Is La Niña against the children? Impact of floods in fertility decisions in Colombia

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Is La Niña against the children? Impact of floods in fertility decisions in Colombia[*]

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Abstract

Households tend to have heterogeneous responses to natural phenomena, such as deciding whether and when to have children. This paper analyzes the mid-term effect of housing affectations caused by the floods during the "*La Niña*" phenomenon on fertility decisions. Unlike some analyses of climate shocks and fertility decisions developed in the context of significant losses in life and infrastructure, "*La Niña*" did not represent a high risk in people's lives. However, it was large enough to generate shocks in families' decisions via loss of jobs and crops or other means of subsistence that could reduce the household's sources of income. We use a difference-in-differences strategy to compare municipalities with high exposure to flooding, measured by the percentage of affected homes, against municipalities with low exposure before and after the climate shock. Our main results suggest an increase of 6% in the average total fertility rate (TFR) in the most flood-affected municipalities during the winter season. We argue that this effect is driven by the Colombian government's broad humanitarian aid policy and the perception of children as income insurance in the long term.

JEL classification: J13; Q54; I19

Keywords: fertility choices; pregnancy; climate shocks; floods.

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Resumen

Los hogares suelen tener respuestas heterogéneas a los fenómenos naturales, como la decisión de tener o no hijos y cuándo hacerlo. Este trabajo analiza el efecto a mediano plazo de las afectaciones a las viviendas causadas por las inundaciones durante el fenómeno de "*La Niña*" sobre las decisiones de fecundidad de los hogares. A diferencia de algunos análisis sobre choques climáticos y decisiones de fecundidad, en un contexto de pérdidas significativas de vidas e infraestructuras, "*La Niña*" no representó un alto riesgo en la vida de las personas. Sin embargo, fue lo suficientemente fuerte como para generar perturbaciones en las decisiones de las familias a través de la pérdida de empleos y cosechas u otros medios de subsistencia que podrían reducir las fuentes de ingresos del hogar. Utilizamos una estrategia de diferencias en diferencias para comparar los municipios con alta exposición a las inundaciones, medida por el porcentaje de viviendas afectadas, frente a municipios con baja exposición antes y después de la perturbación climática. Nuestros principales resultados sugieren un aumento del 6 % en la tasa global de fecundidad (TGF) promedio en los municipios más afectados por las inundaciones durante la ola invernal. Argumentamos que este efecto se debe a la amplia política de ayuda humanitaria del gobierno colombiano y a la percepción de los niños como un seguro de ingresos a largo plazo.

Clasificación JEL: J13; Q54; I19

Palabras clave: Decisiones de fertilidad; embarazo; choques climáticos; inundaciones.

1. Introduction

Floods are one of the most common natural disasters in the world. Rentschler et al. (2022) estimate that about 23% of the world's population (approximately 1.81 billion people) will be directly exposed to a flood in the next 100 years (1-in-100-year floods). Mainly, these climatic phenomena have more substantial negative impacts in low- and middle-income countries (LMIC) than in high-income countries. In LMIC, infrastructure systems, such as drainage and flood protection, are usually less developed, so floods often cause significant damage to the infrastructure and directly impact the inhabitants (Winsemius et al., 2016). Similarly, these types of natural disasters can reverse years of development progress, as the most vulnerable regions also face risks aggravated by climate change, socio-political instability, and resource constraints that hinder effective risk management (Hallegatte et al., 2016; Rentschler et al., 2022). Likewise, it is expected that, by 2100, the frequency of floods will substantially increase in regions such as Southeast Asia, East and Central Africa, and large parts of Latin America, areas where about 89% of the people most exposed to these climatic phenomena live (Hirabayashi et al., 2013; Rentschler et al., 2022).

Similar to many territories in the region, Colombia is a country inclined to the occurrence of various natural phenomena. However, environmental degradation, land use change, unplanned and illegal urbanization, and the proximity of urban centers to hydrographic zones can generate a more significant negative impact of natural disasters (DNP, 2018). Between 2010 and 2011, Colombia suffered an intense winter crisis, the "*La Niña*" phenomenon. This climatic phenomenon generated emergencies associated with floods and landslides that left many people homeless and unemployed (Euscátegui and Hurtado, 2011; Nuñez et al., 2013; OCHA, 2010). Damages and losses related to "*La Niña*" did not occupy large extensions of land (although areas of crops and livestock were affected); however, given its high frequency of occurrence, in the medium and long term, it may represent losses that delay the country's development (DNP, 2018).

Households tend to have heterogeneous responses to natural phenomena (Bilsborrow, 1987; Sellers and Gray, 2019). These responses may include fertility decisions, which generate direct demographic changes. Davis (1963) argues that fertility decisions are related to a behavioral component. According to him, decision-making is based on achieving objectives, which, in turn, depend on existing conditions and available means, which may change, *ex-post*, to a climatic shock of a substantial magnitude. Davis and López-Carr (2010) explain that some environmental shocks may affect households by reducing the probability of having a source of income. Additionally, climate shocks could decrease the provision of health systems and the demand for health care (Bremner et al., 2010; de Sherbinin et al., 2007). Thus, natural disasters can also affect decisions about whether or not to have children, the period for having children, and the number of children (de Sherbinin et al., 2007; Sellers and Gray, 2019).

This paper analyzes the mid-term effect of housing affectations caused by the floods during "*La Niña*" on fertility decisions. Unlike some analyses of natural phenomena and fertility decisions that were developed in a context of significant losses in terms of people's lives and infrastructure (Finlay, 2009; Nobles et al., 2015; Davis, 2017), "*La Niña*" did not represent a high risk in lives lost, but it was large enough to generate shocks in families' decisions via loss of jobs and crops or other means of subsistence that could reduce the household's sources of income. In this way, our central hypothesis is that fertility was reduced in the short and medium term in the municipalities with the most significant damage to housing. To test our hypothesis, we collect data from different sources to build a municipality-year-level panel focused on the 2006 to 2015 window. To construct our dependent and treatment variables, we use information from the vital statistics system (natality data/births count) and emergency reports (floods, landslides, and gales, among others). We use a difference-in-difference strategy to compare municipalities with high exposure to flooding, measured by the percentage of affected homes, against municipalities with low exposure before and after the climate shock.

The "*La Niña*" phenomenon (2010-2011) is an interesting case study as long as it did not represent a high risk to people's lives but damaged many infrastructures. Usually, as explained above, natural phenomena studied in the literature tend to have not only material losses but also significant lives lost. According to Davis (2017) and Sellers and Gray (2019), the fertility impacts of climatic events are often very heterogeneous, yielding both positive and negative effects. For example, Alam and Pörtner (2018) analyze the relationship between adverse shocks to household income, fertility decisions, and contraceptive use in Tanzania. The authors find that the probability of pregnancies and births is lower in households that experienced any affectation or damage to their crops during the climate shock. They argue that the decrease in pregnancies is due to a deliberate decision by households to use traditional contraceptive methods (such as the rhythm and abstinence method) and not due to other reasons such as increased working hours, migration of one of the household members, the health of the partner, among others. For his part, Davis (2017) evaluates the effect of Hurricane Mitch on women's fertility in Nicaragua. Using data from household surveys before and after the climatic phenomenon, the author finds a higher fertility probability after the natural disaster in the most affected municipalities. Nonetheless, fertility tends to normalize between 4 and 6 years after the shock.

Along the same line, Nobles et al. (2015) and Finlay (2009) find that there is a reduction in fertility decisions due to climate changes, but once these phenomena cease, there is a *boom* of births in the most affected areas. Finlay (2009) uses cross-sections of the Demographic and Health Surveys of India, Pakistan, and Turkey to run an analysis using a difference-in-differences empirical strategy. Similarly, Nobles et al. (2015) use a longitudinal panel to investigate the response in fertility decisions to an unanticipated mortality shock caused by a tsunami in the Indian Ocean. From another lens, but with similar data to ours, Barreca et al. (2018) estimate the effects of temperature shocks on birth rates in the United States. To analyze this, they use vital statistics data and climate data such as temperature and precipitation between 1931 and 2010. The authors find that average temperatures above 80 degrees Fahrenheit cause significant reductions in birth rates 8 to 10 months after the event. However, this substantial reduction is accompanied by increased birth rates in subsequent periods but fails to compensate for the loss. The authors argue that this reduction in fertility is through an impact on reproductive health rather than an issue of reduced household sexual activity.

Other articles have analyzed the effect of natural phenomena on fertility and child development in different contexts, such as earthquakes, tsunamis, and storms (Carta et al., 2012; Tong et al., 2010; Brando and Santos, 2015). Carta et al. (2012) find a 27% increase in births between 9 and 15 months after an earthquake in Italy; meanwhile, Tong et al. (2010) argue that there were no substantial differences in terms of fertility between the counties affected by severe storms and those not affected. From the perspective of child development and human capital, Brando and Santos (2015) analyze the effects of precipitation shocks during the "*La Niña*" phenomenon (2010-2011) on the medical outcomes of newborns and the cognitive development of the minors most exposed to the shocks. The authors find that exposure to powerful climatic events during the gestation period reduces newborns' birth weight and weight gain per month, as well as their current weight and height. Similarly, the authors show that exposure to these climatic phenomena during the first two years of life increases the risk of socioemotional problems and decreases cognitive test scores. To our knowledge, this article is the closest to ours as it addresses a similar problem in the same context. However, there are significant differences between the approaches, data and methodology employed. First, while Brando and Santos (2015) want to understand the implications on newborn medical outcomes and child development, we focus on mid-term fertility dynamics. Second, the authors use a longitudinal survey conducted on a particular population (*ELCA*, Universidad de Los Andes); in contrast, our article employs administrative data from vital statistics records. Finally, Brando and Santos (2015) use the number of days of heavy rainfall to which the household was exposed to, while our article exploits the reports of weather-related emergencies to measure the exposure to "*La Niña*." Moreover, we explore the heterogeneous responses between the regions, and analyze whether municipalities that used to have flooded areas before "*La Niña*" (2010-2011) internalize this perturbation and respond differently from municipalities that experience an unexpected perturbation.

The literature has identified different possible mechanisms driving the effects of climate shocks on fertility decisions. On the one hand, family unity, the *replacement* effect, and income security for old age are some of the explanations for fertility increases (positive effects) (Nobles et al., 2015; Sellers and Gray, 2019; Finlay, 2009; Schultz, 1997; Cain, 1983). On the other hand, livelihood limitations for households after the shock, physical and psychological damages that the parents could have suffered, and its possible repercussions on children's development could explain the reduction in fertility (Bongaarts and Feeney, 1998; Lambin et al., 2006; Davis and López-Carr, 2010; Sellers and Gray, 2019; Davis, 2017). Likewise, some mechanisms can affect both directions, such as the frequency of sexual intercourse and the contraceptive use (Cohan and Cole, 2002; Sellers and Gray, 2019; Barreca et al., 2018; Alam and Pörtner, 2018). Carta et al. (2012) argue that many households affected by an earthquake in Italy sought motherhood to normalize their lives after an emotionally traumatic experience. Similarly, Vail et al. (2012) explain that once experiencing a high mortality event, households seek greater unity with their significant others or community. Nobles et al. (2015) show an increase in fertility at the aggregate level after a tsunami in the Indian Ocean. The authors explain that mothers who lost at least one child during the disaster are likelier to have another child after the event. Similarly, the authors indicate that women who had no children before the tsunami were likelier to have children after the event.

People with the lowest incomes are the most vulnerable to the reduction in the capacity to exploit natural resources, as their livelihoods depend mainly on the environmental services of the areas where they live (Ellis, 1999; Hope, 2002; MEA, 2005; Bremner et al., 2010; Eakin and Lemos, 2010). Restrictions on access to natural resources can affect household fertility in ambiguous ways. On the one hand, children may bolster long-term household income security and diversification, creating an incentive for fertility in times of economic hardship, particularly in regions where state capacity for retirement and protection is low (Cain, 1981, 1983). However, in the short run, childrearing comes at a high cost to households, and more so when climatic shocks and environmental disruptions reduce household income or family/community support for childcare (Eloundou-Enyegue et al., 2000; Birchenall and Soares, 2009; Portner, 2014; Kochar, 1999). In the context of rural areas and developing countries, children are used in certain household chores as a compensation mechanism for the loss of income and assets (Guarcello et al., 2010), mainly in work related to the use of natural resources, such as firewood or water collection (Filmer and Pritchett, 2002; Biddlecom et al., 2005; Basu and Van, 1998; Beegle et al., 2006). Likewise, many children are perceived as *income insurance* in less developed countries, seeing them as income providers in the future (Pörtner, 2001). In LMIC, households often link children to the labor market as a buffer mechanism for the shock they face (Bernal-Macías, 2021; Ferreira and Schady, 2009), particularly in areas where climate change affects the natural resources that families use for their livelihoods. Despite this, Kim and Prskawetz (2009) find that crop failure in Indonesia does not significantly affect household fertility. However, the authors suggest that unemployment is associated with increases in fertility in the short term, followed by declines as more time elapses after the job loss. Table 1 summarizes the mechanisms exposed above.

Our main results suggest a significant increase of 6% in the average Total Fertility Rate (TFR) in the most flood-affected municipalities during the winter season. These results hold even with different robustness tests and heterogeneous effects exercises. We argue in Section 5.4 that this effect is driven by

Table 1: Effects of climate shock on fertility decisions

Main hypothesis	**Mechanisms in the literature**		**Main results**
	Positive effects	*Negative effects*	
"*La Niña*" was large enough to generate shocks in families' decisions via loss of jobs and crops or other means of subsistence that could reduce the household's sources of income. In this way, the fertility could be reduced in the short and medium term in the municipalities with the most significant damage to housing.	Family unity (Nobles et al., 2015; Sellers and Gray, 2019; Carta et al., 2012; Vail et al., 2012)	Psychological/Health damage (both parents and newborns) (Bongaarts and Feeney, 1998; Portner, 2010; Sellers and Gray, 2019; Davis, 2017)	Our main results suggest a significant increase of 6% in the average Total Fertility Rate (TFR) in the most flood-affected municipalities during the winter season. Additionally, the municipalities with high flood susceptibility had a 6.4% increase in their average TFR after the climate event. Meanwhile, we do not find a significant effect on fertility in low-susceptibility municipalities.
	Insurance and "*Replacement effect*" for the death of a child (Finlay, 2009; Nobles et al., 2015; Schultz, 1997; Cain, 1981, 1983)	Limitations in household resources (Bongaarts and Feeney, 1998; Lambin et al., 2006; Davis and López-Carr, 2010; Sellers and Gray, 2019; Davis, 2017)	
		Having children is expensive in the short term (Birchenall and Soares, 2009; Portner, 2014)	
		The family needs to work more to solve the negative shock (Kochar, 1999; Carta et al., 2012; Nobles et al., 2015)	

the Colombian government's broad humanitarian aid policy and the perception of children as income insurance in the long term. The government's policy sought to reduce the negative impacts of the winter wave from different fronts, such as through temporary shelters, housing repair, a rental support program, a cultural and social activation, and emergency employment programs. Additionally, we analyze whether municipalities that tend to have flooded areas internalize this type of climatic perturbation and respond differently from municipalities that experience an unexpected perturbation. The results show that municipalities with high flood susceptibility have a 6.4% increase in their average TFR, which is consistent with the postulates of Pörtner (2006) and Cain (1983), who argue that children are used as insurance in the riskiest environments so that the family can perceive support during other times of crisis. Meanwhile, similar to Kim and Prskawetz (2009), we do not find a significant effect on fertility in low-susceptibility municipalities.

The remainder of this paper is organized as follows. Section 2 explain the context of the "*La Niña*" phenomenon in Colombia in 2010-2011. Section 3 describes our data and summary statistics for the main variables. Section 4 explains the details of our econometric strategy and identification. Section 5 discusses the results, heterogeneous effects, and robustness checks. Section 6 concludes.

2. Context: The "*La Niña*" Phenomenon (2010-2011) in Colombia

The "*La Niña*" phenomenon in Colombia is characterized by a substantial increase in rainfall and a decrease in temperatures, particularly in the *Caribe*, *Pacífico*, *Centro oriente*, *Eje cafetero*, northern *Llano*, and northern *Centro sur* regions (Euscátegui and Hurtado, 2011; de la Mata and Valencia-Amaya, 2014) (see Figure 1). Generally, in the southwest of the country (*Orinoquía* and *Amazonía*), rainfall and temperature tend to have standard trends. "*La Niña*" is associated with emergencies such as slow floods, flash floods, and landslides, mainly explained by heavy rains above the historical average (Euscátegui and Hurtado, 2011; OCHA, 2010). According to Euscátegui and Hurtado (2011), the "*La Niña*" phenomenon from 2010-2011 started in July 2010 and finished in May 2011.[1] However, Brando and Santos (2015), using the *Southern Oscillation Index* (SOI)[2], argue that the period between July 2010 and December 2011 presented the highest values of the SOI, and it was after December 2011 that the SOI was set in its standard range. To analyze the "*La Niña*" phenomenon, we use the July 2010 - December 2011 window.

Figure 1 shows Colombia's map indicating the 1) hydrographic zones (rivers, streams, lakes, ponds, and wetlands) in dark blue and 2) the flooded areas in 2010-2011 in light blue. The solid dark lines represent a regional division using the classification of *Sistema General de Regalías*[3] and the dashed gray lines denote the Colombian provinces or subregions.[4] We can note that flooded areas are mainly placed near hydrographic zones. These types of floods are called fluvial floods, which occur when the water level in a river or lake increases and overflows onto the adjacent land. Additionally, we identify that in the northern area of *Llanos*, there is a sizeable flooded zone; however, it seems that there is no hydrographic zone there. We call these floods pluvial floods, which occur when extreme rainfall creates a flood independent of an overflowing water body, mainly explained by the low levels of soil drainage[5] (Rentschler et al., 2022).

The "*La Niña*" Phenomenon (2010-2011) was an important climatological event in the region, not only because of its intensity but also for its duration (Euscátegui and Hurtado, 2011; BID-CEPAL, 2012; de la Mata and Valencia-Amaya, 2014). It is estimated that there were losses of 11.2 billion pesos, about 2% of the national GDP (BID-CEPAL, 2012; Nuñez et al., 2013; DNP, 2018). The heavy rains caused

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[1] Euscátegui and Hurtado (2011) uses the *Oceanic Niño Index* (ONI) to identify the period of "*La Niña*". The ONI is interpreted as the Pacific Ocean surface temperature anomaly relative to the average in the region. Three-month moving averages must be calculated to identify a "*La Niña*" event. The phenomenon is declared when the difference is less than -0.5ºC.

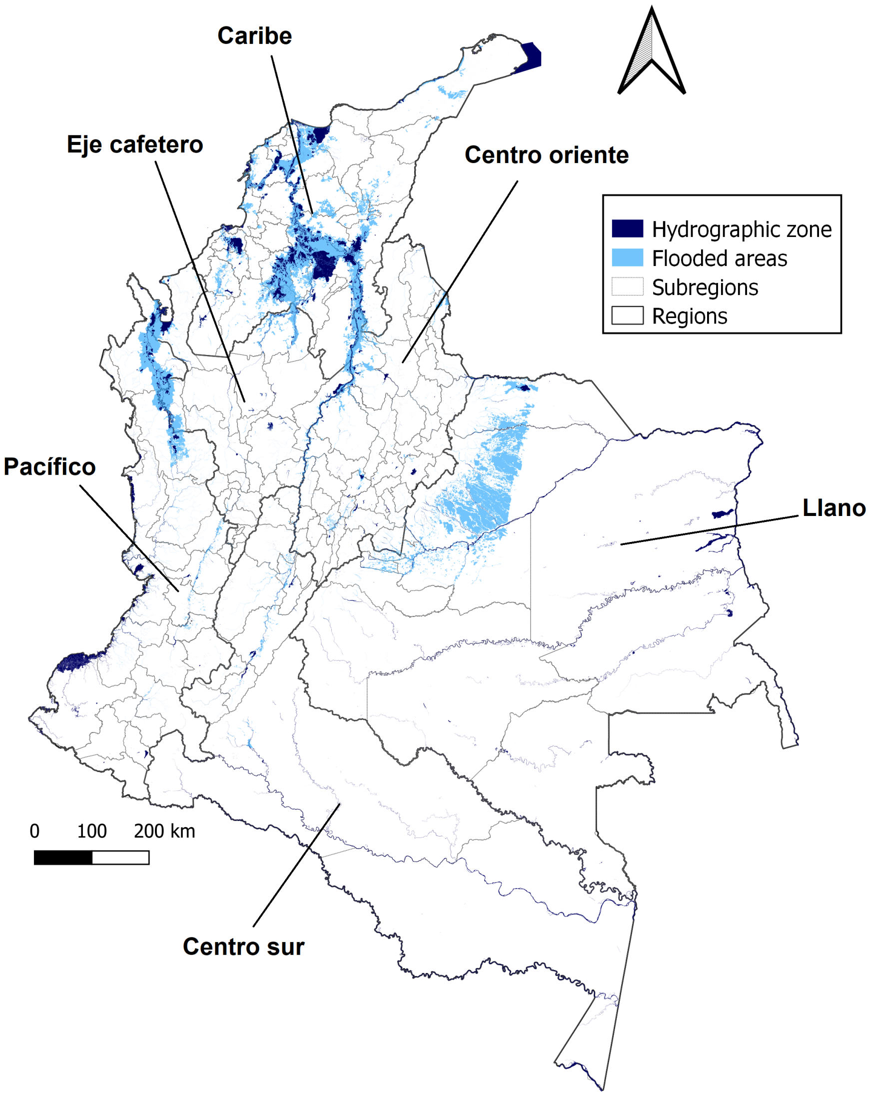
[2] Values of the Southern Oscillation Index above 8 are used to define episodes of "*La Niña*" (Brando and Santos, 2015).

[3] We use the regional classification proposed by Article 45 of Law 2056 of 2020.

[4] The main political-administrative divisions in Colombia are departments and municipalities; however, there is another type of intermediate division between department and municipality called province/subregion. Its primary use is to collect information and supervise common projects between the territories (Ramírez and de Aguas, 2016).

[5] See: `https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood.`

Figure 1: Flooded areas in Colombia (2010-2011)



Notes: Dark blue areas represent the hydrographic zones (rivers, streams, lakes, ponds, and wetlands), and the light blue areas show the flooded areas by "*La Niña*" in 2010-2011. The solid dark lines represent a regional division using the classification of *Sistema General de Regalías*. *Caribe* region: Atlántico, Bolívar, Cesar, Córdoba, La Guajira, Magdalena, San Andrés, Providencia y Santa Catalina, and Sucre. *Centro oriente* region: Boyacá, Cundinamarca, Norte de Santander, Santander, and Bogotá D.C.. *Eje cafetero* region: Antioquia, Caldas, Quindío, and Risaralda. *Pacífico* region: Cauca, Chocó, Nariño, and Valle del Cauca. *Centro sur* region: Amazonas, Caquetá, Huila, Putumayo, Tolima. *Llano* region: Arauca, Casanare, Guainía, Guaviare, Meta, Vaupés, and Vichada. The dashed gray lines denote the Colombian provinces or subregions, an intermediate division between departments and municipalities.

the rivers to overflow, and the high soil saturation levels made it difficult to drain the water in the flooded areas. Additionally, landslides have destroyed or blocked roads, leaving entire cities and towns isolated (OCHA, 2010). "*La Niña*" affected particularly vulnerable populations, as they live in territories unsuitable for building houses (BID-CEPAL, 2012) and have more difficulties accessing the labor market, the educational system, and health services (Nuñez et al., 2013). The Inter-American Development Bank

(BID by its Spanish acronym) and the United Nations Economic Commission for Latin America and the Caribbean (CEPAL by its Spanish acronym) developed an extensive report about the damages and losses of the winter wave (2010-2011) in Colombia (BID-CEPAL, 2012). They calculated that more than three million people were affected by "*La Niña*" (about 7.0% of the national population), most of them residing in rural areas. According to the report, 58.5% of the affected assets were houses, mainly caused by flooding (69% of the damage to homes). Other emergencies that affected homes were landslides (14.8%), gales (8%), and avalanches (2.3%).

Figure 2 presents six panels, each one for each region. The vertical axis of each subfigure denotes the number of damaged houses, and the horizontal axis designates a quarterly time series from 2002Q1 to 2015Q4. The first (left) red dashed line corresponds to the start of "*La Niña*" in 2010Q3 (July 2010), and the last (right) red dashed line represents the final quarter of the event (2011Q4, December 2011). Floods represent about 57.2% of the "*La Niña*" emergencies reported between July 2010 and December 2011.[6] We define a simple classification of emergencies in which we let alone the flood emergencies and aggregate the other events (avalanches, landslides, electrical storms, and gales). The dark blue line represents the damaged houses caused by floods, and the yellow line shows the damaged houses caused by the other emergencies related to "*La Niña*". We note prominent peaks of affectations in the "*La Niña*" period in each region. Nevertheless, in the *Centro sur* region, we cannot appreciate the difference between before and after the climate shock, though this region presented a relatively low number of damaged houses concerning the other regions. We can contrast this result with Figure 1, in which the *Centro sur* is the least affected region. Figure A.1 in the Appendix shows similar time series representing the quarterly average rainfall by region. It shows denser and stronger rainfall peaks in the "*La Niña*" period.

3. Data

To analyze the mid-term effects of the "*La Niña*" phenomenon on fertility decisions, we collect data from different sources to build a municipality-year level panel focused on the 2006 to 2015 window. To construct our dependent and treatment variables, we use information from the vital statistics system (natality data/births count) from Colombian Statistics Department (DANE from the Spanish acronym) and emergency reports (floods, landslides, gales, among others) collected by the Disaster Risk Management Unit (UNGRD from the Spanish acronym), respectively. Additionally, we include two more datasets to capture municipalities' characteristics (control variables) and heterogeneous effects: (1) the annual panel of Colombian municipalities, maintained and hosted by the Center for Economic Development Studies from Universidad de Los Andes (CEDE from the Spanish acronym) and (2) the Municipal Disaster Risk Index estimated by National Planning Department (DNP from the Spanish acronym).

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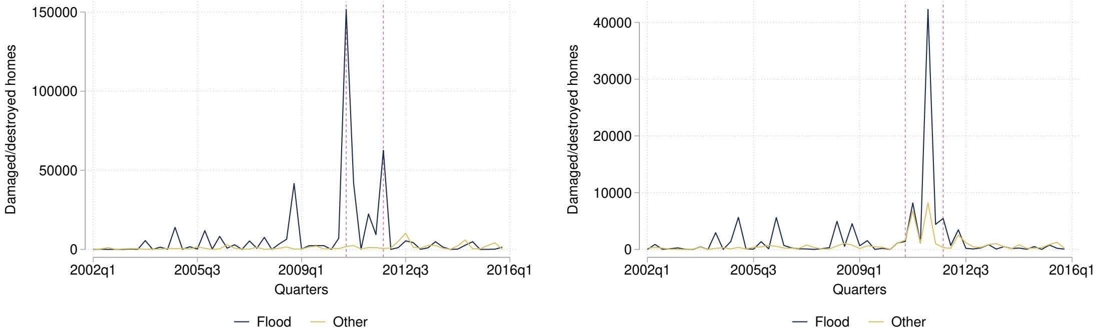
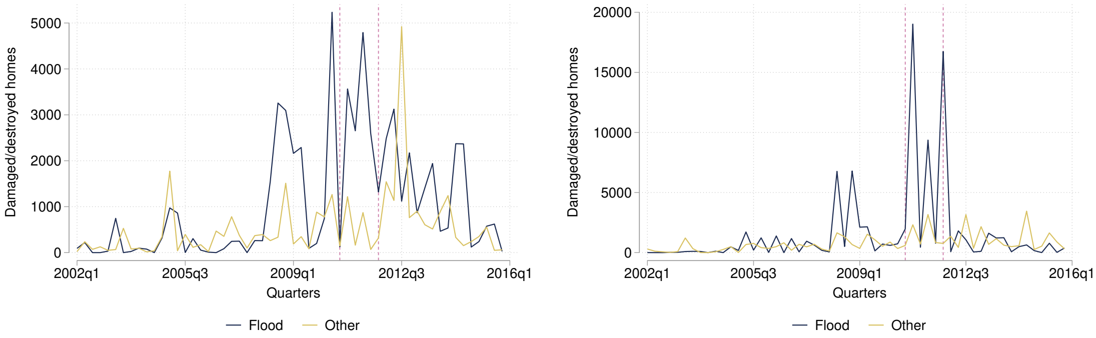
[6] According to de la Mata and Valencia-Amaya (2014) from 1998 to 2011, floods, landslides, and strong winds represented the 85 percent of all climate-related events in the country (floods, 51%; landslides, 21%; strong winds, 13%).

Figure 2: Damaged/destroyed homes by region



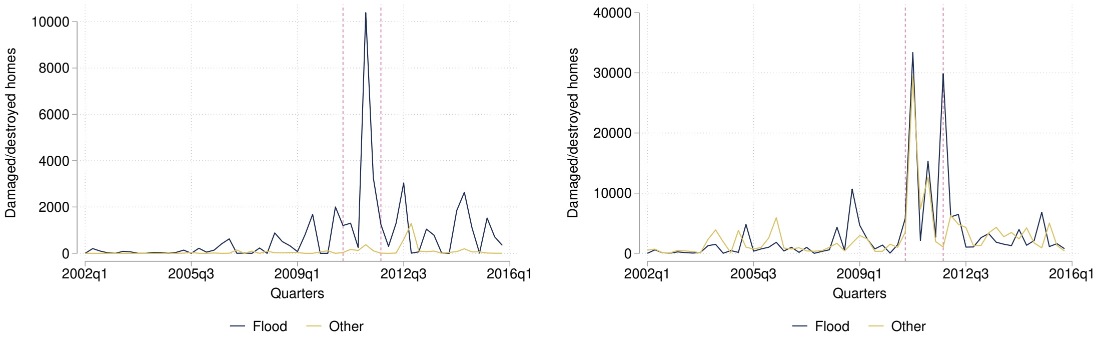
(a) Caribe

(b) Centro oriente



(c) Centro sur

(d) Eje cafetero



(e) Llano

(f) Pacífico

Notes: The vertical axis of each subfigure denotes the number of damaged houses, and the horizontal axis designates a quarterly time series from 2002Q1 to 2015Q4. The first (left) red dashed line corresponds to the start of "*La Niña*" in 2010Q3 (July 2010), and the last (right) red dashed line represents the final quarter of the event (2011Q4, December 2011). We define a simple classification of emergencies in which we let alone the flood emergencies and aggregate the other events (avalanches, landslides, electrical storms, and gales). The dark blue line represents the damaged houses caused by floods, and the yellow line shows the damaged houses caused by the other emergencies related to "*La Niña*".

3.1. Natality Data

We compile municipality-by-year birth counts from National Vital Statistics System reports for 2006-2015. We obtain this data from DANE. However, this information is collected by the Integrated Information System of the Ministry of Health and Social Protection (SISPRO from the Spanish acronym). Birth statistics are produced based on information from live birth certificates in the national territory. The databases contain information about sex, the department and municipality of occurrence, the mother's department and municipality of residence, and the age and educational level of both parents, among others variables. With this data, we can calculate total fertility rates, age-specific fertility rates, indicators of the demand for health care services, and newborn health outcomes. However, we only use this dataset to construct our dependent variable, a municipality-by-year total fertility rate (TFR).[7] To construct the municipality-by-year TFR, we define seven five-year age groups ($a = 15-19; 20-24; 25-29; 30-34; 35-39; 40-44;$ and $45-49$) to calculate the age-specific fertility rates (ASFR, f_a).[8] We calculate the annual number of births based on the mother's residence, not the baby's place of birth. Once we have the ASFR, we sum up all of them and multiply it by n, which is 5 in this case (because we define five-year age groups). Finally, we divide the result by 1,000. Equation (1) resumes this information:

$$TFR_{mt} = \frac{\sum_{a=15-19}^{45-49} f_{a,mt}}{1000} \times 5 \tag{1}$$

3.2. Emergency Data

We explore "*La Niña*" shock effects using emergency reports from UNGRD. This dataset contains the reports of traffic accidents, mining accidents, plane crashes, avalanches, landslides, floods, and explosions in Colombian municipalities. In primitive data, an observation is defined as a singular event (floods or other emergencies), in a specific area (municipality), on a particular day. Each observation has associated different affectations such as the number of dead, missing, and injured people, the number of houses destroyed and affected, and roads damaged. To capture the "*La Niña*" shock, we only use emergency reports on climatic phenomena associated with the rainy season: avalanches, landslides, electrical storms, gales, and floods. Floods represent about 57.2% of the "*La Niña*" emergencies reported between July 2010 and December 2011. We define a simple classification of emergencies in which we let alone the flood emergencies and aggregate the other events (avalanches, landslides, electrical storms, and gales). We keep the observations between July 2010 and December 2011 and collapse the event-municipality-day data to the event-municipality data around the "*La Niña*" period.

This climate shock did not represent a high risk in people's lives, but the number of people affected by damage to homes is large enough to alter families' decisions. For this reason, we focus on infrastructure damage and only gather information about the affected houses. According to Figure 2, flood emergencies are the most frequent and devastating event during "*La Niña*". We use exposure to floods as our primary treatment variable. Nevertheless, we analyze the effect of the other "*La Niña*" emergencies on fertility as a robustness check. To create a measure of exposure to floods caused by "*La Niña*," we calculate the

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[7] Other variables such as antenatal care visits, births attended by a health professional, percentage of low weight at birth, the APGAR tests, preterm birth, and C-Section delivery are beyond the scope of this article.

[8] ASFR are defined as the quotient between the total number of births that occurred in a year T between the ages $(x, x+n)$ and the female population of childbearing age of the same age group in the same period (generally per thousand).

percentage of houses affected by the floods in each municipality using the 2009 housing projections from DANE[9] and the number of destroyed and affected houses. We identify that 71.35% of the municipalities in our sample were affected by the floods (777 of 1,089 municipalities). Though this number is high, the distribution of the percentage of houses affected shows that the percentile 75th is 16.58% (the upper quartile), and the median is 5.40%, meaning that in most cases, less than 10% of their homes were flooded. Following the above, we define our primary treatment variable as a dummy that equals 1 for municipalities with more than 15% of affected houses and 0 otherwise (see equation (2)). We prove alternative treatment measures using different cutoffs in the robustness checks (Section 5.2).

$$Flood_m = \begin{cases} 0 & \text{, if the percentage of houses affected by floods } < 15\% \\ 1 & \text{, if the percentage of houses affected by floods } \geq 15\% \end{cases} \tag{2}$$

Unlike this paper, some authors represent climate shocks using rainfall shocks. In the literature, they define shocks as i) the number of days or months exposed to rainfall shocks (Brando and Santos, 2015), ii) the deviation of the long-run or pre-treatment period rainfall mean (Bernal-Macías, 2021; Marchetta et al., 2018; Dell et al., 2014; de la Mata and Valencia-Amaya, 2014), or iii) according to specific sample percentiles of rainfall (Burke et al., 2015). We prefer our climate shock definition for two reasons. First, floods also capture the rainfall shocks. We can capture both fluvial and pluvial floods. A fluvial flood occurs when the water level in a river or lake increases and overflows onto the adjacent land. The water level rise could be due to excessive rain. A pluvial flood occurs when extreme rainfall creates a flood independent of an overflowing water body[10] (Rentschler et al., 2022). Second, our shock measure captures the actual damage in each municipality as long as we can observe information about the number of affected houses by floods.[11] Looking at the rainfall information, we cannot capture the damage, as we only can identify the rainfall alterations but not quantify the affectations.

3.3. Other data sources

We include a set of municipality-level characteristics from the annual panel of Colombian municipalities, maintained and hosted by the CEDE from Universidad de Los Andes. We use a dataset with the measures of rural share (% rural population), average height above the mean sea level (in meters), distance to the department's capital (in kilometers), a poverty measure based on Unsatisfied Basic Needs, and Log-population in 2009. Additionally, to analyze some heterogeneous effects and to purge possible endogeneity in the estimation, we include the periodical flood zone area from the Municipal Disaster Risk Index

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[9] See: `https://www.dane.gov.co/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-viviendas-y-hogares`

[10] See: `https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood.`

[11] As an alternative measure of weather shocks, de la Mata and Valencia-Amaya (2014) use the number of floods experienced by a municipality m in year t to examine the relationship between the floods and the incidence of dengue and malaria during the period 2007-2011.

(estimated by DNP) that captures the flood susceptibility of each municipality.[12] We create a categorical variable called *Flood Susceptibility*. We assign a municipality to the *High* flood susceptibility group if the municipality has at least one hectare that is frequently flooded; otherwise, we assign it to the *Low* flood susceptibility group.

3.4. Selection of municipalities for the analysis

The primary sample includes 1,077 municipalities of the 1,122 municipalities in Colombia. Figure 3 shows a flowchart for the municipalities' sampling selection. In the first level, we keep the Colombian municipalities with population registers between 2006 and 2015 (N: 1,118); in other words, the municipalities with at least one inhabitant in that time window. In the second level, we select the municipalities with a population of less than 200,000 in 2009, based on the DANE population projections (N: 1,090). We drop the most important cities and capitals to make the municipalities more comparable with those where the emergency occurred (Guerra-Cújar et al., 2022). In the third level, we drop only one municipality which did not report any birth in 2006-2009 (N: 1,089). Finally, in the last level, we keep the municipalities without an atypical ratio of houses damaged by floods (N: 1,077).[13] To calculate the summary statistics and estimate the econometric models, we weight the municipalities by the number of live births between 2006 to 2009 for women between 15 and 49 years old. We use a weight up to 2009 because "*La Niña*" started in July 2010. However, our post-treatment time variable starts in 2011, as we should expect fertility effects to occur at least since February 2011.

3.5. Summary Statistics

Table 2 represents a simple municipality frequencies two-way table of flood susceptibility levels (rows) and treatment classification (columns). Based on treatment definition[14], there are 193 municipalities (17.9% of our sample) exposed to floods during "*La Niña*." We identify 338 high flood susceptibility municipalities in our primary sample, around 31.4% of the sample. As we expect, the percentage of treated municipalities in the *Low* flood susceptibility group is lower than in the *High* group, with 10.8% and 33.4%, respectively. In the same way, there are more high flood susceptibility municipalities in the treated group than in the non-treated ones.

Table 3 summarizes the total fertility rates (Panel A) and municipal characteristics (Panel B) over the pre-treatment period (2006-2010). These statistics are means-calculated using the number of live births

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[12] This risk index aims to classify the municipalities according to the population's risk before events related to floods, torrential flows, and mass movements. The risk index was created in 2018. It internalizes the "*La Niña*" phenomenon of 2010-2011; therefore, we cannot use it explicitly. However, the periodical flood zone area estimates the area usually flooded in each municipality regardless of what happened in the "*La Niña*" period.

[13] The 12 dropped municipalities had heavy floods, showing percentages of houses affected by floods above 130%. The municipalities belonged to the departments: Atlántico (1), Bolívar (3), Cesar (1), Chocó (3), Magdalena (2), Risaralda (1) and Sucre (1). The municipalities are not adjacent. We decided to drop them from the primary sample but included them in the robustness checks and the appendix tables.

[14] A municipality is treated if the percentage of houses affected by floods is greater or equal to 15%.

Figure 3: Flowchart for the municipalities selection

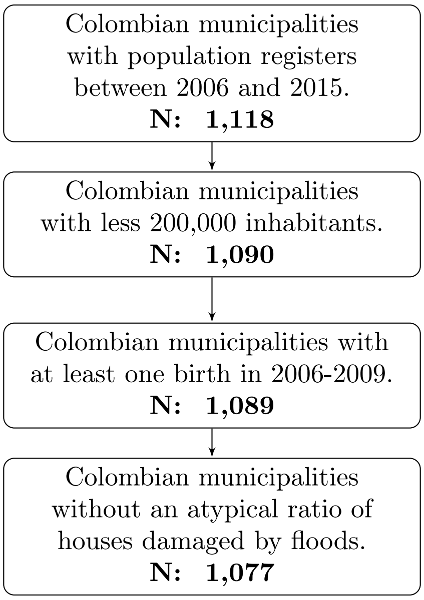

Table 2: Treated and non-treated municipalities by flood susceptibility

	Non-treated	Treated	**Total**
Flood Suscept.: *Low*	659 [61.19]	80 [7.43]	739 [68.62]
Flood Suscept.: *High*	225 [20.89]	113 [10.49]	338 [31.38]
Total	884 [82.08]	193 [17.92]	1,077 [100]

Notes: This table presents in levels the treated and non-treated municipalities by flood susceptibility. The treated municipalities are those with a percentage of houses affected by floods greater or equal to 15% ($Flood_m = 1$). We report the relative frequency of each cell in square brackets. Table A.1 in the Appendix reports the same table but with the 1,089 municipalities sample.

between 2006 to 2009 as weights. In Colombia, on average, there were 2.1 live births per woman in that period. Following the downward trend of births over time, Guerra-Cújar et al. (2022) reports 1.9 live births per woman in the 2011-2014 window. Additionally, Panel A shows TFR by region[15] and flood susceptibility classification. The TFR by region shows different patterns. The *Pacífico* and *Caribe* regions have the lowest TFR, with 1.65 and 2.09 live births per woman, respectively. In contrast, the *Centro sur* region has the highest average TFR in the country, with 2.35 live births per woman. According to our data, the high flood susceptibility municipalities have higher TFR than the low flood susceptibility group. Panel B summarizes the municipal characteristics (control variables). The share of the rural population was more than 41.56% in at least half municipalities in the country. Even some municipalities have 100% of their population living in rural areas. The average height above the mean sea level was 922.57 meters.

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[15] We use the regional classification proposed by Article 45 of Law 2056 of 2020.

Table 3: Summary Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Municipalities	Mean	Mean unweighted	Standard deviation	Median	Min	Max
Panel A: Total fertility rate	1,077	2.10	1.90	0.60	2.05	0	10.60
By region:							
Caribe	179	2.09	1.88	0.54	2.06	0.49	3.42
Centro oriente	362	2.15	2.02	0.49	2.11	0.14	4.02
Centro sur	122	2.39	2.13	0.51	2.37	0	4.41
Eje cafetero	171	2.16	1.92	0.75	1.99	0.76	5.03
Llano	76	2.24	1.98	0.60	2.11	0	10.60
Pacífico	167	1.65	1.44	0.42	1.60	0.31	3.55
By flood susceptibility:							
High	338	2.25	1.91	0.65	2.21	0	10.60
Low	739	1.99	1.90	0.53	1.93	0.12	4.41
Panel B: Municipal characteristics							
Rural index (% rural pop.)	1,077	42.37	58.85	25.32	41.56	1.87	100
Height above the mean sea level	1,077	922.57	1,151.86	919.17	605	1	3,350
Distance to capital	1,077	77.94	82.04	61.44	62.59	0	493.08
Unsatisfied Basic Needs	1,077	40.95	45.63	21.22	39.19	5.43	100
Log-population in 2009	1,077	10.47	9.40	0.97	10.47	6.34	12.18

Notes: This table presents summary statistics for the main variables of interest between 2006 and 2010. All the columns present weighted versions (by the number of live births between 2006 to 2009) of the summary statistics, except for Column 3. Table A.2 in the Appendix reports the same table but with the 1,089 municipalities sample.

4. Empirical Strategy

To estimate the effect of housing affectations caused by the floods during the "*La Niña*" phenomenon on fertility decisions, we use a difference-in-differences strategy. The estimation compares municipalities with high exposure to flooding, measured by the percentage of affected homes, against municipalities with low exposure, before and after the climate shock. The equation is the following:

$$TFR_{mdsrt} = \alpha_m + \mu_d + \zeta_s + \eta_r + \delta_t + \beta_1(Time_t \times Flood_m) + \sum_{c \in X_m} \gamma^{'} c \times Time_t + \epsilon_{mdsrt} \tag{3}$$

Subscripts m, d, s, r, and t represent a municipality, department, subregion (province), region, and year, respectively. The set of fixed effects are represented by α_m (municipality), μ_d (department), ζ_s (subregion), η_r (region), and δ_t (year). $Time_t$ is a dummy that equals one from 2011 forward. Our analysis is focused on the "*La Niña*" period between July 2010 and December 2011. However, our post-treatment time variable starts in 2011, as we should expect fertility effects to occur at least since February 2011. $Flood_m$ measures the exposure to flooding in each municipality. This variable is equal to 1 if the percentage of houses affected by floods is greater or equal to 15% and 0 otherwise (see equation (2)). We prove alternative treatment measures using different cutoffs in the robustness checks. β_1 is our coefficient of interest, which captures the differential change in the TFR, after the climate shock, in municipalities more exposed to the "*La Niña*" phenomenon than those less exposed to it.

X_m is a vector of pre-treatment control variables interacting with the $Time_t$ dummy to account for differential trends in the municipal attributes. Control variables are rural share (% rural population), average height above the mean sea level (in meters), distance to the department's capital (in kilometers), a poverty measure based on Unsatisfied Basic Needs, and Log-population in 2009. ϵ_{mdsrt} is the error term clustered at the subregion (province) level. We prefer this clustering level more than a municipality level, as treatment assignment is correlated with belonging to a subregion (Abadie et al., 2022) (see Figure 1).

All regressions are weighted by the number of live births between 2006 to 2009. We calculate the annual number of deliveries based on the mother's residence, not the baby's place of birth. According to Guerra-Cújar et al. (2022), the weighted estimations give more importance to domains that traditionally contribute more to fertility rates in the country, which minimizes the role of atypical fertility rates in small municipalities.

Difference-in-differences is a quasi-experimental approach. The primary assumption behind the difference-in-differences model is that, in the absence of the "*La Niña*" phenomenon, the TFR in municipalities more exposed to the climate shock would have evolved similarly to those less exposed municipalities. This assumption is known as *parallel trends.* To test for parallel trends, we estimate the following dynamic equation:

$$TFR_{mdsrt} = \alpha_m + \mu_d + \zeta_s + \eta_r + \sum_{j \in T} \beta_j (Flood_m \times \delta_j) + \sum_{c \in X_m} \sum_{j \in T} \gamma' c \times \delta_j + \epsilon_{mdsrt} \tag{4}$$

The T set includes all years of our sample period except 2010, the year right before we expect the effects of "*La Niña*." Additionally, we interact control variables with the time dummy variables. The parameters β_j can be interpreted as the difference in the TFR in municipalities more exposed to the climate shock compared to municipalities less exposed in year j relative to 2010. If the pre-treatment coefficients are not statistically significant, we can assume that the parallel trends assumption can be met.

To test for heterogeneous effects, we estimate two equations. First, we want to understand the differentiated effects by region. We estimated the equation (3) but using regional samples. In these estimations, ϵ_{mdsrt} is an error term clustered at the municipality level.[16] Second, to analyze the effects of flood susceptibility, we estimate the equation (5) as a variation of the main equation (equation (3)).

$$TFR_{mdsrt} = \alpha_m + \mu_d + \zeta_s + \eta_r + \delta_t + \sum_{i=1}^{2} \beta_i (Time_t \times Flood_m \times F.Suscept_{mi}) + \sum_{c \in X_m} \gamma' \times Time_t + \epsilon_{mdt} \tag{5}$$

Here, $F.Suscept_{mi}$ allows us to differentiate municipalities in the *Low* flood susceptibility group ($i = 1$)

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[16] We do not use an error term clustered at the subregion level, as we select a smaller sample.

from those in the *High* flood susceptibility group ($i = 2$). This categorization will allow us to understand whether the climate shock affected those municipalities that have internalized the climate shocks (because they have usually flooded areas) or whether the impacts are greater in municipalities that experience an unexpected shock. To evaluate the validity of the parallel trends assumption, we estimate a dynamic version of equation (5) (the event studies by flood susceptibility groups are presented in the Appendix).

5. Results

5.1. Main results

Table 4 summarizes the results from equation (3). We estimate a difference-in-difference specification to analyze the effect of the affectations caused by floods during "*La Niña*" in 2010-2011 on fertility decisions. In Columns 1, 2, and 3, we use a balanced panel of ten years (2006-2015) for the primary municipality sample (1,077 municipalities). Using our treatment classification[17], we identify 193 treated municipalities, which represents 17.92% of the sample. Column 1's specification includes region, subregion, department, and municipality fixed-effects. Column 2 shows the specification of Column 1, but with year fixed-effects. Finally, in Column 3, we estimate the specification of Column 2, including several pre-treatment municipality characteristics[18] to control for differential changes in the TFR after the climate shock.

Columns 1 and 2 report a β_1 coefficient statistically significant equals 0.202. It suggests that the municipalities more affected by "*La Niña*" between July 2010 and December 2011 presented a differential increase in the TFR of 0.202 births per woman in their reproductive age (15 to 49 years old) after the climate shock. This effect is equivalent to 9.61 percent of the TFR pre-treatment mean (=0.202/2.101) or 0.34 standard deviations (=0.202/0.598). Column 3 (our main specification) reports a β_1 coefficient equals 0.125, which is equivalent and statistically significant to 5.95 percent of the TFR pre-treatment mean (=0.125/2.101) or 0.21 standard deviations (=0.125/0.598).

In order to test for parallel trends and give a causal inference to our findings, we estimate the dynamic equation (4). Figure 4 shows that before the start of the climate shock, the pre-treatment coefficients (parameters β_j) are not statistically significant. The parameters β_j can be interpreted as the difference in the TFR in municipalities more exposed to the climate shock compared to municipalities less exposed in year j relative to 2010. According to our results, we can assume that our estimation fulfills the parallel trends assumption.

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[17] A municipality is treated if the percentage of houses affected by floods is greater or equal to 15%.

[18] These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009.

Table 4: Total fertility rate and floods

	(1)	(2) TFR	(3)
Time × Flood	0.202*** (0.057)	0.202*** (0.057)	0.125*** (0.046)
Observations	10,770	10,770	10,770
Municipalities	1,077	1,077	1,077
Flooded municipalities	193	193	193
% Flooded municipalities	17.920	17.920	17.920
R-squared	0.824	0.829	0.840
Adjusted R-squared	0.801	0.806	0.819
Region FE	Yes	Yes	Yes
Province/Subregion FE	Yes	Yes	Yes
Department FE	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Controls	No	No	Yes
Mean Dep. Var.	2.101	2.101	2.101
Std. Dev. Dep. Var.	0.598	0.598	0.598

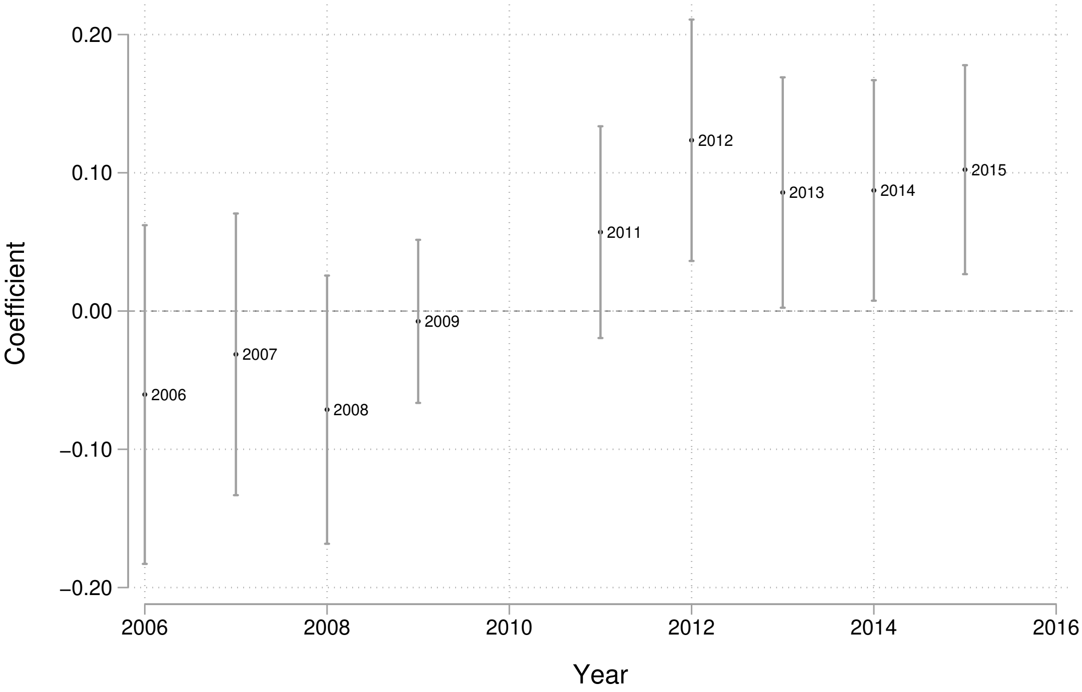
Notes: This table presents the results from the main specification in equation (3). All regressions are weighted by each municipality's number of live births between 2006 to 2009. *Time* is a dummy equal to 1 for the period after 2010 (2011-2015). *Flood* is a dummy variable that takes the value of 1 if the municipality had more than 15% of its homes affected by floods between July 2010 and December 2011. Controls are interacted with the *Time* dummy. These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009. Mean and standard deviation of the dependent variable is calculated for the pre-treatment period (2006-2010). Clustered robust standard errors at the province/subregion level are in parenthesis. Significance levels: *p<0.1; **p<0.05; ***p<0.01.

5.2. Robustness checks

In this section, we perform a series of robustness exercises to see if the results presented in the previous section hold up. In the first robustness test, we present alternative treatment cutoffs to show the evolution of the effect using different intensities of the climate shock. Our second robustness check set considers an analysis based on estimating equation (3) but implementing minor modifications such as including the whole sample, adding the other emergencies related to "*La Niña*", and estimating a regression without weights. We show that the results are similar to the main estimates in all the scenarios.

Table 5 presents the results from the main specification in equation (3), but with alternative treatment measures. In Columns 1, 3, 4, and 5, $Flood_m$ is a dummy variable that takes the value of 1 if the municipality had more than 10%, 30%, 45%, and 60% of its homes affected by floods between July 2010 and December 2011, respectively. Column 2 shows the last column (4) presented in Table 4 for an easy comparison. Using our most flexible treatment measure (>10%), Column 1 suggests that the municipalities more affected by "*La Niña*" presented a differential increase in the TFR of 0.084 births per woman in their reproductive age (15 to 49 years old) after the climate shock. This effect is equivalent to 4 percent of

Figure 4: Dynamic difference-in-differences



Notes: This figure presents the coefficients from our specification presented in equation (4). We present the point estimates of the regressions and the confidence of interval at 95%.

the TFR pre-treatment mean (=0.084/2.101) or 0.14 standard deviations (=0.084/0.598). Column 5, our largest cutoff point, reports a β_1 coefficient equals 0.206, which is equivalent and statistically significant to 9.8 percent of the TFR pre-treatment mean (=0.206/2.101) or 0.34 standard deviations (=0.206/0.598). The findings show a positive correlation between the size effect and the cutoff point, except for Column 4. The above suggests that as the impact of flooding increases, the municipality will have more alterations in fertility decisions.

Table 6 shows our second set of robustness. Column 1 shows the Column 4 presented in Table 4 for an easy comparison. Column 2 shows the regression results using the 1,089 municipalities' sample. Column 3 reports the results using a flood and other emergencies related to the "*La Niña*" treatment. Column 4 estimates the equation (3), but without the municipality birth weights. Every coefficient is statistically significant and similar to the β_1 coefficient in the main regression. Column 4 reports the lowest coefficient; however, it is still statistically significant, positive, and similar to the others. These findings show that the results of the main specification are robust and hold up with alternative scenarios.

5.3. Heterogeneous effects

We want to understand the differentiated effects by region. We estimated the equation (3) using regional samples. This estimation includes all sets of fixed-effect and control variables; however, unlike the main

Table 5: Total fertility rate and floods - Alternative treatments

	(1)	(2)	(3) TFR	(4)	(5)
Treatment cutoff:	$\geq 10\%$	$\geq 15\%$	$\geq 30\%$	$\geq 45\%$	$\geq 60\%$
Time × Flood	0.084** (0.038)	0.125*** (0.046)	0.196** (0.080)	0.169* (0.085)	0.206** (0.103)
Observations	10,770	10,770	10,770	10,770	10,770
Municipalities	1,077	1,077	1,077	1,077	1,077
Flooded municipalities	263	193	96	60	48
% Flooded municipalities	24.419	17.920	8.913	5.571	4.457
R-squared	0.840	0.840	0.841	0.840	0.840
Adjusted R-squared	0.819	0.819	0.820	0.819	0.819
Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	2.101	2.101	2.101	2.101	2.101
Std. Dev. Dep. Var.	0.598	0.598	0.598	0.598	0.598

Notes: This table presents the results from the main specification in equation (3), but with alternative treatment measures. In Columns 1, 3, 4 and 5, *Flood* is a dummy variable that takes the value of 1 if the municipality had more than 10%, 30%, 45%, and 60% of its homes affected by floods between July 2010 and December 2011. Column 2 shows the last column (4) presented in Table 4 for an easy comparison. *Time* is a dummy equal to 1 for the period after 2010 (2011-2015). All regressions include region, province/subregion, department, municipality, and year fixed effects. Controls are interacted with the *Time* dummy. These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009. All regressions are weighted by each municipality's number of live births between 2006 to 2009. Clustered robust standard errors at the province/subregion level are in parenthesis. Significance levels: *p<0.1; **p<0.05; ***p<0.01.

specification, we model the error term, ϵ_{mdsrt}, clustering at the municipality level and not at the subregion level. Table 7 summarizes the results by region. According to our findings, only *Caribe* (Column 1) reports a statistically significant β_1 coefficient. The effect is equal to an increase of 0.112 births per woman during their reproductive age after the climate shock, equivalent to 5.37 percent of the TFR pre-treatment sample mean (=0.112/2.086) or 0.21 standard deviations (=0.112/0.543). Figure A.2 in the Appendix plots the dynamic difference-in-difference coefficients. We can infer that all regions meet the assumption of parallel trends, except *Centro sur* and *Centro oriente*.

The results can be driven by the number of treated municipalities and the percentage of flooded municipalities in each region. *Caribe* is the region with more treated municipalities in levels (83). Additionally, the treated municipalities represent 46.4% of the total *Caribe*'s municipalities, whereas, in the other regions, this ratio is at the most 17.4% in *Pacífico*, with 29 treated domains of 167. The percentage of flooded municipalities in the rest is 15.5% in *Centro oriente* (=56/362), 11.8% in Llano (=9/76), and 6.6% in *Centro sur* (=8/122), and 4.6% in *Eje cafetero* (=8/171).

To analyze the effects of flood susceptibility, we estimate the equation (5) as a variation of the main equation (equation (3)). As we mentioned in Sections 3 and 4, we use the *periodical flood zone area* variable from the Municipal Disaster Risk Index that represents the area usually flooded in each municipality;

Table 6: Total fertility rate and floods - Some modifications

	(1)	(2)	(3)	(4)
	TFR			
Time × Flood	0.125***	0.121***		0.083**
	(0.046)	(0.046)		(0.036)
Time × Flood + others			0.124***	
			(0.041)	
Observations	10,770	10,890	10,770	10,770
Municipalities	1,077	1,089	1,077	1,077
Flooded municipalities	193	205	261	193
% Flooded municipalities	17.920	18.824	24.233	17.920
R-squared	0.840	0.841	0.841	0.766
Adjusted R-squared	0.819	0.819	0.819	0.735
Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean Dep. Var.	2.101	2.100	2.101	2.101
Std. Dev. Dep. Var.	0.598	0.598	0.598	0.598

Notes: This table presents the results from the main specification in equation (3), but with some modifications. Column 1 shows the last column (4) presented in Table 4 for an easy comparison. Column 2 shows the regression results using the 1,089 municipalities' sample. Column 3 reports the results using a flood and other emergencies related to the "*La Niña*" phenomenon treatment. Column 4 estimates the equation (3), but without the municipality birth weights. *Flood* is a dummy variable that takes the value of 1 if the municipality had more than 15% of its homes affected by floods between July 2010 and December 2011. *Time* is a dummy equal to 1 for the period after 2010 (2011-2015). All regressions include region, province/subregion, department, municipality, and year fixed effects. Controls are interacted with the *Time* dummy. These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009. All regressions are weighted by each municipality's number of live births between 2006 to 2009. Clustered robust standard errors at the province/subregion level are in parenthesis. Significance levels: *p<0.1; **p<0.05; ***p<0.01.

in other words, it captures the flood susceptibility of each municipality. We assign a municipality to the "Flood Susceptibility: *High*" group if the municipality has at least one hectare that is frequently flooded; otherwise, we assign it to the "Flood Susceptibility: *Low*" group. This categorization will allow us to understand whether the climate shock affected those municipalities that have internalized the climate shocks (because they have usually flooded areas) or whether the impacts are greater in municipalities that experience an unexpected shock. Like Table 4, Column 1's specification in Table 8 includes region, subregion, department, and municipality fixed-effects. Column 2 shows the specification of Column 1, but with year fixed-effects. Column 3 represents the specification of Column 2, including control variables. Table 8 reports the difference between both coefficients (*High* vs. *Low*) after the flood exposure in each specification. Additionally, we include the number of treated municipalities, the number of high flood susceptibility municipalities, and the intersection of those groups. We also inform the percentage of each group against the whole primary sample (1,077 municipalities). We identify 193 treated municipalities (17.92%), 338 high flood susceptibility (31.38%), and 113 treated and high flood susceptibility municipalities (10.49%).

Table 7: Total fertility rate and floods by region

	(1)	(2)	(3)	(4)	(5)	(6)
			TFR			
Region:	Caribe	Centro oriente	Centro sur	Eje cafetero	Llano	Pacífico
Time × Flood	0.112**	-0.079	0.073	0.116	0.124	-0.043
	(0.048)	(0.085)	(0.076)	(0.181)	(0.129)	(0.075)
Observations	1,790	3,620	1,220	1,710	760	1,670
Municipalities	179	362	122	171	76	167
Flooded municipalities	83	56	8	8	9	29
% Flooded municipalities	46.369	15.469	6.557	4.678	11.842	17.365
R-squared	0.848	0.786	0.829	0.892	0.749	0.835
Adjusted R-squared	0.826	0.759	0.805	0.877	0.712	0.812
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var	2.086	2.154	2.392	2.164	2.237	1.646
Std. Dev. Dep. Var	0.543	0.486	0.508	0.750	0.601	0.419

Notes: This table presents the results from the main specification in equation (3) by region. All regressions are weighted by each municipality's number of live births between 2006 to 2009. *Time* is a dummy equal to 1 for the period after 2010 (2011-2015). *Flood* is a dummy variable that takes the value of 1 if the municipality had more than 15% of its homes affected by floods between July 2010 and December 2011. All regressions include province/subregion, department, municipality, and year fixed effects. Controls are interacted with the *Time* dummy. These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009. Mean and standard deviation of the dependent variable is calculated for the pre-treatment period (2006-2010). Clustered robust standard errors at the municipality level are in parenthesis. Significance levels: *p<0.1; **p<0.05; ***p<0.01.

Columns 1 and 2 report a β_2 coefficient statistically significant equals 0.187 (*High* flood susceptibility group (i = 2)). It suggests that the municipalities more affected by "*La Niña*" between July 2010 and December 2011 and with a high flood susceptibility presented a differential increase in the TFR of 0.187 births per woman in their reproductive age (15 to 49 years old) after the climate shock. This effect is equivalent to 8.9 percent of the TFR pre-treatment mean (=0.187/2.101) or 0.31 standard deviations (=0.187/0.598). Column 3 (+ controls) reports a β_2 coefficient equals 0.134, which is equivalent and statistically significant to 6.38 percent of the TFR pre-treatment mean (=0.134/2.101) or 0.22 standard deviations (=0.134/0.598). We do not find any statistically significant coefficient in the *Low* flood susceptibility group. Although the coefficients of the *High* group are statistically significant and the coefficients of the *Low* group are not statistically different from zero, we find no statistically significant difference when we estimate the difference between the two groups. Figure A.3 in the Appendix plots the dynamic difference-in-difference coefficients. Both groups seem to meet the assumption of parallel trends.

5.4. Discussion

The "*La Niña*" phenomenon (2010-2011) generated an unprecedented winter crisis in Colombia. Thousands of families lost their homes and jobs, and some saw their crops and areas destined for livestock and pasture affected, which meant a powerful shock to household income (OCHA, 2010; Nuñez et al., 2013). In particular, this paper analyzes the mid-term effect of floods during the "*La Niña*" phenomenon on

Table 8: Total fertility rate, floods, and flood susceptibility

	(1)	(2) TFR	(3)
Time × Flood × Flood Suscept.: *High*	0.187***	0.187***	0.134**
	(0.071)	(0.071)	(0.068)
Time × Flood × Flood Suscept.: *Low*	0.057	0.057	0.050
	(0.054)	(0.054)	(0.043)
Differences between coefficients after the flood exposure ($p-$values)			
(F. Suscept.: *High*) - (F. Suscept.: *Low*)	0.129	0.129	0.0833
	(0.168)	(0.168)	(0.305)
Observations	10,770	10,770	10,770
Municipalities	1,077	1,077	1,077
Flooded municipalities	193	193	193
% Flooded municipalities	17.920	17.920	17.920
High suscept. municipalities	338	338	338
% High suscept. municipalities	31.383	31.383	31.383
Flooded and High suscept. municipalities	113	113	113
% Flooded and High suscept. municipalities	10.492	10.492	10.492
R-squared	0.827	0.831	0.842
Adjusted R-squared	0.804	0.809	0.821
Region FE	Yes	Yes	Yes
Province/Subregion FE	Yes	Yes	Yes
Department FE	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Controls	No	No	Yes
Mean Dep. Var.	2.101	2.101	2.101
Std. Dev. Dep. Var.	0.598	0.598	0.598

Notes: This table presents the results from the specification in equation (5). All regressions are weighted by each municipality's number of live births between 2006 to 2009. *Time* is a dummy equal to 1 for the period after 2010 (2011-2015). *Flood* is a dummy variable that takes the value of 1 if the municipality had more than 15% of its homes affected by floods between July 2010 and December 2011. We assign a municipality to the *High* flood susceptibility group if the municipality has at least one hectare that is frequently flooded; otherwise, we assign it to the *Low* flood susceptibility group. Controls are interacted with the *Time* dummy. These controls include rural index (% rural pop.), height above mean sea level, linear distance to the capital of the department, unsatisfied basic needs index, and log-population in 2009. Mean and standard deviation of the dependent variable is calculated for the pre-treatment period (2006-2010). Clustered robust standard errors at the province/subregion level are in parenthesis. Significance levels: *p<0.1; **p<0.05; ***p<0.01.

fertility decisions of affected households. In order to capture the exposure to floods caused by "*La Niña*", we use the percentage of damaged or destroyed houses in each municipality. Housing can be considered one of the most crucial household assets, so an event like "*La Niña*" could be understood as a negative income shock. This shock would imply a reallocation of household resources as families have to adjust their current consumption according to the new budgetary restrictions (Davis and López-Carr, 2010; Lambin et al., 2006). Childrearing is one of the household's decisions, which increases its relative cost in the short term when the household faces a climate shock that reduces household income (Eloundou-Enyegue et al., 2000; Birchenall and Soares, 2009; Portner, 2014; Kochar, 1999). Along the same line, natural catastrophes force couples to reallocate fertility time to the extent that parents need to work harder to counter the negative shock (Kochar, 1999; Carta et al., 2012; Nobles et al., 2015). Under this logic, our central hypothesis was that the most affected municipalities would reduce fertility in the short and medium term in response to a negative income shock. However, our main results suggest a statistically significant increase of 6% (approximately) in the average TFR in the most flood-affected municipalities during the winter season. These results hold even with different robustness tests and heterogeneous effects exercises. Next, we discuss the potential reasons for this finding.

According to Figure 4, the most significant increase in the TFR occurs one year after the end of the climate event (2012), that is, during the year of repair and reconstruction of the affected areas. To understand this positive effect on average fertility is necessary to consider the programs developed by the national government and the conditions of the affected households. According to Nuñez et al. (2013), the Colombian state had a broad humanitarian aid policy that sought to reduce the negative impacts of the winter wave from different fronts. According to the authors, the national government prioritized the construction of temporary shelters in agreement with the Colombian Red Cross, which aimed to ensure adequate conditions for the affected families. In addition, the national government designed a housing repair program and a rental support program, which allocated economic resources to the affected families so that they could return to their homes as long as they were not in an area of imminent risk and vulnerability. Other government assistance included cultural and social activation and emergency employment programs. We face data limitations in monetary transfers (disaggregated aids by municipality-year level) to carry out econometric exercises to validate the previous statements. However, Table 9 presents supportive information which shows the widespread deployment of government aid. As one would expect, the most affected departments (the *Caribe* region) received a more significant proportion of the aid designated to counteract the impacts of the climate shock.

On the other hand, many affected families resided in areas of high vulnerability and minimum sanitary conditions (OCHA, 2010; BID-CEPAL, 2012). In contexts such as these, it is common for children to be used in specific household tasks to compensate for the loss of income and assets (Guarcello et al., 2010). Particularly in rural areas and in developing countries, children are perceived as *insurance*, being seen as a provider of income in the long term, thus creating an incentive for fertility in times of economic hardship, especially in regions where state capacity for retirement and protection is low (Cain, 1981, 1983; Pörtner, 2001). Table 8 analyzes heterogeneous effects by the level of flood susceptibility. This categorization allows us to understand whether municipalities that tend to have flooded areas (Flood Suscept.: *High*) internalize this type of climatic perturbation and respond differently from municipalities that experience an unexpected perturbation (Flood Suscept.: *Low*). The results show that municipalities with high susceptibility have a 6.4% increase in their average TFR, which is consistent with the postulates of Pörtner (2006) and Cain (1983), who argue that children are used as insurance in the riskiest environments so that

Table 9: Aid provided by *Colombia Humanitaria*

Panel A: Humanitarian aid provided by Colombia Humanitaria

Type of humanitarian aid	**Units**
Food and sanitary kits	1,129,359
School kits	250,000
Mats	57,975
Kitchen kits	92,760

Panel B: Temporary shelters

Department	**# of families to be served**	**Housing units built before Sept. 2012**	**% of compliance**
Atlántico	790	790	100
Risaralda	215	215	100
Bolívar	1,067	960	90
Cauca	451	278	67
Magdalena	3,004	1,160	39
Antioquia	984	140	14
Boyacá	50	0	0
Córdoba	60	0	0

Panel C: Households benefited by rental payments in municipalities affected by "*La Niña*" (2010-2011)

Deparment	**# of households**	**Deparment**	**# of households**
Atlántico	10,822	Santander	1,022
Magdalena	6,754	Cauca	965
Sucre	6,435	Cesar	795
Norte de Santander	5,793	Boyacá	612
Bolívar	5,321	Tolima	479
Nariño	3,127	Valle del Cauca	380
Cundinamarca	1,981	Huila	179
Risaralda	1,610	Quindio	112
Antioquia	1,355	La Guajira	86
Caldas	1,326		

Notes: Adapted from Nuñez et al. (2013) (*Cuadro 1* - p. 60, *Cuadro 5* - p. 111, and *Cuadro 7* - p.149). Panel A uses data from *Colombia Humanitaria* until April 15, 2013. Panel B and Panel C use data until September 28, 2012.

they can perceive support during other times of crisis. Meanwhile, in low-susceptibility municipalities, the results are similar to those of Kim and Prskawetz (2009), who find that, in the face of a negative shock to household income in Indonesia, there is no significant effect on fertility.

We close the discussion by acknowledging some limitations in our analysis. First, this article analyzes fertility from a municipal perspective and not at the household level. Along the same lines, the emergency database identifies the affected municipality and the magnitude of the damage; however, our data fails to identify the specifically affected household. It may generate biases in our estimates to the extent that the TFR we calculate at the municipality level captures births in households directly affected by the floods and births in households that live in affected municipalities but did not suffer any damage. Second, to perform an analysis using the TFR for all municipalities in Colombia, we opted for an annual analysis rather than a monthly or quarterly one.[19] However, this choice of data frequency prevents us from performing a short-term analysis, similar to Barreca et al. (2018), to see the direct implications of flooding on the temporality of fertility. Finally, while it is possible to estimate age-specific fertility rates, this analysis is left for future research. Nonetheless, heterogeneous effects are expected across different groups, with younger women being affected to a greater extent.

6. Concluding remarks

This paper analyzes the mid-term effect of housing affectations caused by the floods during "*La Niña*" on fertility decisions. Our central hypothesis was that fertility would be reduced in the short and medium term in the municipalities with the most significant damage to housing. We collected data from different sources to build a municipality-year level panel focused on the 2006 to 2015 window to test our hypothesis. To construct our dependent and treatment variables, we used information from the vital statistics system (natality data/births count) and emergency reports (floods, landslides, and gales, among others). We estimated a difference-in-difference strategy to compare municipalities with high exposure to flooding, measured by the percentage of affected homes, against municipalities with low exposure before and after the climate shock.

Our main results suggest a significant increase of 6% (approximately) in the average TFR in the most flood-affected municipalities during the winter season. We argue that this effect is driven by the Colombian government's broad humanitarian aid policy and the perception of children as income insurance in the long term. This policy sought to reduce the negative impacts of the winter wave from different fronts, such as through temporary shelters, housing repair, a rental support program, cultural and social activation, and emergency employment programs. Additionally, we analyze whether municipalities that tend to have flooded areas internalize this type of climatic perturbation and respond differently from municipalities that experience an unexpected perturbation. The results show that municipalities with high flood susceptibility have a 6.4% increase in their average TFR, which is consistent with the postulates of Pörtner (2006) and Cain (1983), who argue that children are used as insurance in the riskiest environments so that they can perceive support during other times of crisis. Meanwhile, similar to Kim and Prskawetz (2009), we do not find a significant effect on fertility in low-susceptibility municipalities.

The negative impacts of climatic phenomena are a problem for a country's development. Under this logic, it is necessary to analyze the risk conditions to which people are exposed and understand the factors that can help or hinder the recovery of households after such a shock. In particular, understanding the dynamics between climatic emergencies and fertility allows us to design better public policies and target

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[19] Many municipalities reported few births in the year, using the annual aggregate data, we could have information for all municipalities.

health care and prevention services. According to Portner (2010) and Brando and Santos (2015), children born immediately after a climate shock have worse health outcomes than those who were not exposed to the shock. The above implies that one of the priorities of the national and subnational governments should be to guarantee access to quality health services to the families most exposed to these shocks. Similarly, if fertility incentives are driven by the search for a sense of long-term income security, it is essential that the national government develop policies to prevent a possible increase in the child labor market. Future extensions of this work could focus on carrying out a study disaggregated by parents' educational level to analyze household vulnerability from a differentiated approach.

References

Abadie, A., Athey, S., Imbens, G., and Wooldridge, J. (2022). When Should You Adjust Standard Errors for Clustering? Technical report, Working Paper, arXiv.

Alam, S. and Pörtner, C. (2018). Income shocks, contraceptive use, and timing of fertility. *Journal of Development Economics*, 131:96–103.

Barreca, A., Deschenes, O., and Guldi, M. (2018). Maybe Next Month? Temperature Shocks and Dynamic Adjustments in Birth Rates. *Demography*, 55:1269–1293.

Basu, K. and Van, P. (1998). The economics of child labor. *The American Economic Review*, 88(3):412–427.

Beegle, K., Dehejia, R., and Gatti, R. (2006). Child labour and agricultural shocks. *Journal of Development Economics*, 81:80–96.

Bernal-Macías, C. (2021). Child labor, rainfall shock, and financial inclusion: Evidence from rural Colombia. Technical report, Facultad de Economía, Universidad del Rosario, Bogotá D.C.

BID-CEPAL (2012). Valoración de daños y pérdidas Ola invernal en Colombia 2010-2011. Technical report, BID-CEPAL-DNP.

Biddlecom, A., Axinn, W., and Barber, J. (2005). Environmental Effects on Family Size Preferences and Subsequent Reproductive Behavior in Nepal. *Population and Environment*, 26.

Bilsborrow, R. (1987). Population Pressures and Agricultural Development in Developing Countries: A Conceptual Framework and Recent Evidence. *World Development*, 15(2):183–203.

Birchenall, J. and Soares, R. (2009). Altruism, fertility, and the value of children: Health policy evaluation and intergenerational welfare. *Journal of Public Economics*, 93:280–295.

Bongaarts, J. and Feeney, G. (1998). On the quantum and tempo of fertility. *Population and Development Review*, 24(2):271–291.

Brando, J. F. and Santos, R. J. (2015). La Niña y los niños: Effects of an unexpected winter on early life human capital and family responses. Technical report, Documentos CEDE, Universidad de Los Andes, Bogotá D.C.

Bremner, J., Lopez-Carr, D., Suter, L., and Davis, J. (2010). Population, poverty, environment, and climate dynamics in the developing world. *Interdisciplinary Environmental Review*, 11:112–126.

Burke, M., Hsiang, S., and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, 527:235–239.

Cain, M. (1981). Risk and insurance: Perspectives on fertility and agrarian change in india and bangladesh. *Population and Development Review*, 7(3):435–474.

Cain, M. (1983). Fertility as an Adjustment to Risk. *Population and Development Review*, 9(4):688–702.

Carta, G., D'Alfonso, A., Colagrande, I., Catana, P., Casacchia, M., and Patacchiola, F. (2012). Post-earthquake birth-rate evaluation using the brief cope. *The Journal of Maternal-Fetal & Neonatal Medicine*, 25(11):2411–2414.

Cohan, C. and Cole, S. (2002). Life course transitions and natural disaster: Marriage, birth, and divorce following hurricane hugo. *Journal of Family Psychology*, 16:14–25.

Davis, J. (2017). Fertility after natural disaster: Hurricane Mitch in Nicaragua. *Population and Environment*, 38(4):448–466.

Davis, J. and López-Carr, D. (2010). The effects of migrant remittances on population-environment dynamics in migrant origin areas: international migration, fertility, and consumption in highland Guatemala. *Population and Environment*, 32:216–237.

Davis, K. (1963). The Theory of Change and Response in Modern Demographic History. *Population Index*, 29(4):345–366.

de la Mata, D. and Valencia-Amaya, M. (2014). The Health Impacts of Severe Climate Shocks in Colombia. Technical report, IDB Working Paper Series No. IDB-WP-498.

de Sherbinin, A., Carr, D., Cassels, S., and Jiang, L. (2007). Population and Environment. *Annual Review of Environment and Resources*, 32:345–373.

Dell, M., Jones, B., and Olken, B. (2014). What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature*, 52:740–798.

DNP (2018). Índice Municipal de Riesgos de Desastres Ajustado por Capacidades. Technical report, DNP.

Eakin, H. and Lemos, M. (2010). Institutions and change: The challenge of building adaptive capacity in latin america. *Global Environmental Change-human and Policy Dimensions - GLOBAL ENVIRON CHANGE*, 20:1–3.

Ellis, F. (1999). Rural livelihood diversity in developing countries: Evidence and policy implications. *ODI Natural Resources Perspectives*, 40.

Eloundou-Enyegue, P. M., Stokes, C. S., and Cornwell, G. T. (2000). Are there crisis-led fertility declines? evidence from central cameroon. *Population Research and Policy Review*, 19(1):47–72.

Euscátegui, C. and Hurtado, G. (2011). Análisis del impacto del fenómeno de “La Niña” 2010-2011 en la hidroclimatología del país. Technical report, IDEAM.

Ferreira, F. and Schady, N. (2009). Aggregate economic shocks, child schooling, and child health. *The World Bank Research Observer*, 24:147–181.

Filmer, D. and Pritchett, L. (2002). Environmental degradation and the demand for children: Searching for the vicious circle in Pakistan. *Environment and Development Economics*, 7:123–146.

Finlay, J. (2009). Fertility Response to Natural Disasters The Case of Three High Mortality Earthquakes. Technical report, Policy Research Working Paper 4883, World Bank.

Guarcello, L., Mealli, F., and Rosati, F. (2010). Household vulnerability and child labor: The effect of shocks, credit rationing, and insurance. *Journal of Population Economics*, 23:169–198.

Guerra-Cújar, M. E., Prem, M., Rodríguez-Lesmes, P., and Vargas, J. (2022). A Peace Baby Boom? Evidence from Colombia’s Peace Agreement. Technical report, Institute For Advanced Study in Toulouse: IAST, Toulouse.

Hallegatte, S., Bangalorem, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., and Vogt-Schilb, A. (2016). *Shock Waves Managing the Impacts of Climate Change on Poverty*. World Bank, Washington, DC.

Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H., and Kanae, S. (2013). Global flood risk under climate change. *Nature Climate Change*, 3:816–821.

Hope, R. (2002). Wildlife harvesting, conservation and poverty: The economics of olive ridley egg exploitation. *Environmental Conservation*, 29:375–384.

Kim, J. and Prskawetz, A. (2009). External shocks, household consumption and fertility in indonesia. *Population Research and Policy Review*, 29.

Kochar, A. (1999). Smoothing Consumption by Smoothing Income: Hours-of-Work Responses to Idiosyncratic Agricultural Shocks in Rural India. *The Review of Economics and Statistics*, 81(1):50–61.

Lambin, E., Geist, H., and Rindfuss, R. (2006). *Introduction: Local processes with global impacts*, pages 1–8.

Marchetta, F., Sahn, D., and Tiberti, L. (2018). School or Work? The Role of Weather Shocks in Madagascar. Technical report, IZA Discussion Papers, No. 11435, Bonn.

MEA (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

Nobles, J., Frankenberg, E., and Thomas, D. (2015). The Effects of Mortality on Fertility: Population Dynamics After a Natural Disaster. *Demography*, 52:15–38.

Nuñez, J., Hurtado-Caycedo, C., Páez, F., Bateman, A., Pinzón, C., Gutiérrez, C., and Castillo, J. (2013). *Evaluación de los programas para la atención del Fenómeno de la Niña 2010-2011*. Fedesarrollo, Bogotá D.C.

OCHA (2010). Temporada de lluvias 2010 Fenómeno de La Niña. Informe de Situación 6. Technical report, OCHA.

Portner, C. (2010). Natural Hazards and Child Health. Technical report, Working Paper Center for Studies in Demography and Ecology, University of Washington.

Portner, C. (2014). Gone with the Wind? Hurricane Risk, Fertility, and Education. Technical report, Working Paper Center for Studies in Demography and Ecology, University of Washington.

Pörtner, C. (2001). Children as Insurance. *Journal of Population Economics*, 14(1):119–136.

Pörtner, C. (2006). Gone With the Wind? Hurricane Risk, Fertility and Education. *SSRN Electronic Journal*.

Ramírez, J. C. and de Aguas, J. M. (2016). Configuración territorial de las provincias de Colombia. Ruralidad y redes. Technical report, CEPAL.

Rentschler, J., Salhab, M., and Jafino, B. (2022). Flood exposure and poverty in 188 countries. *Nature Communications*, 13(3527).

Schultz, P. (1997). Demand for children in low income countries. *Handbook of Population and Family Economics*, 1.

Sellers, S. and Gray, C. (2019). Climate shocks constrain human fertility in Indonesia. *World Development*, 117:357–369.

Tong, V., Zotti, M., and Hsia, J. (2010). Impact of the Red River Catastrophic Flood on Women Giving Birth in North Dakota, 1994–2000. *Maternal and child health journal*, 15:281–288.

Vail, K., Juhl, J., Arndt, J., Vess, M., Routledge, C., and Rutjens, B. (2012). When death is good for life: Considering the positive trajectories of terror management. *Personality and Social Psychology Review*, 16:303–329.

Winsemius, H., Aerts, J., van Beek, L., Bierkens, M., Bouwman, A., Jongman, B., Kwadijk, J., Ligtvoet, W., Lucas, P., van Vuuren, D., and Ward, P. (2016). Global drivers of future river flood risk. *Nature Climate Change*, 6:381–385.

A. Appendix

A.1. Table and Figures

Table A.1: Treatment and flood susceptibility - whole sample

	Non-treated	Treated	**Total**
Flood Suscept.: *Low*	659 [60.51]	82 [7.53]	741 [68.04]
Flood Suscept.: *High*	225 [20.66]	123 [11.29]	348 [31.96]
Total	884 [81.18]	205 [18.82]	1,089 [100]

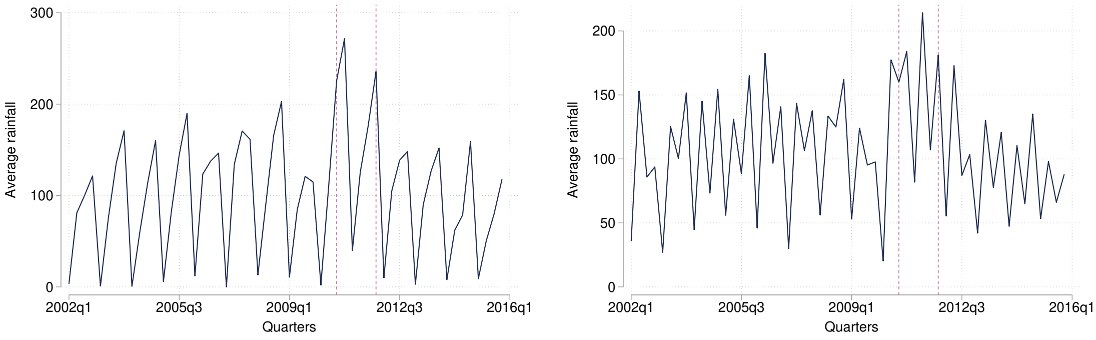
Notes: This table presents in levels the treated and non-treated municipalities by flood susceptibility for the whole sample (1,089 municipalities). The treated municipalities are those with a percentage of houses affected by floods greater or equal to 15% ($Flood_m = 1$). We report the relative frequency of each cell in square brackets.

Table A.2: Summary Statistics - whole sample

	(1) Municipalities	(2) Mean	(3) Mean unweighted	(4) Standard deviation	(5) Median	(6) Min	(7) Max
Panel A: Total fertility rate:	1,089	2.10	1.90	0.60	2.05	0	10.60
By region:							
Caribe	187	2.08	1.88	0.54	2.06	0.49	3.42
Centro oriente	362	2.15	2.02	0.49	2.11	0.14	4.02
Centro sur	122	2.39	2.13	0.51	2.37	0	4.41
Eje cafetero	172	2.16	1.92	0.75	1.99	0.76	5.03
Llano	76	2.24	1.98	0.60	2.11	0	10.60
Pacífico	170	1.64	1.43	0.42	1.60	0.31	3.55
By flood susceptibility:							
High	348	2.25	1.90	0.65	2.20	0	10.60
Low	741	1.99	1.90	0.53	1.93	0.12	4.41
Panel B: Municipal characteristics:							
Rural index (% rural pop.)	1,089	45.37	58.85	25.30	41.56	1.87	100
Height above mean sea level (Mts)	1,089	922.57	1,151.86	919.17	605	1	3,350
Distance to capital	1,089	77.94	82.04	61.44	62.59	0	493.08
Unsatisfied Basic Needs	1,089	40.95	45.63	21.22	39.19	5.43	100
Log-population in 2009	1,089	10.47	9.40	0.97	10.47	6.34	12.18

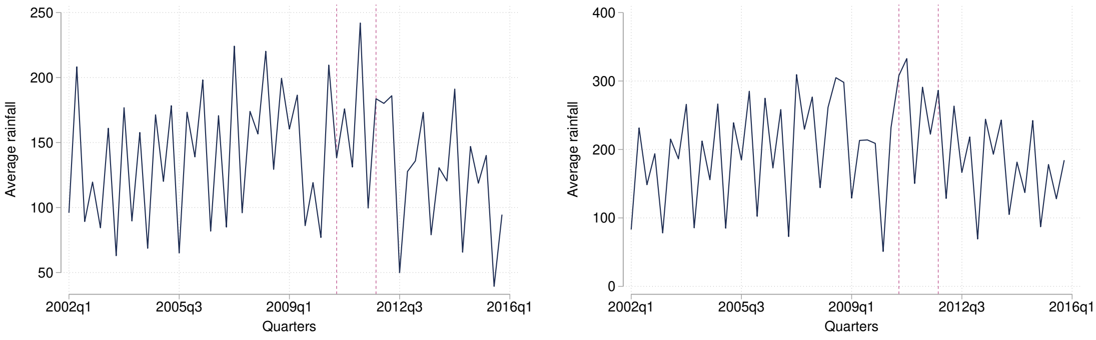
Notes: This table presents summary statistics for the main variables of interest between 2006 and 2010 for the whole sample (1,089 municipalities). All the columns present weighted versions (by the number of live births between 2006 to 2009) of the summary statistics, except for Column 3.

Figure A.1: Quarterly rainfall by region



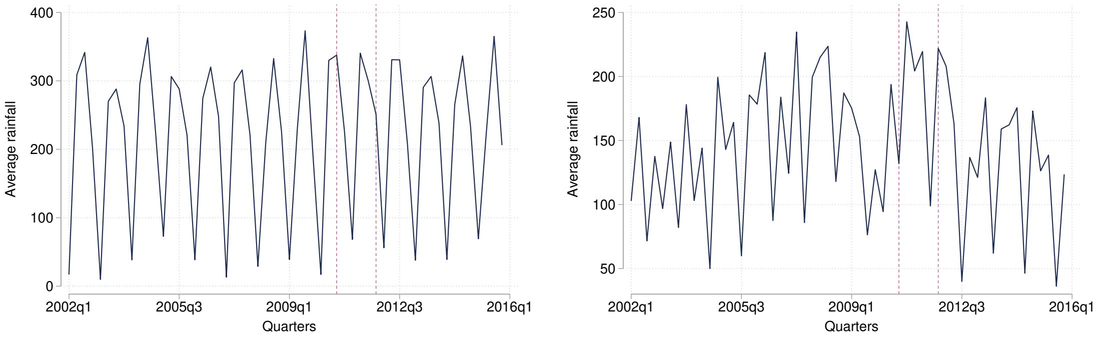
(a) Caribe

(b) Centro Oriente



(c) Centro Sur

(d) Eje cafetero

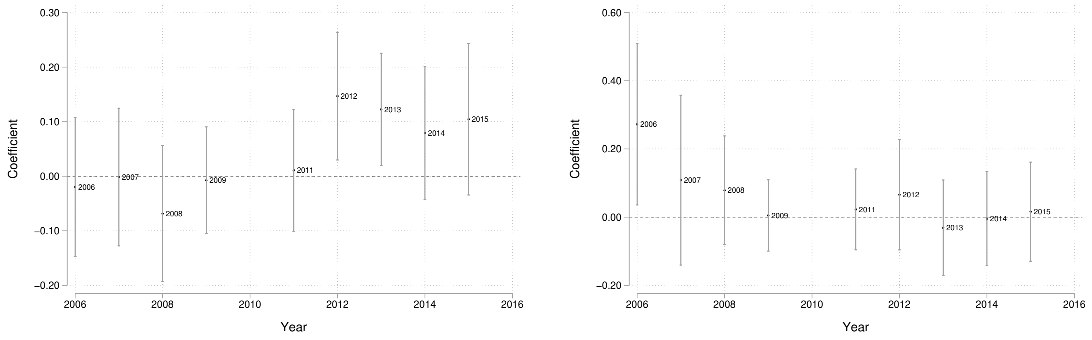


(e) Llano

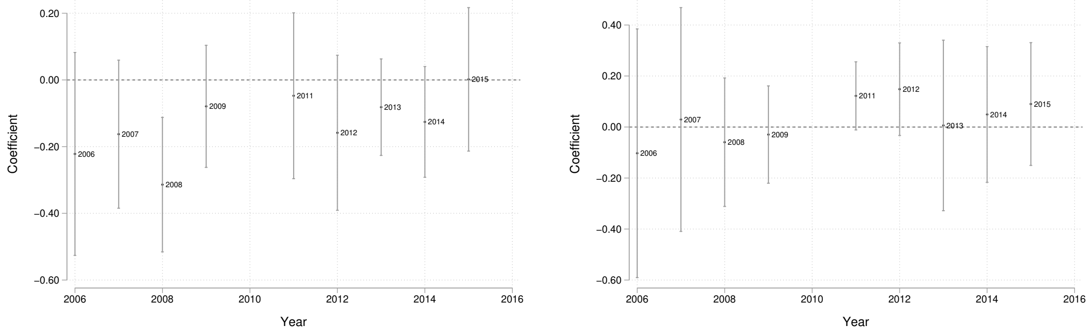
(f) Pacífico

Notes: The vertical axis of each subfigure denotes the average rainfall and the horizontal axis designates a quarterly time series from 2002Q1 to 2015Q4. The first (left) red dashed line corresponds to the start of "*La Niña*" in 2010Q3 (July 2010), and the last (right) red dashed line represents the final quarter of the event (2011Q4, December 2011).

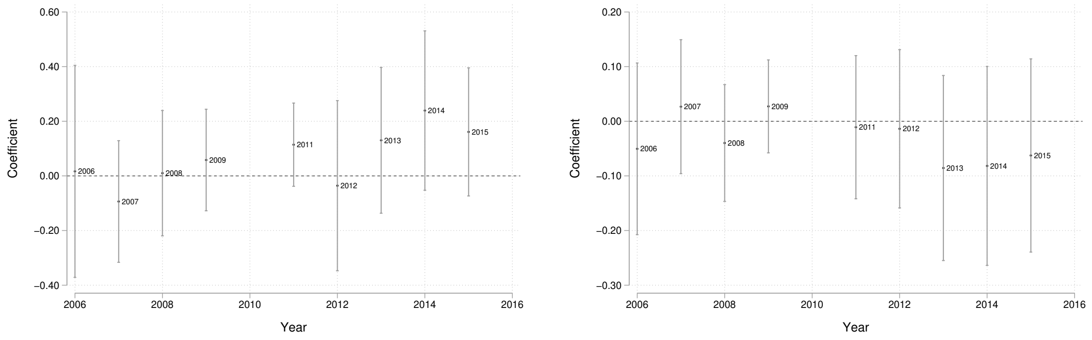
Figure A.2: Dynamic difference-in-differences by region



(a) Caribe (b) Centro Oriente



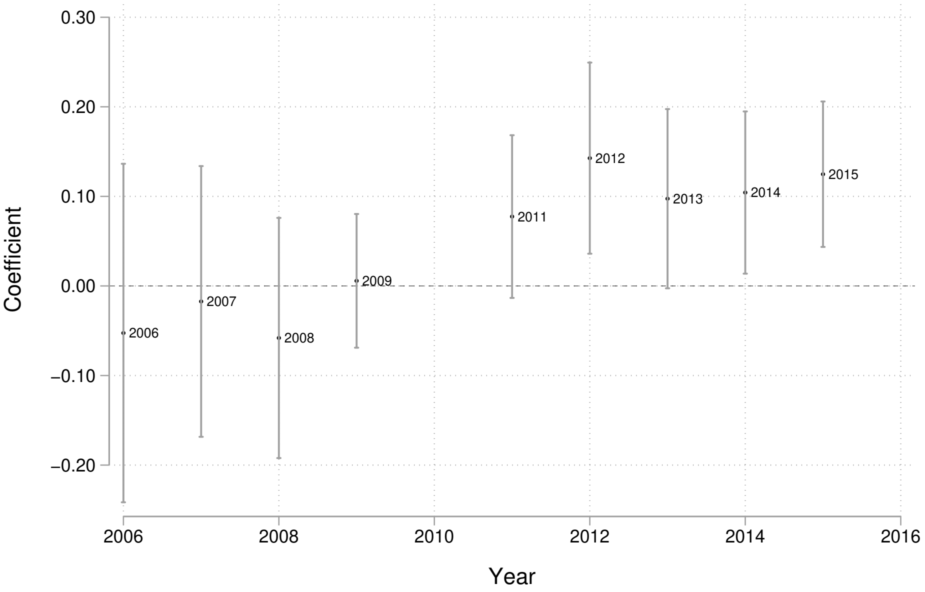
(c) Centro Sur (d) Eje cafetero



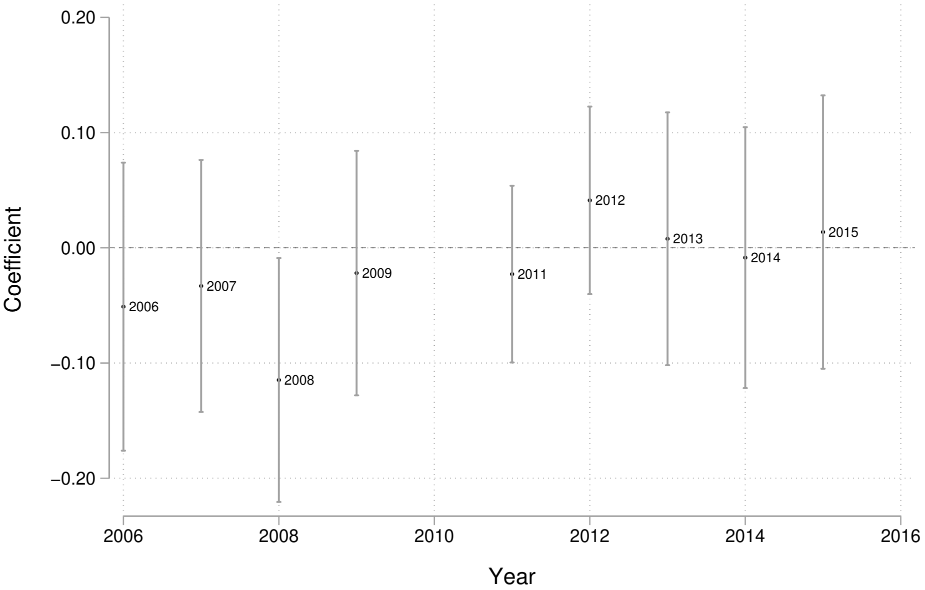
(e) Llano (f) Pacífico

Notes: This figure presents the coefficients from our specification presented in equation (4) by region. We present the point estimates of the regressions and the confidence of interval at 95%.

Figure A.3: Dynamic difference-in-differences by flood susceptibility



(a) Flood susceptibility: *High*



(b) Flood susceptibility: *Low*

Notes: This figure presents the coefficients from our specification presented in equation (5). We present the point estimates of the regressions and the confidence of interval at 95%.