 at the Mexico-US border. The EMIF aims at providing a representative picture of migration flows between Mexico and the US, in both directions. Individuals in transit are screened at several survey points along the border which are regularly updated to account for changes in geographical patterns and border enforcement measures. Those identified as migrants are individually interviewed[7]. The representativeness of the EMIF data is assessed by Rendall et al. (2009) who conclude to the particularly good coverage of male flows and undocumented flows[8]. Using the survey sampling weights, and information on the state of origin of surveyed migrants, we construct a database of yearly migration flows for the 31 Mexican states of origin plus the Federal district. The migration database used in this article exploits 13 waves of the EMIF survey that could be matched with climatic data covering the 1999-2011 period.As in Chort and De La Rupelle (2016), we choose to focus on male flows, since according to Rendall et al. (2009) the EMIF tends to under-represent migrant women. Using information collected in the survey, we are able to identify authorized and unauthorized migrants, and thus to separately analyze documented and undocumented migration flows[9].

For a relatively small number of observations, we observe zero total and/or undocumented flows (5 state-year cells for total flows representing 1% of observations, and 12

[6]http://www.colef.net/emif/

[7]The survey design is described in detail in each yearly report provided by the EMIF team, available at: `http://www.colef.mx/emif/publicacionesnte.php` and additional information on the survey design and the computation of the sampling weights are provided on the website of the EMIF (`http://www.colef.net/emif/diseniometodologico.php`).

[8]The advantages and drawbacks of using the EMIF data to analyze Mexico-US migration flows are also extensively discussed in Chort and De La Rupelle (2016)

[9]Unauthorized migrants are defined as individuals who declare having no document to cross the border nor to work in the U.S.

state-year cells for undocumented flows representing 2.5% of the total sample). As a high share of migrant flows are undocumented, the proportion of zero flows is larger for documented flows (9.5% of state-year observations). We explore two alternative ways of dealing with this issue. First, we set the value of the log migration rate to $ln(0.001)$ and control in all regressions for a dummy variable equal to one when the flow is zero. However, zero cells are not expected to be qualitatively different from non-zero ones, but rather result from migration flows that are too small to be captured by the EMIF surveys. An arguably more adequate treatment of zero flows consists in taking the cube root function of the dependent variable rather than the log. The different methods provide very similar results. We choose to present in the main tables of the paper the results obtained with the cube root transformation of the migrant share, while regression results obtained with the alternative treatments of zero flows are shown in Appendix (Table 5).

Descriptive statistics are provided in Table 4. Male migrants account for 0.5% on average of the total population of their state of origin and most of them (64% on average over 1999-2011) are undocumented. From 2004 to 2011, 43.5% of documented migrants declare that their main motive for migration is family reunification whereas 97% of undocumented migrants intend to migrate to the U.S. to work or in search of a job[10]. Note that the share of documented migrants migrating to join a family member has continuously increased over the period, reaching 60.2% in 2011, which reflects tightening migration restrictions in the U.S. These statistics confirm that documented and undocumented migrants flows have specific characteristics and must be studied separately.

3.2 Climatic shocks, economic variables, and public programs

We construct a state-level data set of hurricanes affecting Mexico between 1990 and 2012, from the Historical Hurricane Track tool developed by the U.S. National Oceanic and Atmospheric Administration (NOAA)[11]. We gather information on the number and

[10]Detailed information on the main reason for migration is available until 2004 only.
[11]http://www.csc.noaa.gov/hurricanes/

intensity of hurricanes and storms affecting each Mexican State and create two yearly state-level variables for the number of hurricanes and storms, and the maximum storm intensity registered in the year.

In addition, we use satellite data from the "Tropical Rainfall Measuring Mission" (TRMM)[12] and monthly gridded time series provided by the Department of Geography of the University of Delaware to construct state-level variables capturing deviations in precipitations and air temperatures from long-term averages. The TRMM is a joint project between the NASA and the Japanese Aerospace Exploration Agency which has been launched in 1997 to study tropical rainfalls, and is therefore well adapted to the Mexican context. Moreover, various technological innovations (including a precipitation radar, flying for the first time on an earth orbiting satellite) and the low flying altitude of the satellite increase the accuracy of the climatic measures. Interestingly enough, the TRMM products combine satellite measures with monthly terrestrial rain gauge data. Last, the measures are provided for 0.25 x 0.25 degree grid squares (around 25 km X 25 km), which allows us to construct very precise climatic variables. We construct rainfall and temperature state-level variables for the two main meteorological seasons in Mexico, the rainy season (spanning from May to October) and the dry season[13]. Following Beine and Parsons (2015), we create state-level seasonal normalized rainfall and air temperature variables (z-scores)[14].

Data on income, population, agriculture and crime come from the Mexican Instituto Nacional de Estadística y Geografía (INEGI)[15]. Since the definition of GDP aggregates

[12] A survey published in 1998 in the *American Journal of Agricultural Economics* stresses the progress expected in improved climate measure and forecast from the TRMM mission.

[13] We also investigate the impact of yearly shocks, but find no significant effect on migration (results available upon request).

[14] To construct seasonal z-scores, we first assign grid points to states based on latitude and longitude coordinates, then compute state-level total precipitations or average temperatures for each season, state-level long term seasonal averages and state-level seasonal standard deviations. Long term averages are obtained by combining the land and satellite data sources described above. The normalized variable is the state-level rainfall or temperature value minus the state-level long-run mean, divided by the state-level standard deviation over the observation period. For example, a positive value for the rainfall z-score for year t and season s in state i means that for year t, season s has been an especially rainy season in state i. Conversely, a negative value means that precipitations have been lower than (long-term) average in state i and season s of year t.

[15] Some of our variables taken from the census, and in particular Mexican population at the state

by the INEGI has changed in 2003, we interact the lagged GDP variable with a dummy equal to one for years 2004 to 2009.

State level data on PROCAMPO payments were aggregated based on individual data provided by the Mexican ministry of agriculture (SAGARPA), which allows us to construct the share of total transfers at the state level received by individuals in the *ejido* sector. Aggregate data on total annual amounts distributed at the state level under the Fonden program come from the open data Mexican government's website[16].

4 Empirical model

We estimate the following empirical model accounting for error serial and spatial correlation, following Conley and Ligon (2002). [17].

$$\begin{aligned} MIGR_{i,t} &= \beta_1' CLIM_{i,t-1} + \beta_2' CLIM_{i,t-1,s} \times POL_{i,t-1} + \beta_3 POL_{i,t-1} \\ &\quad + \delta lnGDP_{i,t-1} + \gamma' Z_{i,t-1} + D_i + D_t + \epsilon_{i,t} \end{aligned}$$

with $MIGR_{i,t}$ the cube root of the migration rate from Mexican origin state i at time t (per 10,000 population), $CLIM_{i,t-1}$ a set of climatic variables measured in origin state i at time $t-1$, including rainfall and temperature anomalies and $POL_{i,t-1}$ represent either the state-level amounts distributed under Fonden or the state-level share of PROCAMPO benefits distributed to farmers in the *ejido* sector. Additional specifications also investigate the impact of total amounts distributed under PROCAMPO (see Table 10). $lnGDP_{i,t-1}$ is the log of the real GDP per capita in state i at time $t-1$, and $Z_{i,t-1}$ a set of additional controls for Mexican states i at time $t-1$, including the state-level

level, are linearly extrapolated for the years in which they are not available.

[16] `https://datos.gob.mx/`

[17] The code for STATA developed by Hsiang (2010), based on Conley (1999) is available at `http://www.fight-entropy.com/2010/06/standard-error-adjustment-ols-for.html`. Parameters are estimated by OLS, and standard errors are corrected accounting for serial correlation over 1 period and for spatial correlation up to a distance cutoff set at 800km. All results are robust to allowing for autocorrelation over 2 periods and to a 500km distance cutoff.

unemployment rate and share of homicides at time $t-1$. D_i and D_t are state and year fixed effects.

We exploit the information contained in the micro-data used to construct aggregate flows to estimate the above equation for documented and undocumented flows separately. We expect a different impact of climatic shocks on migration depending on the type of economic activity in the Mexican states of origin. In particular, states in which agriculture is predominant are expected to be more vulnerable to adverse climatic shocks through direct channels such as crop destruction or lower yields, or to benefit more from positive shocks. We should thus observe larger effects of weather shocks on economic decisions in agricultural states. To explore potential non-linearities in the effect of climatic shocks on migration depending on state agricultural activity, we interact our climatic variables with dummies for the different quartiles of the average share of agricultural land in total state area for 2002-2005.

In addition to climatic and agricultural variables and following Beine and Parsons (2015), we include in all specifications the state-level GDP per capita and unemployment rate measured in $t-1$[18] As in Chort and De La Rupelle (2016), we control for social factors likely to influence migration decisions by including the rate of homicides in the state of origin.The approach of Cai et al. (2016) and Cattaneo and Peri (2016) is different, as they choose to include only fixed effects as controls arguing that, by doing so, they are better able to measure the total effect of climate on migration. A similar argument is put forward by Dallmann and Millock (2016), who point out the fact that economic variables are likely to be endogenous to contemporaneous climate shocks (Burke et al., 2015; Dell et al., 2009) and choose to exclude them from their analysis. However, parsimonious specifications imply the risk of omitting relevant factors explaining migration. As a way of avoiding these potential endogeneity concerns while accounting for the important role of

[18] As we do not observe internal migration flows in our data, we estimate alternative specifications, in which we further include in the set of regressors the log of the mean population weighted value of the GDP per capita in all other Mexican states, to partly capture the impact of a change in the attractiveness of other potential destinations which are not in our database, ie other Mexican states. Results are unchanged (available upon request).

non climate-related GDP growth on migration, we estimate an alternative specification in which our only economic and social control is the GDP per capita with two lags, which is certainly exogenous enough to climate anomalies measured in $t-1$. The results obtained are shown in Appendix (Table 6, Table 9) and are very similar to those of our main regressions.

5 Results

5.1 Impact of rainfall and temperatures

In Table 1, we present the results of GMM estimation of equation (1) for male flows (column 1 and 2), documented male flows (columns 3 and 4) and undocumented male flows (column 5 and 6). All specifications include state of origin and year fixed-effects and standards errors are corrected for autocorrelation and spatial correlation. The dependent variable is the cube root of the migration rate at the Mexican state level (per 10,000 inhabitants)[19].

Consistent with Chort and De La Rupelle (2016), we find a significant and positive impact of GDP in Mexican states of origin, especially at the beginning of the period for documented flows, suggesting that growth at origin tends to increase migration[20]. The unemployment rate is found to significantly impact migration of the undocumented only, confirming that undocumented migration is a response to an increase in home unemployment. Note already that the fact that documented migration is not significantly affected by unemployment is consistent with the greater diversity of migration motives among documented migrants, and contributes to explaining the different impact of the Fonden program on the two types of flows through the labor market channel. The sign of the coefficients on the homicide variable is negative (although not significant), consistent

[19] As above mentioned, results are robust to an alternative treatment of zero flows (see Table Table 5 in Appendix).

[20] As a change occurred in the computation of GDP in Mexico in 2003, the GDP variable is interacted with a dummy variable equal to one after 2003.

with Chort and De La Rupelle (2016)[21].

Neither the yearly number of hurricane nor the maximum hurricane intensity is found to significantly affect migration.

As for seasonal rainfall and temperature shocks, we find contrasted results for documented and undocumented flows, and depending on the agricultural activity in the state of origin (columns 4 and 6). The only significant effect of climate shocks common to both documented and undocumented migration flows is the positive impact of temperature deviations during the rainy season, significant in states from quartiles 2 and 3 for undocumented flows, and weakly significant in states from quartile 3 only for documented flows.

For documented flows, the coefficient on the rainfall variable during the rainy season is negative and significant (column 3). The decomposition of the effect in column 4 by quartiles of the share of agricultural land in total state area indicates that the effect is driven by the lowest two quartiles. Regarding temperatures, deviations from long term averages during the dry season are negatively correlated with documented migration flows (column 3), and again the effect is driven by the least agricultural states, the coefficient being significant for the second quartile of agricultural land share only (column 4).

A different pattern is observed for undocumented flows (columns 5 and 6). By contrast with results on documented flows, rainfall shocks during the rainy season have no effect except a positive one for states in the fourth agricultural quartiles (though weakly significant). The coefficient on rainfall deviations during the dry season is negative (column 5) and is driven by states in the highest two agricultural quartiles (column 6). As for temperatures, as noted above, the positive coefficients on temperature deviations during the rainy season are observed for both types of flows and driven by agricultural quartiles 2 and 3. By contrast, shocks during the dry season have the opposite effect on documented and undocumented flows, although they are driven in both cases by states in the second

[21] Chort and De La Rupelle (2016) show that the impact of violence is even more negative in the states where violence is directed at migrants (kidnapping and ransom demands), suggesting that an increase in violence is associated with higher migration costs.

agricultural quartile. The coefficient on deviations in temperatures during the dry season is indeed positive for undocumented flows.

Table 1: Determinants of Mexico-US migration flows - Cube root dependent variables

	Total male flows		Documented male flows		Undocumented male flows	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln GDP per capita $_{t-1}$	1.043***	0.999***	0.716***	0.725***	0.706***	0.669***
	(0.09)	(0.08)	(0.08)	(0.07)	(0.09)	(0.08)
Ln GDP per capita $_{t-1}$ X post 2003	-0.585***	-0.530***	-0.423***	-0.428***	-0.323**	-0.293**
	(0.12)	(0.11)	(0.14)	(0.15)	(0.13)	(0.12)
Unemployment rate $_{t-1}$	0.062*	0.070*	-0.017	-0.020	0.121***	0.138***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)
Ln share of homicides $_{t-1}$	-0.112	-0.104	-0.027	-0.038	-0.039	-0.018
	(0.11)	(0.11)	(0.12)	(0.11)	(0.07)	(0.08)
Nb hurricanes $_{t-1}$	0.066	0.050	-0.055	-0.047	0.101*	0.072
	(0.07)	(0.08)	(0.07)	(0.08)	(0.06)	(0.06)
Hurricane max intensity $_{t-1}$	-0.012	0.001	0.031	0.040	-0.040	-0.034
	(0.03)	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)
Rain deviations $_{t-1}$ - rainy season	-0.056		-0.097**		-0.009	
	(0.04)		(0.04)		(0.04)	
Rain deviations $_{t-1}$ - dry season	-0.063*		0.022		-0.056*	
	(0.04)		(0.04)		(0.03)	
Temp deviations $_{t-1}$ - rainy season	0.123**		0.088		0.062	
	(0.05)		(0.06)		(0.04)	
Temp deviations $_{t-1}$ - dry season	-0.046		-0.100*		0.032	
	(0.04)		(0.06)		(0.04)	
Rain $_{t-1}$ X quartile 1 of agri share - rainy season		-0.186***		-0.209**		-0.035
		(0.07)		(0.08)		(0.07)
Rain $_{t-1}$ X quartile 2 of agri share - rainy season		0.024		-0.112		-0.018
		(0.07)		(0.08)		(0.08)
Rain $_{t-1}$ X quartile 3 of agri share - rainy season		0.003		0.037		0.003
		(0.06)		(0.04)		(0.06)
Rain $_{t-1}$ X quartile 4 of agri share - rainy season		0.028		-0.026		0.050
		(0.06)		(0.07)		(0.05)
Rain $_{t-1}$ X quartile 1 of agri share - dry season		-0.069		0.021		-0.023
		(0.07)		(0.08)		(0.06)
Rain $_{t-1}$ X quartile 2 of agri share - dry season		0.008		0.060		-0.029
		(0.04)		(0.04)		(0.04)
Rain $_{t-1}$ X quartile 3 of agri share - dry season		-0.073		0.083		-0.113**
		(0.05)		(0.08)		(0.06)
Rain $_{t-1}$ X quartile 4 of agri share - dry season		-0.127**		-0.018		-0.107**
		(0.05)		(0.06)		(0.04)
Temp $_{t-1}$ X quartile 1 of agri share - rainy season		0.074		0.165		-0.015
		(0.07)		(0.11)		(0.06)
Temp $_{t-1}$ X quartile 2 of agri share - rainy season		0.229***		0.087*		0.154**
		(0.06)		(0.05)		(0.07)
Temp $_{t-1}$ X quartile 3 of agri share - rainy season		0.211***		0.097		0.183***
		(0.06)		(0.06)		(0.06)
Temp $_{t-1}$ X quartile 4 of agri share - rainy season		0.096		0.050		0.028
		(0.07)		(0.08)		(0.05)
Temp $_{t-1}$ X quartile 1 of agri share - dry season		-0.121*		-0.151		-0.046
		(0.07)		(0.10)		(0.07)
Temp $_{t-1}$ X quartile 2 of agri share - dry season		0.025		-0.106		0.106**
		(0.06)		(0.07)		(0.05)
Temp $_{t-1}$ X quartile 3 of agri share - dry season		-0.037		0.017		-0.009
		(0.04)		(0.06)		(0.04)
Temp $_{t-1}$ X quartile 4 of agri share - dry season		-0.089		-0.139*		0.033
		(0.05)		(0.08)		(0.05)
N	416	416	416	416	416	416

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Determinants of Mexico-US migration flows : positive, negative and extreme climate shocks - Cube root dependent variables

	Total male flows (1)	(2)	Documented male flows (3)	(4)	Undocumented male flows (5)	(6)
Ln GDP per capita $_{t-1}$	1.029***	1.033***	0.706***	0.689***	0.813***	0.837***
	(0.09)	(0.08)	(0.07)	(0.08)	(0.09)	(0.09)
Ln GDP per capita $_{t-1}$ X post 2003	-0.572***	-0.569***	-0.411***	-0.396**	-0.437***	-0.459***
	(0.12)	(0.12)	(0.15)	(0.16)	(0.13)	(0.12)
Unemployment rate $_{t-1}$	0.059	0.054	-0.020	-0.017	0.099***	0.100***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)
Ln share of homicides $_{t-1}$	-0.103	-0.102	-0.024	-0.030	-0.041	-0.050
	(0.10)	(0.10)	(0.11)	(0.11)	(0.07)	(0.07)
Nb hurricanes $_{t-1}$	0.057	0.059	-0.061	-0.042	0.083	0.079
	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)
Hurricane max intensity $_{t-1}$	-0.008	-0.011	0.034	0.026	-0.073***	-0.071**
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
Positive rain deviations $_{t-1}$ - rainy season	-0.052		-0.053		0.002	
	(0.05)		(0.04)		(0.05)	
Negative rain deviations $_{t-1}$ - rainy season	-0.069		-0.206**		0.053	
	(0.09)		(0.10)		(0.08)	
Positive rain deviations $_{t-1}$ - dry season	-0.020		0.041		-0.003	
	(0.04)		(0.05)		(0.04)	
Negative rain deviations $_{t-1}$ - dry season	-0.161*		0.003		-0.171**	
	(0.09)		(0.09)		(0.09)	
Positive temp deviations $_{t-1}$ - rainy season	0.128**		0.088		0.025	
	(0.06)		(0.08)		(0.04)	
Negative temp deviations $_{t-1}$ - rainy season	0.142*		0.136		0.059	
	(0.07)		(0.12)		(0.05)	
Positive temp deviations $_{t-1}$ - dry season	-0.086*		-0.152**		0.001	
	(0.05)		(0.07)		(0.05)	
Negative temp deviations $_{t-1}$ - dry season	0.007		-0.034		0.069	
	(0.06)		(0.09)		(0.06)	
Rain deviations $_{t-1}$ - rainy season		-0.058		-0.044		0.013
		(0.05)		(0.05)		(0.06)
Rain deviations $_{t-1}$ - dry season		-0.110*		0.032		-0.073
		(0.06)		(0.06)		(0.06)
Temp deviations $_{t-1}$ - rainy season		0.169***		0.143**		0.037
		(0.06)		(0.06)		(0.05)
Temp deviations $_{t-1}$ - dry season		-0.101*		-0.073		-0.045
		(0.06)		(0.06)		(0.05)
rain deviations $_{t-1}$ - rainy season X zscore >1.5		0.023		-0.023		0.006
		(0.06)		(0.06)		(0.06)
rain deviations $_{t-1}$ - dry season X zscore >1.5		0.081		-0.012		0.048
		(0.08)		(0.06)		(0.08)
temp deviations $_{t-1}$ - rainy season X zscore >1.5		-0.056		-0.065		-0.024
		(0.07)		(0.09)		(0.05)
temp deviations $_{t-1}$ - dry season X zscore >1.5		0.073		-0.065		0.107
		(0.08)		(0.08)		(0.07)
rain deviations $_{t-1}$ - rainy season X zscore <-1		-0.072		-0.255**		0.028
		(0.10)		(0.12)		(0.10)
rain deviations $_{t-1}$ - dry season X zscore <-1		0.070		0.010		0.028
		(0.05)		(0.07)		(0.08)
temp deviations $_{t-1}$ - rainy season X zscore <-1		-0.055		-0.124		0.074
		(0.06)		(0.08)		(0.09)
temp deviations $_{t-1}$ - dry season X zscore <-1		0.121*		-0.001		0.142***
		(0.06)		(0.08)		(0.04)
N	416	416	416	416	416	416

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2 goes further by exploring separately the impact of positive and negative deviations from long term averages in rainfall and temperatures. Regarding documented flows, results shown in column 3 suggest that the negative coefficient on rainfall deviations during the rainy season observed in Table 1 (columns 3 and 4) is driven by negative rainfall deviations. The negative and significant coefficient on the negative rain deviations variable (rainy season) in Table 2, column 3, indicates that lower than average precipitations at origin during the rainy season increase documented migration. The impact of temperature anomalies during the dry season goes through positive shocks: an increase in temperatures decreases documented migration.

For undocumented flows, when introducing separately the different types of shocks, we find a negative coefficient on the negative rainfall variable during the dry season (column 7). Lower than average rainfall during the dry season increase undocumented migration suggestive of drought-driven migration. This finding is consistent with previous evidence of drought driven migration in the Mexican context (Pugatch and Yang, 2011; Chort, 2014; Chort and De La Rupelle, 2016; Nawrotzki et al., 2013).

Columns 2, 4 and 6 explore the effect of extreme shocks by interacting rainfall and temperature variables with dummies for large positive shocks (z-score, i.e. normalized deviations from the long-term average over 1.5) and negative shocks (z-score below -1). Results shown in column 4 suggest that the negative coefficient on rainfall shocks during the rainy season observed for documented migrant flows is driven by large negative shocks (with a z-score lower than -1). None of the results presented above for undocumented flows is driven by extreme shocks. However, as indicated by the negative coefficient on extreme negative temperature deviations during the dry season, abnormally low negative temperatures during the dry season are found to increase migration.

Consistent with these findings, our main results are robust to the exclusion of year 2010 which follows the exceptional drought episode of 2009[22]. Results are shown in Table 7 in Appendix, replicating Table 1.

[22] Climate variables enter our main specifications with one lag.

5.2 Role of public policies

In Table 3, we explore the effect of the two public programs presented in Section 2, PROCAMPO and Fonden, on climate-driven migration. The Fonden program being a disaster fund, amounts received are conditioned upon the occurrence of a shock. As a consequence, the proportion of state-year cells with zero registered amounts is high. We choose to adopt the same methodology as for the dependent variables to deal with this issue and consider the cube root of the yearly per capita amounts received, rather than the log[23]. Regarding PROCAMPO, our variable of interest is the state-level share of total transfers received by farmers in the *ejido* sector. In alternative specifications, shown in Appendix (Table 10), we explore the impact of log distributed amounts per capita under PROCAMPO.

As the first payments under the Fonden program were effective in 2000, the sample is restricted to the 2000-2011 period. Columns 1, 4, and 7 replicate specifications 1, 3, and 5 of Table 1 on the reduced sample. The comparison of the two tables shows that the effect of climatic variables on migration is robust on the 2000-2011 sub-period.

First, we find no strong evidence of an impact of the amount received under Fonden when it is not interacted with climatic shocks. The coefficient on Fonden amounts is positive for documented male flows, yet it is not significant when interaction terms between Fonden amounts and climatic variables are added (columnn 6). By contrast, the coefficient on the share of PROCAMPO funds received by households in the *ejido* sector is positive and highly significant, consistent with earlier findings suggesting that *ejidos* concentrate rural poverty and are a major source of migrants to the US (Janvry et al., 1997). An increase in the redistributive nature of the program may thus help liquidity constrained beneficiaries to fund their migration to the US.

When interacting the amounts distributed under PROCAMPO or Fonden and rainfall

[23]Note that results are qualitatively unchanged when taking the log of Fonden amounts (per capita) to which we add 0.01 (which is lower than the lowest observed value for the variable in the sample), see Table 8 in Appendix.

and temperature variables we find contrasted results[24]. For both programs the interaction terms with climatic variables are not significant in the case of documented flows.

Note that if we rather focus on total state-level amounts received under PROCAMPO (Table 10 in Appendix), we find that the sign of the coefficient on temperature deviations during the dry season turns positive when interaction terms are introduced (Table 10, column 5), while the coefficient on the interaction term between the latter variable and PROCAMPO amounts is negative and highly significant. These findings suggest that the correlation between temperature deviations during the dry season and migration is positive and that the effect of temperatures is reversed by an increase in PROCAMPO payments. Since the results shown in Table 2 suggest that the effect of temperatures during the dry season goes through positive rather than negative shocks, the PROCAMPO program is found to reverse the main effect of an increase in temperatures. However such result is not robust across specifications[25].

Coming back to Table 3, columns 8 and 9, we find that both PROCAMPO and Fonden have a significant mitigating impact on climate-induced undocumented migration. As discussed above, rain deviations during the dry season are negatively correlated with undocumented migration, consistent with drought-driven migration. However, the interaction term with the per capita amounts distributed under Fonden is positive and significant, showing a mitigating effect of the Fonden program. Similarly, an increase in the share of PROCAMPO received by producers in the *ejido* sector is associated with a lower migration response to rainfall anomalies.

These results are robust to restricting the set of economic and social controls to the GDP with a two-year lag (see Table 9 in Appendix) or to taking both the Fonden variables in log rather than use a cube root transformation (Table 8).

[24]In alternative specifications we add interaction terms between PROCAMPO and Fonden payments and hurricane variables. The coefficients on the interaction terms for hurricane variables are never significant (results available upon request).

[25]More precisely, the negative and significant coefficient on the interaction term is robust across specifications, but the positive coefficient on deviations in temperatures during the dry season is not significant when controlling only for GDP with two lags, nor, in 7 cases out of 11, by dropping years one by one.

Differences in the impact of the two programs on documented and undocumented flows may be explained in part by the different motivations behind both types of migrations. Results presented in Table 10, column 7, show that unlike documented flows, undocumented flows are highly sensitive to variations in unemployment. This finding is consistent with descriptive evidence on the different motives for migrating in the two groups. Indeed, while the overwhelming majority of undocumented migrants (over 97%) migrate for labor related reasons, migration motives are more diverse with family reunification playing an important role. The coefficient on the unemployment variable is slightly lower when including interaction terms between Fonden amounts and climatic variables, suggesting that part of the unemployment effect may be captured by the Fonden interactions. This result is consistent with the labor market impact of Fonden evidenced by de Janvry et al. (2016) and highlighted in the theoretical discussion presented above. Indeed, one of the impacts of Fonden is to increase local labor demand, and since undocumented migration is more sensitive to employment than documented migration, we expect Fonden to have a greater mitigating impact on undocumented than on documented migration.

Another explanation for the different impacts of the two programs on documented and undocumented flows could be linked to the specific time schedules of the two types of migration. Indeed, in order to migrate to the US with official documents, candidates need to await visas for several months. We may thus observe a delayed impact of shocks and public policies, current documented migration being affected by climate shocks and transfers that occurred two years earlier rather than the previous year. We investigate this assumption by exploring the impact of climate shocks and public programs with two lags. We do not find any impact of climate shocks two years earlier on current documented and undocumented migration, which rules out such an interpretation based on different times constraints (results available upon request).

Table 3: Determinants of Mexico-US migration flows - Impact of public policies, 2001-2011 - Cube root dependent variables

	Total male flows			Documented male flows			Undocumented male flows		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln GDP per capita $_{t-1}$	0.905***	0.916***	0.858***	0.600***	0.642***	0.587***	0.595***	0.601***	0.542***
	(0.13)	(0.11)	(0.13)	(0.10)	(0.09)	(0.11)	(0.14)	(0.12)	(0.13)
Ln GDP per capita $_{t-1}$ X post 2003	-0.466***	-0.446***	-0.377***	-0.376**	-0.403**	-0.350**	-0.176	-0.167	-0.079
	(0.14)	(0.13)	(0.14)	(0.17)	(0.17)	(0.17)	(0.16)	(0.15)	(0.16)
Unemployment rate $_{t-1}$	0.040	0.041	0.024	-0.022	-0.025	-0.024	0.087***	0.089***	0.070**
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Ln share of homicides $_{t-1}$	0.089	0.054	0.093	0.116	0.062	0.115	0.063	0.044	0.071
	(0.12)	(0.11)	(0.12)	(0.16)	(0.17)	(0.16)	(0.09)	(0.08)	(0.08)
Nb hurricanes $_{t-1}$	0.114	0.128*	0.140**	-0.008	-0.013	0.001	0.129**	0.144**	0.150***
	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)
Hurricane max intensity $_{t-1}$	-0.051	-0.063*	-0.067*	-0.007	-0.012	-0.014	-0.054	-0.063**	-0.069**
	(0.04)	(0.04)	(0.03)	(0.06)	(0.06)	(0.06)	(0.03)	(0.03)	(0.03)
Share PROCAMPO to ejidos $_{t-1}$	0.327***	0.274***	0.332***	0.329***	0.354***	0.321***	0.286***	0.253***	0.302***
	(0.09)	(0.10)	(0.10)	(0.12)	(0.13)	(0.11)	(0.08)	(0.10)	(0.08)
Cube root amount Fonden $_{t-1}$	0.035*	0.036*	0.009	0.040*	0.042*	0.032	0.011	0.013	-0.022
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Rain deviations $_{t-1}$ - rainy season	-0.063	-0.048	-0.082	-0.099*	-0.010	-0.099	-0.027	0.010	-0.071
	(0.05)	(0.07)	(0.05)	(0.05)	(0.07)	(0.06)	(0.05)	(0.06)	(0.05)
Rain deviations $_{t-1}$ - dry season	-0.044	-0.217***	-0.153***	0.034	0.030	0.013	-0.048	-0.198**	-0.153***
	(0.03)	(0.08)	(0.05)	(0.05)	(0.11)	(0.07)	(0.04)	(0.10)	(0.05)
Temp deviations $_{t-1}$ - rainy season	0.164***	0.185**	0.154***	0.147**	0.216*	0.144**	0.057	0.048	0.034
	(0.06)	(0.09)	(0.05)	(0.07)	(0.12)	(0.06)	(0.04)	(0.07)	(0.05)
Temp deviations $_{t-1}$ - dry season	-0.090*	-0.200**	-0.128**	-0.152**	-0.212	-0.176**	0.005	-0.054	-0.008
	(0.05)	(0.10)	(0.06)	(0.08)	(0.14)	(0.09)	(0.04)	(0.09)	(0.05)
Rain deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.029			-0.122			-0.060	
		(0.07)			(0.09)			(0.06)	
Rain deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.214***			0.013			0.183*	
		(0.08)			(0.13)			(0.10)	
Temp deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.044			-0.108			0.003	
		(0.12)			(0.17)			(0.10)	
Temp deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.153			0.093			0.076	
		(0.13)			(0.16)			(0.12)	
Rain deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.007			0.000			0.017
			(0.01)			(0.01)			(0.01)
Rain deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.042***			0.007			0.042***
			(0.01)			(0.01)			(0.01)
Temp deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.010			0.006			0.015
			(0.02)			(0.03)			(0.01)
Temp deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.021**			0.012			0.010
			(0.01)			(0.01)			(0.01)
N	351	351	351	351	351	351	351	351	351

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

Using unique panel data documenting migration flows from Mexican states to the US over the 1995-2009 period, we explore the impact of hurricanes, rainfall and temperature shocks on migration rates to the US and the mitigating role of two public programs of different types, the PROCAMPO agricultural cash-transfer program and the Fonden disaster fund. We exploit the panel dimension of our data to control for origin and year fixed effects and account for spatial and serial correlation. In addition the micro-based state-level data that we use allow us to separately analyse documented and undocumented flows. We find that seasonal weather variability has a strong impact on outmigration rates from Mexican states, though affecting differently documented and undocumented flows. In particular, lower than average precipitations and temperatures during the dry season significantly increase undocumented migration, consistent with Munshi (2003) or Nawrotzki et al. (2013), especially from the most agricultural states. Note that climatic shocks are expected to affect both internal and international migration. As we focus on international migration, our results provide a lower bound of the impact of climatic factors on human mobility. Regarding the role played by public policies, we find evidence of a mitigating impact of the disaster fund Fonden and the agricultural cash-transfers PROCAMPO, on undocumented flows only. An increase in amounts transferred under Fonden or in the share of PROCAMPO received by farmers in the *ejido* sector reduces the undocumented migration response to rainfall anomalies. By contrast, the two programs dot not affect documented migration after a shock. As weather variability is believed to increase as a consequence of climate change, recurring droughts episodes are expected to contribute to increase migration flows from Mexican states. Consistent with de Janvry et al. (2016), this paper highlights the impact on climate-induced migration of well targeted public policies through a faster economic recovery.

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Appendix

Table 4: Summary statistics

Variable	Mean	Std. Dev.	N
Cube root male migration rate	3.343	1.142	416
Cube root male documented migration rate	2.111	1.132	416
Cube root male undocumented migration rate	2.812	1.111	416
Ln male migration rate	3.371	1.479	416
Ln male documented migration rate	1.411	2.939	416
Ln undocumented male migration rate	2.728	1.904	416
Ln GDP per capita $_{t-1}$	4.811	0.584	416
Ln GDP per capita $_{t-1}$ X post 2003	2.827	2.281	416
Unemployment rate $_{t-1}$	3.118	1.392	416
Ln share of homicides $_{t-1}$ per 10^5 pop	2.186	0.716	416
Nb hurricanes $_{t-1}$	0.293	0.637	416
Hurricane max intensity $_{t-1}$	0.519	1.182	416
Rain deviations $_{t-1}$ - rainy season	0.525	1.038	416
Rain deviations $_{t-1}$ - dry season	0.128	1.01	416
Temp deviations $_{t-1}$ - rainy season	0.534	0.994	416
Temp deviations $_{t-1}$ - dry season	0.263	0.939	416
Rain $_{t-1}$ X quartile 1 of agri share - rainy season	0.168	0.581	416
Rain $_{t-1}$ X quartile 2 of agri share - rainy season	0.221	0.594	416
Rain $_{t-1}$ X quartile 3 of agri share - rainy season	0.057	0.494	416
Rain $_{t-1}$ X quartile 4 of agri share - rainy season	0.079	0.578	416
Rain $_{t-1}$ X quartile 1 of agri share - dry season	0.021	0.449	416
Rain $_{t-1}$ X quartile 2 of agri share - dry season	0.09	0.616	416
Rain $_{t-1}$ X quartile 3 of agri share - dry season	-0.014	0.425	416
Rain $_{t-1}$ X quartile 4 of agri share - dry season	0.031	0.517	416
Temp $_{t-1}$ X quartile 1 of agri share - rainy season	0.223	0.595	416
Temp $_{t-1}$ X quartile 2 of agri share - rainy season	0.122	0.463	416
Temp $_{t-1}$ X quartile 3 of agri share - rainy season	0.088	0.542	416
Temp $_{t-1}$ X quartile 4 of agri share - rainy season	0.101	0.575	416
Temp $_{t-1}$ X quartile 1 of agri share - dry season	0.138	0.486	416
Temp $_{t-1}$ X quartile 2 of agri share - dry season	0.075	0.417	416
Temp $_{t-1}$ X quartile 3 of agri share - dry season	0.029	0.497	416
Temp $_{t-1}$ X quartile 4 of agri share - dry season	0.021	0.517	416
Rain deviations $_{t-1}$ - rainy season X zscore > 1.5	0.373	0.804	416
Rain deviations $_{t-1}$ - dry season X zscore > 1.5	0.21	0.724	416
Temp deviations $_{t-1}$ - rainy season X zscore > 1.5	0.302	0.796	416
Temp deviations $_{t-1}$ - dry season X zscore > 1.5	0.128	0.472	416
Rain deviations $_{t-1}$ - rainy season X zscore < -1	-0.105	0.373	416
Rain deviations $_{t-1}$ - dry season X zscore < -1	-0.091	0.349	416
Ln amount Procampo $_{t-1}$ thousands pesos per 10^4 pop (2001-2011)	4.581	1.25	351
Share PROCAMPO to ejidos $_{t-1}$ (2001-2011)	0.708	0.376	351
Cube root amount Fonden $_{t-1}$ thousands pesos per 10^6 pop (2001-2011)	1.936	2.408	351
Cum rainfall shocks - rainy season $t-1$ to $t-3$	1.465	2.219	416
Cum rainfall shocks - dry season $t-1$ to $t-3$	0.393	1.928	416

Table 5: Determinants of Mexico-US migration flows - Log dependent variables

	Total male flows		Documented male flows		Undocumented male flows	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln GDP per capita $_{t-1}$	1.016***	0.967***	0.806***	0.841***	0.483***	0.443***
	(0.11)	(0.11)	(0.20)	(0.21)	(0.11)	(0.11)
Ln GDP per capita $_{t-1}$ X post 2003	-0.471***	-0.400**	-0.746*	-0.789*	0.006	0.037
	(0.15)	(0.16)	(0.45)	(0.47)	(0.16)	(0.16)
Unemployment rate $_{t-1}$	0.053	0.058	0.035	0.033	0.142**	0.164***
	(0.04)	(0.04)	(0.08)	(0.08)	(0.06)	(0.06)
Ln share of homicides $_{t-1}$	-0.134	-0.126	-0.017	-0.022	-0.010	0.013
	(0.14)	(0.14)	(0.28)	(0.26)	(0.12)	(0.13)
Nb hurricanes $_{t-1}$	0.020	0.016	-0.231	-0.225	0.116	0.098
	(0.13)	(0.13)	(0.23)	(0.24)	(0.15)	(0.15)
Hurricane max intensity $_{t-1}$	0.010	0.012	0.052	0.062	-0.004	-0.001
	(0.07)	(0.07)	(0.11)	(0.11)	(0.07)	(0.07)
Rain deviations $_{t-1}$ - rainy season	-0.078		-0.249**		-0.055	
	(0.05)		(0.13)		(0.06)	
Rain deviations $_{t-1}$ - dry season	-0.044		0.107		-0.047	
	(0.05)		(0.13)		(0.06)	
Temp deviations $_{t-1}$ - rainy season	0.097*		0.136		0.125	
	(0.06)		(0.13)		(0.08)	
Temp deviations $_{t-1}$ - dry season	-0.038		-0.230*		0.038	
	(0.04)		(0.13)		(0.07)	
zeroNSUR_men	-6.860***	-6.796***				
	(0.49)	(0.48)				
Rain $_{t-1}$ X quartile 1 of agri share - rainy season		-0.210**		-0.429		-0.098
		(0.10)		(0.32)		(0.16)
Rain $_{t-1}$ X quartile 2 of agri share - rainy season		-0.021		-0.437**		-0.084
		(0.07)		(0.19)		(0.10)
Rain $_{t-1}$ X quartile 3 of agri share - rainy season		-0.005		0.050		0.003
		(0.06)		(0.07)		(0.07)
Rain $_{t-1}$ X quartile 4 of agri share - rainy season		-0.016		-0.100		-0.008
		(0.06)		(0.16)		(0.06)
Rain $_{t-1}$ X quartile 1 of agri share - dry season		-0.027		0.106		0.062
		(0.12)		(0.29)		(0.13)
Rain $_{t-1}$ X quartile 2 of agri share - dry season		0.001		0.140		-0.066
		(0.05)		(0.12)		(0.06)
Rain $_{t-1}$ X quartile 3 of agri share - dry season		-0.073		0.218		-0.117
		(0.05)		(0.19)		(0.08)
Rain $_{t-1}$ X quartile 4 of agri share - dry season		-0.105**		0.070		-0.112**
		(0.05)		(0.14)		(0.05)
Temp $_{t-1}$ X quartile 1 of agri share - rainy season		-0.023		0.253		0.044
		(0.10)		(0.30)		(0.13)
Temp $_{t-1}$ X quartile 2 of agri share - rainy season		0.229***		0.081		0.243**
		(0.08)		(0.15)		(0.10)
Temp $_{t-1}$ X quartile 3 of agri share - rainy season		0.212***		0.206		0.261**
		(0.08)		(0.14)		(0.10)
Temp $_{t-1}$ X quartile 4 of agri share - rainy season		0.087		0.037		0.085
		(0.08)		(0.15)		(0.08)
Temp $_{t-1}$ X quartile 1 of agri share - dry season		-0.003		-0.299		-0.005
		(0.13)		(0.44)		(0.16)
Temp $_{t-1}$ X quartile 2 of agri share - dry season		-0.014		-0.272		0.077
		(0.06)		(0.17)		(0.08)
Temp $_{t-1}$ X quartile 3 of agri share - dry season		-0.057		-0.032		0.005
		(0.04)		(0.12)		(0.06)
Temp $_{t-1}$ X quartile 4 of agri share - dry season		-0.090		-0.236		0.048
		(0.06)		(0.15)		(0.06)
zeroNSUR_mendoc			-3.221***	-3.158***		
			(0.32)	(0.32)		
zeroNSUR_men_undoccrosswork					-4.571***	-4.559***
					(0.40)	(0.40)
N	416	416	416	416	416	416

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Determinants of Mexico-US migration flows (GDP with two lags, without unemployment and homicides) - Cube root dependent variables

	Total male flows		Documented male flows		Undocumented male flows	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln GDP per capita $_{t-2}$	0.967***	0.949***	0.592***	0.596***	0.756***	0.764***
	(0.06)	(0.06)	(0.07)	(0.07)	(0.06)	(0.05)
Ln GDP per capita X post 2003 $_{t-2}$	-0.556***	-0.524***	-0.297**	-0.302**	-0.363***	-0.372***
	(0.12)	(0.10)	(0.13)	(0.14)	(0.12)	(0.10)
Nb hurricanes $_{t-1}$	0.062	0.047	-0.056	-0.048	0.092	0.076
	(0.08)	(0.09)	(0.07)	(0.09)	(0.07)	(0.07)
Hurricane max intensity $_{t-1}$	-0.013	0.000	0.030	0.039	-0.039	-0.035
	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)
Rain deviations $_{t-1}$ - rainy season	-0.068*		-0.106***		-0.013	
	(0.04)		(0.04)		(0.04)	
Rain deviations $_{t-1}$ - dry season	-0.066*		0.017		-0.054	
	(0.04)		(0.04)		(0.04)	
Temp deviations $_{t-1}$ - rainy season	0.142***		0.100*		0.076**	
	(0.05)		(0.06)		(0.04)	
Temp deviations $_{t-1}$ - dry season	-0.058		-0.103*		0.024	
	(0.04)		(0.06)		(0.04)	
Rain $_{t-1}$ X quartile 1 of agri share - rainy season		-0.202***		-0.221***		-0.047
		(0.07)		(0.08)		(0.08)
Rain $_{t-1}$ X quartile 2 of agri share - rainy season		-0.009		-0.155**		-0.035
		(0.08)		(0.08)		(0.08)
Rain $_{t-1}$ X quartile 3 of agri share - rainy season		-0.029		0.027		-0.044
		(0.06)		(0.05)		(0.07)
Rain $_{t-1}$ X quartile 4 of agri share - rainy season		0.031		-0.042		0.074*
		(0.04)		(0.05)		(0.04)
Rain $_{t-1}$ X quartile 1 of agri share - dry season		-0.075		0.016		-0.029
		(0.07)		(0.08)		(0.07)
Rain $_{t-1}$ X quartile 2 of agri share - dry season		0.008		0.046		-0.007
		(0.04)		(0.05)		(0.04)
Rain $_{t-1}$ X quartile 3 of agri share - dry season		-0.122***		0.022		-0.136***
		(0.04)		(0.07)		(0.05)
Rain $_{t-1}$ X quartile 4 of agri share - dry season		-0.098*		0.020		-0.103**
		(0.06)		(0.07)		(0.04)
Temp $_{t-1}$ X quartile 1 of agri share - rainy season		0.090		0.174*		-0.000
		(0.07)		(0.10)		(0.07)
Temp $_{t-1}$ X quartile 2 of agri share - rainy season		0.218***		0.089*		0.101*
		(0.06)		(0.05)		(0.06)
Temp $_{t-1}$ X quartile 3 of agri share - rainy season		0.225***		0.112*		0.181***
		(0.07)		(0.06)		(0.05)
Temp $_{t-1}$ X quartile 4 of agri share - rainy season		0.121		0.052		0.057
		(0.08)		(0.09)		(0.05)
Temp $_{t-1}$ X quartile 1 of agri share - dry season		-0.117*		-0.155		-0.017
		(0.07)		(0.10)		(0.07)
Temp $_{t-1}$ X quartile 2 of agri share - dry season		0.023		-0.137*		0.106*
		(0.06)		(0.08)		(0.05)
Temp $_{t-1}$ X quartile 3 of agri share - dry season		-0.083*		-0.028		-0.020
		(0.05)		(0.06)		(0.04)
Temp $_{t-1}$ X quartile 4 of agri share - dry season		-0.075		-0.087		0.013
		(0.06)		(0.09)		(0.05)
N	416	416	416	416	416	416

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Determinants of Mexico-US migration flows - 1999-2011, without 2010 (2009 being an exceptional drought) - Cube root dependent variables

	Total male flows		Documented male flows		Undocumented male flows	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln GDP per capita $_{t-1}$	1.039***	1.002***	0.699***	0.717***	0.707***	0.689***
	(0.09)	(0.08)	(0.08)	(0.07)	(0.09)	(0.08)
Ln GDP per capita $_{t-1}$ X post 2003	-0.605***	-0.546***	-0.441***	-0.447***	-0.351***	-0.338***
	(0.12)	(0.11)	(0.14)	(0.15)	(0.14)	(0.12)
Unemployment rate $_{t-1}$	0.066	0.069	-0.010	-0.017	0.126***	0.143***
	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)
Ln share of homicides $_{t-1}$	-0.114	-0.111	-0.014	-0.034	-0.024	-0.012
	(0.12)	(0.13)	(0.13)	(0.12)	(0.08)	(0.08)
Nb hurricanes $_{t-1}$	0.066	0.051	-0.059	-0.054	0.116*	0.091
	(0.07)	(0.08)	(0.07)	(0.08)	(0.06)	(0.06)
Hurricane max intensity $_{t-1}$	-0.009	-0.002	0.034	0.039	-0.041	-0.041
	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)
Rain deviations $_{t-1}$ - rainy season	-0.048		-0.080**		-0.005	
	(0.04)		(0.04)		(0.04)	
Rain deviations $_{t-1}$ - dry season	-0.067*		0.015		-0.060*	
	(0.04)		(0.04)		(0.03)	
Temp deviations $_{t-1}$ - rainy season	0.127**		0.094		0.064	
	(0.05)		(0.06)		(0.04)	
Temp deviations $_{t-1}$ - dry season	-0.046		-0.097*		0.032	
	(0.04)		(0.06)		(0.04)	
Rain $_{t-1}$ X quartile 1 of agri share - rainy season		-0.159**		-0.157*		-0.005
		(0.08)		(0.09)		(0.07)
Rain $_{t-1}$ X quartile 2 of agri share - rainy season		0.002		-0.154		-0.046
		(0.09)		(0.10)		(0.09)
Rain $_{t-1}$ X quartile 3 of agri share - rainy season		-0.023		0.034		-0.053
		(0.06)		(0.04)		(0.07)
Rain $_{t-1}$ X quartile 4 of agri share - rainy season		0.033		-0.034		0.070
		(0.05)		(0.05)		(0.05)
Rain $_{t-1}$ X quartile 1 of agri share - dry season		-0.080		0.001		-0.031
		(0.08)		(0.08)		(0.06)
Rain $_{t-1}$ X quartile 2 of agri share - dry season		0.027		0.063		-0.011
		(0.04)		(0.05)		(0.04)
Rain $_{t-1}$ X quartile 3 of agri share - dry season		-0.113***		0.024		-0.131***
		(0.04)		(0.07)		(0.05)
Rain $_{t-1}$ X quartile 4 of agri share - dry season		-0.109*		0.026		-0.125***
		(0.06)		(0.07)		(0.05)
Temp $_{t-1}$ X quartile 1 of agri share - rainy season		0.076		0.177*		-0.031
		(0.07)		(0.11)		(0.07)
Temp $_{t-1}$ X quartile 2 of agri share - rainy season		0.218***		0.060		0.132**
		(0.06)		(0.04)		(0.06)
Temp $_{t-1}$ X quartile 3 of agri share - rainy season		0.220***		0.098		0.201***
		(0.07)		(0.06)		(0.05)
Temp $_{t-1}$ X quartile 4 of agri share - rainy season		0.104		0.034		0.052
		(0.07)		(0.09)		(0.05)
Temp $_{t-1}$ X quartile 1 of agri share - dry season		-0.115		-0.132		-0.043
		(0.08)		(0.10)		(0.07)
Temp $_{t-1}$ X quartile 2 of agri share - dry season		0.037		-0.135*		0.123**
		(0.06)		(0.08)		(0.05)
Temp $_{t-1}$ X quartile 3 of agri share - dry season		-0.066		-0.021		-0.010
		(0.05)		(0.06)		(0.05)
Temp $_{t-1}$ X quartile 4 of agri share - dry season		-0.078		-0.082		0.011
		(0.07)		(0.09)		(0.05)
N	416	416	416	416	416	416

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Determinants of Mexico-US migration flows - Impact of public policies (Fonden in log), 2001-2011 - Cube root dependent variables

	Total male flows			Documented male flows			Undocumented male flows		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln GDP per capita $_{t-1}$	0.922***	0.932***	0.834***	0.620***	0.661***	0.574***	0.602***	0.608***	0.525***
	(0.13)	(0.11)	(0.12)	(0.10)	(0.09)	(0.12)	(0.14)	(0.12)	(0.12)
Ln GDP per capita $_{t-1}$ X post 2003	-0.482***	-0.462***	-0.361**	-0.394**	-0.421**	-0.336*	-0.184	-0.174	-0.078
	(0.14)	(0.14)	(0.14)	(0.18)	(0.17)	(0.18)	(0.16)	(0.15)	(0.15)
Unemployment rate $_{t-1}$	0.043	0.044	0.027	-0.019	-0.022	-0.021	0.089***	0.091***	0.071**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Ln share of homicides $_{t-1}$	0.098	0.065	0.119	0.126	0.075	0.132	0.064	0.047	0.088
	(0.13)	(0.11)	(0.12)	(0.16)	(0.17)	(0.16)	(0.09)	(0.08)	(0.08)
Nb hurricanes $_{t-1}$	0.106	0.120*	0.127*	-0.016	-0.022	-0.009	0.125**	0.141**	0.144**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)
Hurricane max intensity $_{t-1}$	-0.040	-0.051	-0.057*	0.004	0.001	-0.007	-0.048	-0.058**	-0.060**
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
Share PROCAMPO to ejidos $_{t-1}$	0.328***	0.274***	0.339***	0.330***	0.354***	0.337***	0.286***	0.251***	0.300***
	(0.09)	(0.10)	(0.10)	(0.12)	(0.14)	(0.12)	(0.08)	(0.10)	(0.08)
Ln amount Fonden $_{t-1}$	0.019*	0.019*	-0.002	0.023*	0.024*	0.011	0.004	0.004	-0.015
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rain deviations $_{t-1}$ - rainy season	-0.058	-0.046	-0.072	-0.094*	-0.008	-0.100*	-0.023	0.012	-0.039
	(0.05)	(0.07)	(0.05)	(0.05)	(0.07)	(0.05)	(0.05)	(0.06)	(0.05)
Rain deviations $_{t-1}$ - dry season	-0.045	-0.213***	-0.094***	0.033	0.033	0.022	-0.047	-0.195**	-0.096**
	(0.03)	(0.08)	(0.04)	(0.05)	(0.11)	(0.06)	(0.04)	(0.10)	(0.04)
Temp deviations $_{t-1}$ - rainy season	0.162***	0.179**	0.178***	0.144**	0.211*	0.156**	0.056	0.044	0.064
	(0.06)	(0.09)	(0.06)	(0.07)	(0.12)	(0.07)	(0.04)	(0.07)	(0.04)
Temp deviations $_{t-1}$ - dry season	-0.087*	-0.195*	-0.097**	-0.149**	-0.208	-0.157**	0.007	-0.051	0.004
	(0.05)	(0.10)	(0.05)	(0.07)	(0.14)	(0.08)	(0.04)	(0.09)	(0.04)
Rain deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.025			-0.118			-0.058	
		(0.07)			(0.08)			(0.06)	
Rain deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.208***			0.007			0.180*	
		(0.08)			(0.13)			(0.10)	
Temp deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.038			-0.104			0.009	
		(0.12)			(0.17)			(0.10)	
Temp deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.151			0.091			0.076	
		(0.13)			(0.16)			(0.13)	
Rain deviations $_{t-1}$ - rainy season X Ln amt Fonden $_{t-1}$			0.009			0.011			0.007
			(0.01)			(0.01)			(0.01)
Rain deviations $_{t-1}$ - dry season X Ln amt Fonden $_{t-1}$			0.030***			0.007			0.030***
			(0.01)			(0.01)			(0.01)
Temp deviations $_{t-1}$ - rainy season X Ln amt Fonden $_{t-1}$			0.011			0.002			0.012
			(0.01)			(0.02)			(0.01)
Temp deviations $_{t-1}$ - dry season X Ln amt Fonden $_{t-1}$			0.017**			0.012			0.008
			(0.01)			(0.01)			(0.01)
N	351	351	351	351	351	351	351	351	345

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Determinants of Mexico-US migration flows - Impact of public policies (GDP with two lags, without unemployment and homicides), 2001-2011 - Cube root dependent variables

	Total male flows			Documented male flows			Undocumented male flows		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln GDP per capita $_{t-2}$	0.925***	0.915***	0.893***	0.538***	0.541***	0.528***	0.688***	0.681***	0.651***
	(0.09)	(0.09)	(0.09)	(0.10)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)
Ln GDP per capita X post 2003 $_{t-2}$	-0.458***	-0.426***	-0.400***	-0.257*	-0.262	-0.238	-0.225	-0.204	-0.159
	(0.13)	(0.13)	(0.13)	(0.15)	(0.16)	(0.15)	(0.15)	(0.14)	(0.14)
Nb hurricanes $_{t-1}$	0.072	0.088	0.099	-0.008	-0.003	0.001	0.073	0.088	0.101
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.06)	(0.06)
Hurricane max intensity $_{t-1}$	-0.043	-0.056*	-0.056*	-0.010	-0.018	-0.016	-0.041	-0.052*	-0.056*
	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
Share PROCAMPO to ejidos $_{t-1}$	0.277***	0.213***	0.281***	0.239***	0.236**	0.236***	0.288***	0.247***	0.298***
	(0.06)	(0.08)	(0.06)	(0.09)	(0.09)	(0.09)	(0.06)	(0.09)	(0.06)
Cube root amount Fonden $_{t-1}$	0.036**	0.035**	0.019	0.043**	0.044**	0.033	0.007	0.007	-0.014
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Rain deviations $_{t-1}$ - rainy season	-0.058	-0.024	-0.068	-0.087*	-0.013	-0.088	-0.027	0.027	-0.060
	(0.04)	(0.07)	(0.05)	(0.05)	(0.06)	(0.06)	(0.04)	(0.05)	(0.05)
Rain deviations $_{t-1}$ - dry season	-0.037	-0.212***	-0.128***	0.035	-0.022	0.013	-0.037	-0.186**	-0.129***
	(0.03)	(0.08)	(0.04)	(0.04)	(0.10)	(0.06)	(0.04)	(0.09)	(0.05)
Temp deviations $_{t-1}$ - rainy season	0.114*	0.130	0.103*	0.100	0.154	0.093	0.038	0.042	0.014
	(0.06)	(0.09)	(0.06)	(0.06)	(0.12)	(0.07)	(0.04)	(0.07)	(0.05)
Temp deviations $_{t-1}$ - dry season	-0.051	-0.208*	-0.082	-0.108	-0.204	-0.130	0.021	-0.086	0.010
	(0.05)	(0.11)	(0.06)	(0.07)	(0.14)	(0.09)	(0.04)	(0.09)	(0.05)
Rain deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.052			-0.104			-0.081	
		(0.07)			(0.08)			(0.05)	
Rain deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.217***			0.075			0.184**	
		(0.08)			(0.11)			(0.09)	
Temp deviations $_{t-1}$ - rainy season X Share PROCAMPO to ejidos $_{t-1}$		-0.019			-0.070			-0.003	
		(0.12)			(0.15)			(0.09)	
Temp deviations $_{t-1}$ - dry season X Share PROCAMPO to ejidos $_{t-1}$		0.208			0.129			0.137	
		(0.13)			(0.15)			(0.12)	
Rain deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.003			0.001			0.011
			(0.01)			(0.01)			(0.01)
Rain deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.034***			0.008			0.036***
			(0.01)			(0.01)			(0.01)
Temp deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.007			0.007			0.011
			(0.02)			(0.02)			(0.01)
Temp deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.016			0.011			0.007
			(0.01)			(0.01)			(0.01)
N	351	351	351	351	351	351	351	351	351

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Determinants of Mexico-US migration flows - Impact of public policies, 2001-2011 (PROCAMPO amounts) - Cube root dependent variables

	Total male flows			Documented male flows			Undocumented male flows		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln GDP per capita $_{t-1}$	0.911***	0.931***	0.884***	0.498***	0.587***	0.474**	0.559***	0.544***	0.539***
	(0.19)	(0.21)	(0.18)	(0.19)	(0.21)	(0.21)	(0.19)	(0.18)	(0.19)
Ln GDP per capita $_{t-1}$ X post 2003	-0.445***	-0.462***	-0.364**	-0.322**	-0.418***	-0.295*	-0.146	-0.138	-0.059
	(0.14)	(0.15)	(0.14)	(0.16)	(0.16)	(0.16)	(0.18)	(0.17)	(0.17)
Unemployment rate $_{t-1}$	0.049	0.051	0.035	-0.015	-0.017	-0.017	0.094***	0.097***	0.079**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Ln share of homicides $_{t-1}$	0.018	0.018	0.023	0.026	0.017	0.025	-0.006	-0.005	0.003
	(0.11)	(0.11)	(0.10)	(0.13)	(0.13)	(0.13)	(0.08)	(0.08)	(0.08)
Nb hurricanes $_{t-1}$	0.094	0.093	0.122	-0.034	-0.037	-0.025	0.109	0.110	0.132**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)
Hurricane max intensity $_{t-1}$	-0.042	-0.040	-0.058	0.005	0.008	-0.003	-0.044	-0.045	-0.060*
	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.06)	(0.04)	(0.04)	(0.03)
Ln amount PROCAMPO $_{t-1}$	0.058	0.048	0.041	0.157	0.142	0.166	0.088	0.098	0.062
	(0.14)	(0.15)	(0.13)	(0.16)	(0.17)	(0.17)	(0.11)	(0.11)	(0.11)
Cube root amount Fonden $_{t-1}$	0.035*	0.034*	0.009	0.040*	0.042**	0.032	0.011	0.010	-0.022
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Rain deviations $_{t-1}$ - rainy season	-0.064	-0.128	-0.078	-0.101**	-0.071	-0.095	-0.028	0.030	-0.067
	(0.05)	(0.16)	(0.06)	(0.05)	(0.15)	(0.06)	(0.05)	(0.14)	(0.06)
Rain deviations $_{t-1}$ - dry season	-0.045	0.014	-0.149***	0.030	0.307	0.014	-0.050	-0.082	-0.151***
	(0.03)	(0.16)	(0.05)	(0.05)	(0.19)	(0.07)	(0.04)	(0.20)	(0.05)
Temp deviations $_{t-1}$ - rainy season	0.147**	0.183	0.136***	0.131*	0.219*	0.129**	0.043	0.046	0.018
	(0.06)	(0.12)	(0.05)	(0.07)	(0.12)	(0.06)	(0.04)	(0.10)	(0.05)
Temp deviations $_{t-1}$ - dry season	-0.086	-0.058	-0.127**	-0.152**	0.343*	-0.183**	0.007	-0.186	-0.009
	(0.05)	(0.18)	(0.06)	(0.08)	(0.21)	(0.09)	(0.05)	(0.16)	(0.06)
Rain deviations $_{t-1}$ - rainy season X Ln amt PROCAMPO $_{t-1}$		0.014			-0.005			-0.013	
		(0.03)			(0.03)			(0.03)	
Rain deviations $_{t-1}$ - dry season X Ln amt PROCAMPO $_{t-1}$		-0.013			-0.061			0.008	
		(0.03)			(0.04)			(0.04)	
Temp deviations $_{t-1}$ - rainy season X Ln amt PROCAMPO $_{t-1}$		-0.008			-0.023			-0.000	
		(0.03)			(0.03)			(0.02)	
Temp deviations $_{t-1}$ - dry season X Ln amt PROCAMPO $_{t-1}$		-0.007			-0.107***			0.041	
		(0.04)			(0.04)			(0.03)	
Rain deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.005			-0.003			0.014
			(0.01)			(0.01)			(0.01)
Rain deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.040***			0.004			0.040***
			(0.01)			(0.01)			(0.01)
Temp deviations $_{t-1}$ - rainy season X Cube root amt Fonden $_{t-1}$			0.012			0.008			0.017
			(0.02)			(0.03)			(0.01)
Temp deviations $_{t-1}$ - dry season X Cube root amt Fonden $_{t-1}$			0.023**			0.014			0.011
			(0.01)			(0.01)			(0.01)
N	351	351	351	351	351	351	351	351	351

Standard errors corrected for autocorrelation and spatial correlation in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$