Articule

Drought: the silent harm of migration from Central America during the period 1990 to 2019

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Abstract: The worldwide number of migrants has had a rapid increase during the last fifteen years. Despite the extensive research studies that elucidate the increase in migrants' recipient countries, we know little about the relationship between the climate factors and human mobility in the countries of origin. Hence, this study focuses on the effects of weather and the propensity of individuals to leave a territory by measuring the importance of rain precipitation or the lack of it in one of the critical food corridors of Central America, formed by El Salvador, Honduras, and Guatemala. To study the mobility process, we develop a stochastic frontier model; the main result shows a greater propensity to migrate when there is a significant drought event in the place of origin. Some other factors that motivate people to leave their homeland are the effect of other climate events measured through the control system (ENSO), homicide levels, economic performance, and exchange rate. The findings allow differentiating between drought and excess precipitation on a population and mobility to other territories. In addition, these results permit us to derive observable implications of the different effects of flooding and drought and create public policies of prevention, mitigation, and resilience.

Keywords: Migration 1, Northern Triangle of Central America 2, climate change 3, drought 4

1. Introduction

Since the second half of the 20th century, there is an increasing interest in studying climate factors as determinants of the phenomenon of migration around the whole world (Canales and Rojas, 2018; Carrasco and Suarez, 2018). Martínez-Sanesteban (2020) points out that as of 2020, there would be between one million to two hundred million people in the world leaving their place of residence due to climate events such as droughts, flooding, and hurricanes, among others (Maretti et al., 2019). All Central America has been affected by the effects of climate change like heat waves and decreasing seasonal rainfalls. El Salvador, Guatemala, and Honduras, countries that constitute the Northern Triangle of Central America, particularly the Dry Central American corridor located on the Pacific coast, are among the most affected countries. The corridor extends from the former countries to Chiapas in México, through the west of Costa Rica and the western provinces of Panama.

It also covers some dry tropical forests, and it is one of the regions with the most variable weather in the world since the precipitations decrease between 30% to 40% in the years of El Niño (Van der Zee Arias et al., 2012). However, this study includes only

the Dry Corridor that goes along the Northern Triangle of Central America since this geographic intersection represents a point of great interest in studying the migration induced by climate change.

Nowadays, it is common to see families of farmers helplessly looking at how the drought withers their harvests of corn and beans for five consecutive years (Gustin and Henninger, 2019). Hence, the weather effects left those families without crops, trading products, or any flow of resources to face the next agricultural season.

This situation led to an increasing flow of immigrants from the Dry Corridor to the bordering countries and the border with Mexico to flee from hunger and reach the United States to search for better conditions (Gandini, 2020). The situation indicates a strong link between climate change and migration. Some academic studies have investigated the environmental factors as a driving force of the increasing migration and global movement, especially in Central America (Maretti et al., 2019; Casillas, 2020).

While we know the impact of climate change in the increase of migration flows, we know relatively little about the impact of precipitations and their importance on individuals' behavior for leaving their homes searching for better living conditions. In this work, we refer to precipitation events as the excess or lack of rainfalls over a region (Rojas Wiesner and Cruz, 2020)

The main objective of this work is to analyze the effects of drought on human migration. To achieve this, we need to estimate the importance of an extreme climate event in people's behavior to leave their homeland. We develop a stochastic frontier model to analyze the migratory flows as a dynamic process that shows some trends but is subject to multiple factors that cannot be controlled continuously. We will also estimate the degree of influence of additional variables like poverty, unemployment, insecurity, and environmental devastation behind the migration of populations.

Our findings show that drought events influence individuals deciding to move from their place of residence more than other climate events. These findings will help in the future to develop programs to prevent the phenomenon of early change of place of residence. In consequence, these programs may spare lives and family disintegration induced by migration. Also, they will suggest migratory policies that give place to seasonal or circular migration instead of trying to suppress it, generating undocumented and permanent diasporas.

The structure of this work is organized into four sections. The first section describes the Dry Corridor that covers parts of Honduras, Guatemala, and El Salvador. The second section gives an overview of migration theories and climate change and how this topic has been treated in the literature to understand the variables that explain migratory behavior. The third section presents the methodology and the data used in the model proposed to understand the population's drought and migration. Finally, the fourth section presents our conclusions and a discussion of our findings that will help evaluate to which extent the drought motivates more migratory population movements. For example, we will consider if drought causes more migration than the increase in food prices, seed shortages, or crop loss for self-consumption. These factors expel the peasantry from the fields searching for non-agricultural jobs and lead families to depend on remittances to access consumption goods.

Background: Climate change in the Dry Corridor of Central America

Climate change is a threat to agriculture all around the world. It mainly affects coffee, beans, and corn production, which are considered the basic living of many peasants in Central America. The Dry Corridor of Central America is considered a hot spot characterized by periodic reductions of rainfall precipitations (Olivera et al., 2020). These changes endanger the production for self-consumption of the region and the agroindustry that employs almost a third of the population (Gustin and Henninger, 2019; Hotez, Damania, and Battazzi, 2020).

Besides the catastrophic climate panorama, the Dry Corridor's complexity is due to other social problems, such as violence and poverty. These problems lead to millions of people leaving their countries looking for places that offer job security and sustain their families. The most affected and vulnerable areas to climate change are the most deserted by people and offer a gloomy horizon by which Central America will suffer a significant increase in migration by 2050, according to Martin et al. (2018). The number of migrants due to climate conditions could reach more than 143 million worldwide, around 86 million in Sub-Saharan Africa, 40 million in Southern Asia, and 17 million in Central America.

The context of social diversity, natural resources, and geostrategic position have made Central America one of the most historically interesting regions of the American continent. Although, paradoxically, one of the most impoverished and violent as well. The population in Central America is around 50 million. Also, this region is complex due to its location, making it vulnerable to geological risks, like earthquakes and volcanic eruptions. For example, the Managua earthquake of 1972 devastated the capital of Nicaragua. There is a volcanic arc that crosses that region from the south of Mexico to Panama, and it has hundreds of volcanoes, some of them highly active, like the Payaca and the Santa Maria, both in Guatemala (Briones, 2017).

In addition to the geomorphological and hydrological stress aspects, there are socioeconomic and institutional conditions that involve more variables that can affect the election of mobility of the population of the Dry Corridor. An example of this is the effects that El Niño left between the years 2015 and 2016. These were different in each nation affected. Nevertheless, some of them detected the phenomenon on time and prepared for its arrival. Even though each country has different capabilities to face that type of phenomenon, they rely on resources, investment by different economic sectors, and the activation of protocols and creation of funds as preventive measures. For instance, Guatemala, Honduras, and El Salvador prepared themselves to provide food security and humanitarian aid. In contrast, Costa Rica and Belize promoted and stimulated tourism despite the few rainfalls. That caused severe water supply problems for the essential services in the hotel districts and the areas with high flows of the population (Schatan, 2010; Hartley-Ballestero and Suárez-Espinoza, 2020).

The effects of the El Niño phenomenon were devastating for the Dry Corridor of Central American and the rest of Latin America. In 2016, Colombia suffered extensive and destructive bushfires due to the increase in temperature. Paraguay, Parana (Brazil), and Uruguay suffered the effects of floodings that forced at least 200,000 people to leave their homes. The Patricia hurricane, fed by El Niño, destroyed 3,500 homes and damaged 8,650 acres of land in Mexico in October 2017 (Brennan, 2016). In general, the central coast of the Pacific presented an increase in sea temperature, causing a growth in the tide, hence also causing floodings and landslides. In addition, all the Caribean coasts presented an increase in bush and forest fires.

At the beginning of 2015, the Dry Corridor suffered one of the worst rainfall seasons during the El Niño cycle. However, its effects in Central America still aggravate the damages of two years of consecutive drought. As a result, around 3,5 million people require humanitarian aid, and 1,6 million suffer moderate or/and severe food insecurity in the most affected countries, like El Salvador, Guatemala, and Honduras (Rojas et al., 2015).

Finally, it is essential to remark that the consequences of the El Niño phenomenon are strongly associated with the economic dimension. There is a need to develop social and economic policies to mitigate the effects of food shortage on hundreds of thousands of people to migrate within the country or outside of it. It is increasingly clear that the desire to migrate to improve living conditions is partly motivated by

prolonged droughts, the rise in the earth's surface, or the social crises that the climatic phenomena themselves have caused in the population.

The theory: Migration and climate phenomena

In this section, we thoroughly study the contributions of the migratory theories and the hydrometeorological events that will help delve into the relationship between climate and the migration of populations.

First, the neoclassical theory uses the rational election theory to explain a macro-social phenomenon such as migration. This perspective usually invokes the job offer in the recipient country as the driving force of migration, an attraction factor (Arango, 2003:3). However, climate causes can be the expulsion factor for a rational agent.   The migrant makes an individual decision based on the probability of obtaining a self-consumption harvest or paying off a credit given the most recent rainfall or drought.

In the second place, the "new theory of migration" introduces the families as agents with migration strategies supported by a network of local contacts in the place of destination. Families from rural communities are more vulnerable because they face droughts, hurricanes, the drop of prices of crops, or plagues like the coffee rust, among other factors, that induce members of those communities to migrate because of the environmental factors (push effects), but also to reunite with members of the family who previously have migrated to another place (pull effects). From this perspective, the concept of "migratory tradition" helps different populations with accumulated social capital, making it easier for them to migrate than more isolated communities that lack migratory experience and resources to do it.

Hence, regions with a migratory tradition like Zacatecas in Mexico will react to drought by sending more people to other places, while other regions equally or more affected by drought without a migratory tradition will not send more people out. "Using this approximation, the key in the analysis is that migratory decisions do not exclusively obey to the will of the individual actors, but they are inserted in wider groups of people, families or entire communities that collaborate to increase their income, as well as to minimize the economic risks" (Durand and Massey, 2009:15).

The third approach is the neo-Marxist. It appeals to economic politics rather than to rational decisions or family networks. This approach considers that the countries expelling migrants are integrated into the world or hemispheric market differently. For example, the high cost of labor in industrialized countries or regions attracts peasantry from the rural areas. Hence the drought is always considered as an indirect cause of migration instead of a direct cause. This approach includes concepts like the migratory tradition and factors like economic capital as drivers of migrating attempts. For instance, García-Zamora et al. (2007) mention that municipalities in Zacatecas that expel more migrants are the biggest producers of beans instead of smaller producers. Hence, desertification of the state of Zacatecas would only explain migration indirectly by reducing the production of beans due to drought. However, the direct cause of migration of the producers of this legume is related to the fact that the United States exports 28% of the world's production and China exports 14%, and also to the fact that Mexico has solid commercial relations with these countries (García Zamora et al. 2007:981).

The third approach is bound to the theory of world systems, emphasizing the importance of international division of labor and the dependence of developing countries. Moreover, it deconstructs the very concept of "migration caused by climate reasons." Therefore, this is not a good approach for the aim of this paper since we address drought as the leading cause of human mobility in Central America.

Regarding the first two approaches, it is challenging to choose categorically one of them when studying cases. However, there are testimonies among the displaced population by hydrometeorological phenomena about their individual decisions and

collective actions based on the family networks. For instance, according to a study of the Gourma region in Sahel, Africa, Pedersen (1995) identifies six types of migration mainly induced by droughts or fewer cases by the rainy season. They are listed as follows. 1) Long-distance labor migration is done by single men. This one is equivalent to 7% of the total population included in the study. 2) Migration by entire families. 3) Medium-distance migration, either from nearby areas that are more affected or migration to nearby areas less affected by drought. 4) Short-distance reshuffling of the resources allocation within the region affected by drought. 5) Short-distance internal migration from the rural periphery to the cities. 6) Circular internal migration during the wet season, from a delta to the cities.

Each of these types of migration implies that several variables may influence an individual's decision to leave his or her home. This work proposes that the effects of extreme drought have great importance for understanding this behavior. Hence, in this work, we estimate the importance weight of this phenomenon. The premise is that the climate event of extreme drought motivates an individual to migrate. Therefore, the drought events affect the region's agricultural production, exposing the population to food insecurity like crop loss. This phenomenon makes individuals question whether to look for new sources of employment outside their hometowns to cover the survival costs.

Figure 1. Extreme climate events and their effects
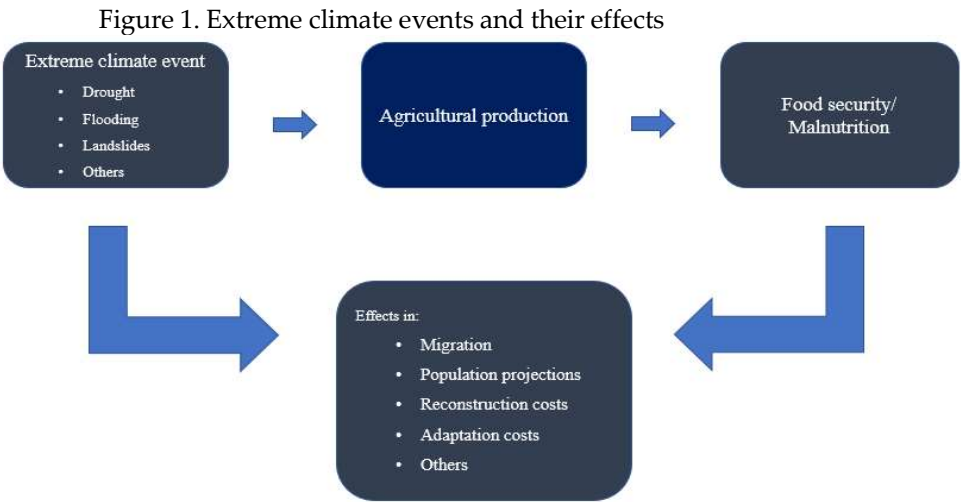
Resources: Olivera & De la Fuente 2021

Figure 1 shows the flow of extreme climate events and their effects, while Table 1 shows other variables affecting migration flows. From Figure 1 and Table 1, we choose the variables for the stochastic frontier model to estimate the weight that drought has on the decision of individuals to migrate. Since we know that the rain and its lack can lead to migration, we can illustrate the profound changes that the Central American Dry Corridor has suffered.

Table 1. Explicative variables of migratory flows

Attraction variables	Expelling variables	Other variables
Salaries	Moving costs and uncertainty	Regional peculiarities
Employment	Unemployment	Individual characteristics of migrants
Productive Infrastructure: industry and services	Productive Infrastructure: agriculture	Population profile in the region
Public Expenditure	Taxation	
Weather	House price	
	Weather	

Source: Modified from Lorenzo, 2011.

Central America faced the worst drought in decades during 2009. The croplands and the rural population were the most affected by it. Almost 40% of the croplands inspected by governments were affected. This drought caused a deficit of croplands for corn, beans, wheat, and sorghum. The main cities of the Dry Corridor suffered from water shortage, residents of slums hijacked water trucks, then social tension appeared. Guatemala is one of the countries affected by this and had to declare a "state of calamity" in the places where the drought caused a shortage of basic food like corn and beans (Malkin, 2009; Klein, 2015).

In addition to the consequences suffered by the urban population in Central America due to drought, there is a growing flow of people to the region, including rural and urban migration from the same country and migration within the region, from other regions, and other continents. Due to these facts, the region is considered a constant ejection of families and individuals, causing a constant crisis in rural and urban areas. Honduras is an example of a critical situation. It is one of the most affected Central American countries by lack of water and by hurricanes of extreme intensity that had caused the loss of crops and the dead of livestock. These climate events confirm that climate change is among the most frequent reasons people leave their country and look for better living conditions elsewhere, mainly in the United States. Consequently, an increase in internal migration in Central America is foreseen (Barthel-Bouchier, 2016; Rojas, 2019).

Migration due to drought is exacerbated by social conditions like poverty, unemployment, insecurity, and environmental devastation. Hence, these are additional elements behind migration. Almost 500,000 migrate every year to the United States, which is the place of residence of around eight million undocumented people, according to specialized organizations (Godoy, 2011).

2. Materials and Methods

Data used in this study correspond to migration and climate variables of Guatemala, Honduras, and El Salvador, which form the Northern Triangle of Central America for the years 1990, 1995, 2000, 2005, 2010, 2013, 2015, 2017, and 2019, are collected from two databases. The migration data collected from the Data Hub of the Migration Policy Institute (MPI). The data consist of demographic, social, and economic data from recent and historical migration flows, net migration, and migration from Europe, America, and Africa. (MPI, 2000). Second, the climate and socioeconomic data by country were collected from the World Bank and the Climate Change Knowledge Portal- CCKP (CCKP, 2020).

Table 2 shows the variables used, their description, units of measure, and the sources where the data were collected. Figure 2 shows the leading countries of destination for the migration flows of each of the three bordering countries. It shows that more than 50% of people were displaced to other countries of the region. Of the migration flow to the United States, 7.25% comes from Guatemala and Honduras, and 13.93% comes from El Salvador. The model uses aggregated data; hence, data for the three countries are added.

Table 2. Description and source of the variables included.

Variable	Description	Data source
Migration	Migration Flow between El Salvador, Guatemala, and Honduras	https://www.migrationpolicy.org/programs/migration-data-hub

Annual precipitation	Precipitation in millimeters, annual accumulated (mm).	https://climateknowledgeportal.worldbank.org/download-data
Annual temperature	Annual average temperature	
Precipitation anomalies	Precipitation higher or smaller than the average precipitation and standard deviation	
Temperature anomalies	Temperature higher or smaller than the average precipitation and standard deviation	
ENSO – El Niño phenomenon	Oscillatory change in sea surface temperature in the equatorial Pacific affects climatic conditions throughout the American continent.	https://climateknowledgeportal.worldbank.org/download-data
Economic and social variables by country	Levels of violence, exchange rate, level of inflation, among others.	https://datos.bancomundial.org/pais

Since this work is centered around the climate variables and their relationships with migration, the variables used are precipitation levels, temperature, and anomalies during the three countries' study. The control variables included are the socioeconomic characteristics of each country. In addition, other variables were included to investigate other elements that may affect the decision to migrate, like exchange rate, consumer price index, violence levels, and inequality indexes.

Methodology

Stochastic frontier models were initially proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). The original specification was introduced to estimate the cross-sectional production function, where the error term has two components: a random component and a non-negative random component. For a more extensive literature review about this methodology, see Forsund, Lovell, and Schmidt (1980), Schmidt (1986), Bauer (1990), and Green (1993). Applications of stochastic frontier models to human migration assume that human migration is restricted by borders, migratory laws, visa issuing, another case. These restrictions do not allow the free movement of the population between countries. Hence, a stochastic frontier model captures the random components of the process and produces more consistent estimates of the migratory flow (Gray and Wise, 2016; Yang et al., 2011).

The frontier stochastic model is defined by Equation (1).

$$y_{it} = f(x_{it}; \beta) \exp(v_{it} - u_{it}); \qquad i=1,...,N. \qquad (1)$$

Where y_{it} is the emigration of country i in year t (exit from the country), x_i is a $k \times 1$ dimension vector of explicative push out variables of country i in year t, and b_i is the vector of unknown parameters, f is the migration frontier function, and v_{it} are i.i.d. noise random variables with a normal distribution $(0, s_v^2)$ and u_{it} are non-negative i.i.d. noise random variables with normal distribution $|N(0, s_u^2)|$, v and u are independent of each other, and they measure the technical inefficiency of migration of country i in year t (Tsionas 2002; Huang 2004; Greene 2008).

The model assumes that the migration processes that displace the population from their place of origin have an error component since it only uses the countries of origin to measure those displacements, but it does not consider the country's movements within the country (Ryan, 2015).
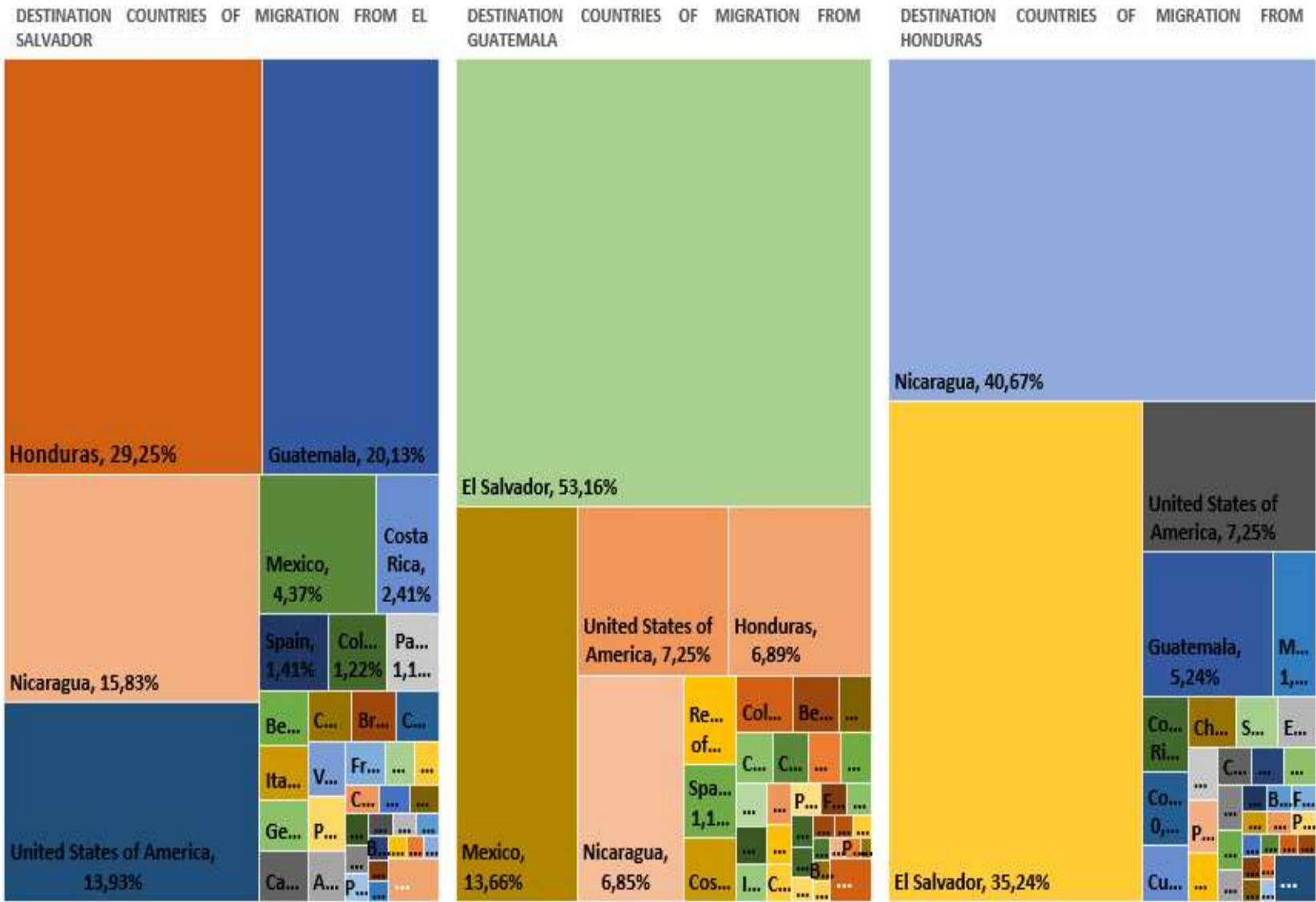
Figure 2 Percentage of population by country of origin and destination country
Source: Authors' elaboration using data from https://www.migrationpolicy.org/programs/migration-data-hub

3. Results

This section may be divided into subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

The parameters estimated with the stochastic frontier model are compared to those estimated by a generalized linear model (GLM) under the exact specifications. Table 3 shows the comparison between models. The frontier model estimates the relationships between migratory flows per country and their relationships with climate variables: precipitation, temperature, and the fluctuations of the sea surface temperature of the Equatorial Pacific (ENSO), also with the socioeconomic variables like exchange rate, consumer's price index, violence levels and inequality index of each country.

Table 3 shows the statistically significant variables. The accumulated annual precipitation and its extreme fluctuations (excess or lack concerning the standard deviation) have a statistically significant association with the migratory flows. This estimation shows evidence that rainfalls produce incentives for migratory movements of attraction to the region or repulsion from the region. On the one hand, excess rainfall stimulates possible local migrations, but attraction to the region by atypical excess of rainfall dominates. On the other hand, precipitations below the average cause major migration movements. Hence, the expulsion or push-out effect dominates in this case. The occurrence of El Niño measured by the ENSO also causes an expulsion effect producing migration but to a lower degree than the precipitation dynamics. The model is used to analyze fluctuations of the dynamics of temperature and its anomalies; however, these resulted statistically non-significant.

Table 3. Parameter estimation of the stochastic frontier model and the GLM for the migration flows of the Northern Triangle of Central America.

Variables	Frontier Migration	GLM Migration
Annual average precipitation (mm)	39.19***	31.88***
	(0.0107)	(10.42)
Rainfall abundance, precipitation higher than the average and standard deviation	-10,175***	-7,438**
	(2.652)	(3,761)
Drought, rainfall under the average and standard deviation	58,335***	21,448**
	(3.552)	(9,468)
ENSO – Fluctuations of the temperature of the sea surface in the Equatorial Pacific- El Niño.	1,092***	736.9
	(0.375)	(451.4)
Exchange rate against US dollar	-1,748***	-1,174***
	(0.811)	(428.2)
Consumer price index	2,053***	2,072**
	(0.399)	(919.3)
Intercept	-14,847***	-17,090
	(32.62)	(21,309)
Temperature and annual average temperature anomalies at the country level	Non-significant	Non- significant
Violence and local homicides	Non-significant	Non- significant
Social inequality and economic level (Gini Index)	Non-significant	Non-significant
Number of Observations	27	27

*** p-value<0.01, ** p-value<0.05, * p- value<0.1

Regarding the socioeconomic variables included, only the exchange rate and the consumer price index are statistically significant to explain the migration process of the three countries. An unfavorable change in the exchange rate against the US dollar attracts immigrants while increasing the consumer price index will create a push-out effect from the country suffering the inflation process. Despite the remaining variables: economic inequality, violence levels, and economic development are not statistically significant, their importance should not be dismissed to explain migration at a local level.

The main result shows that extreme rainfall events (drought and extreme rainfall), the El Niño phenomenon (ENSO), the consumer price index, and the exchange rate against the dollar have direct effects on the movement of people from rural and suburban areas to the countries considered in the model.

4. Discussion

The trend observed in this work is the increase in internal migration because of climate change (loss of crops, hydric stress, increase of sea level). Migration is a human survival strategy to overcome the obstacles of the environment where they live. This trend confirms that climate events of drought are one of the greatest threats to people, ecosystems, and governmental plans of development; hence, it is a challenge to all humankind.

The model results show that the population of the Dry Corridor of Central America suffers from an increase in migration rates and increasing climate risks. Consequently, populations are developing a dependence on foreign economies like remittances, given that the hydric factor harmed agriculture. For example, we mention the case of Honduras, where the depletion of external water sources and the ocean water infiltrating the freshwater sources affected agricultural production. Despite variations in each country in the analysis, there is hydric stress overall. These findings coincide with the specialized literature. Even though extreme rainfall promotes migration, we want to emphasize the importance of extreme drought as the primary driver for the mobility of bigger human groups.

Furthermore, it is vital to have clarity that drought is part of the hydrometeorological climate change phenomena affecting the production of the crops that are susceptible to overexposure of solar radiation, lack of humidity, and loss of nutrients in the soil, together with the increases of temperature and lack of rain during long periods. One of the most affected crops is corn since the lack of it directly affects the fundamental sustain of the population of Central America. Corn plantations cover a fourth of the good lands for agriculture, and it is an essential food source. Hence, the effects of its loss are devastating for the rural populations.

Drought leaves farmers facing the dilemma of waiting for the subsequent rainfalls. The question is: For how long should they wait? If they wait for a short period and it does not rain, the investment could be lost. On the other hand, if they wait for too long, they may start sowing too late for the crops to grow adequately. In worst-case scenarios, the rain would not arrive or arrive in minimal amounts that would not be enough for adequate growth of crops like corn and beans, which are the main products of the Central American Dry Corridor.

This scenario can be stressful for farmers since they must decide whether to eat the seeds destined to be sown or wait and sow them in the future. If they decide to wait, they must find an alternative source of income, or eat the seeds, in which case, they must get new seeds for the next season and possibly pay them using a credit, hoping to pay it back at the end of the season. The dilemma is that droughts can last for more than one harvesting season, and debts acquired may be unsustainable if they last more than three seasons of failed products like corn. Drought also affects other perennial harvests like coffee and fruit, leaving the small producers and workers without daily wages since their sources of indirect income and food that come from the seasonal corn are affected.

- Droughts in Central America have been associated with the El Niño phenomenon. It is a weather pattern that occurs when the temperatures of the Pacific Ocean near the equator fluctuate. This phenomenon happens every two to seven years. The differences in landscape between the dry region of the Pacific coast and the humid region of the Atlantic coast are explained because Central America is an isthmus. This climate difference is a separation between the dry woods in the littoral zone and the rainforest of the Caribbean seaside. "The cold stream of California cools the air in the Pacific coast, preventing a high absorption of steam into the ocean, hence it reduces the possibility of precipitation on that side of the region" (Dirzo and Bonilla, 2013, 25). In the light of this abnormal distribution of precipitations during the rainy season associated with El Niño, this article shows the usefulness of adopting a broader definition of drought as the absence of precipitation.
- An alternative to deal with the lack of agricultural income is the arrival of remittances from family members who decided to migrate to the United States and another region in Central America. The remittances are becoming a standard indicator used in the economic reports to measure the influx of dollars to Central American countries. The effects of the influx of dollars are that it modifies the balance of payments of recipient countries, and at the same time, the inflation process caused by an extraordinary demand can lead to an increase in the consumption of processed food that, in most cases, are imported from other countries. Also, the balance of payments affects the exchange rate of the local currency against the US dollar, increased the prices of imported products, and added to the inflation rate. Migration is a short-term solution for families, although it can become a permanent one. The migration effects are beyond the family scope, but they transcend all the economies involved in the arrival of remittances and departure of people depending on the weather and the food production in rural areas.

The decision of which family member should leave is not a trivial matter, and it is not in the scope of this article. This decision depends on the number of members of the family and their ability to earn income in the destination place, being the senior citizens and the youngest members of the family, the ones who have a lower probability of migrating. Some people in Latin America are resistant to leave parents, children, or friends behind and leave definitively to look for a job out of their homeland and send money to the families who stayed behind. Unfortunately, this situation leads to a clear dependence for survival on the members who left since they are always waiting for them to send money.

The resilience observed in this study is characterized by cycles of some years of migration followed by another number of years dedicated to local farming. However, this resilience is disturbed by policies that close borders and prevent migratory flows. The disturbance of circular migration due to restrictive migratory policies may have paradoxical results like the increase of 9.6 to 51 million Latin American migrants in the United States over 40 years, representing 5% and 16% of the population, respectively (Massey and Pren, 2012). Also, the artificial obstacles for circular migration in Central America could significantly increase undocumented migration to the United States, Mexico, and other Central American countries.

One of the most outstanding findings of this work is that we identify that the migration between countries of the Central American Northern Triangle is cyclical. This behavior may be an indication of the resilience of the agricultural economies analyzed. Hence, during years of scarcity, people migrate to get temporary jobs in other regions, and during years of abundance, they return to produce income from local activities like farming labor and producing food.

5. Conclusions

In this sense, droughts could be the factor that triggers migration affecting food production, foreign currencies (exchange rate), inflation, and finally, the region's economy; migration changes from the production of subsistence food in the place of origin and migrating to look for another source of income. Nevertheless, migration seems not to be definitive. Those that leave forever are always considering going back home; the sending of remittances and the sustain of the families despite the distance presumes an expectation of return.

The findings of this work lead us to make new questions and draw new research lines to address the evaluation of public policies to mitigate climate change. One of them is about the contradictions between migratory security policies and the authorization of cyclical migration. For example, closed wall policies attempt against circular migration within Central America and to the United States and Mexico, making Latin migrants trapped in the US without returning home; this condition could increase the proportion of undocumented migrants.

Another critical remark is the need for understanding migration more broadly, as mobility and not only in terms of the origin and destination of movements. Mobility is a circular motion, and it is counterproductive to put obstacles to it. Trying to stop migration may cause definitive migration, as it has been seen in the United States since the '70s. In the case of migration from Central America, something similar could transform Mexico into a destination country.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, Sazcha Olivera, Maria del Pilar Fuerte and Bernardo Bolaños.; methodology, Sazcha Olivera.; formal analysis and investigation, Sazcha Olivera, Maria del Pilar Fuerte and Bernardo Bolaños resources; data curation, Sazcha Olivera and Maria del Pilar Fuerte; writing—original draft preparation, Sazcha Olivera; writing—review and editing, Sazcha Olivera, Maria del Pilar Fuerte and Bernardo Bolaños.; visualization, Sazcha Olivera. All authors have read and agreed to the published version of the manuscript." Please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to work reported.

Databases consulted:

https://www.migrationpolicy.org/programs/migration-data-hub

https://climateknowledgeportal.worldbank.org/download-data

https://datos.bancomundial.org/pais

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