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MASTER THESIS

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Supervisors: Pascale Motel Combes & Jean-Louis Combes

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MONETARY POLICY AND NATURAL DISASTERS: ANALYSIS FOR LATIN AMERICA

Catarina Braga

Supervisors: Pascale Motel Combes & Jean-Louis Combes

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Declaration

I declare in lieu of oath, that I wrote this thesis myself.

All information derived from the work of others has been acknowledged in the text and the list of references is given.

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Document for registration MASTER student's thesis

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Theses guidelines:

The aim of this thesis is to understand how central banks manages monetary policy in the case of a natural disaster, such as drought, hurricanes, earthquakes and etc. For that, the thesis will count with a three parts: i) literature review of monetary policy management in the presence of a natural disaster, ii) stylized facts analysis of price shocks and macroeconomic management in a natural disaster situation, iii) a panel data analysis to understand if and how monetary policy is affected by natural disasters in Latin America. Therefore, this thesis will count with a quantitative method of analysis.

Recommended resources:

Adam, C. (2013). Coping with adversity: The macroeconomic management of natural disasters. Environmental Science & Policy 27, pp. 99-111.
Alloway, T. (2011, February 23). Monetary policy in a time of natural disaster. Retrieved from Financial Times: https://ftalphaville.ft.com/2011/02/23/495836/monetary-policy-in-a-time-of-natural-disaster/
Benson, C., & Clay, E. (2003). Economic and Financial Impacts of Natural Disasters: an Assessment of Their Effects and Options for Mitigation. London: Overseas Development Institute.
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Okano, M. (2013). Monetary Policy and Natural Disasters: An Extension and Simulation Analysis in the Framework of New Keynesian Macroeconomic Model. Asia Pacific Institute of Research.
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Abstract

Latin America is a tropical region prone to natural disasters; between 1970 and 2018, 2.242 natural disasters took place in the region, resulting in more than USD 320 billion in damages, 295 million affected persons and 509 thousand deaths. Building resilience and preparedness are key elements for the area's development, specifically in a context where climate change effects on natural disasters is unknown. With the aim to contribute to the Sustainable Development Goal Target 17.13 (Global Macroeconomic Stability) and the Sendai Framework Priority 2 (Strengthening disaster risk governance to manage disaster risk), this thesis aims to assess whether monetary policy in the region is effective in absorbing spillover effects of disasters on economic growth. By running a panel analysis on 27 countries in the timeframe of 1970-2018 with random effects, the results reflect that the inflation target and flexible exchange rate are not contributing to alleviate pressure the external shock puts on growth. An exception carries with countries with a low rate of Central Bank governors' irregular turnover. This indicates that the inflation targets and floating exchange rate frameworks are unable to absorb the shocks due to inefficient management, rather than incompatibility with Latin America.

Keywords: Monetary Policy, Natural Disasters, Central Banks, Latin America

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List of Abbreviations

BCB	Central Bank of Brazil
CPI	Consumer Price Index
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
GDP	Gross Domestic Product
HDH	Index of Hurricane
HDI	Human Development Index
IMF	International Monetary Fund
MSWS	Maximum Sustained Wind Speed
OECD	Organisation for Economic Co-operation and Development
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDRR	UN Office for Disaster Risk reduction
USD	American Dollars
WEI	Wind Exposure Index

Introduction

Between 1970 and 2018, more than two thousand natural disasters occurred in Latin America and the Caribbean, causing more than 500 thousand deaths and leaving 295 million affected persons. Disasters can create deep negative impacts in livelihoods. and are often linked to human underdevelopment in health, education, income and economic activity (Hallegate & Przyluski, 2010; Karim & Noy, 2016; Rodríguez-Oreggia, et al., 2008).

The destructive power of disasters calls authorities for action not only in the post-disaster period, but also in building preparedness and resilience. In this sense, The Sendai Framework for Disaster Risk Reduction (UNDRR, 2015) was adopted in 2015, and brings 4 priorities for focused action to guide the work of the United Nations and authorities in all levels of government. Specifically, Priority number 2 encorages coherence among local frameworks of laws, regulations and public policies to strength and manage governance in disaster risk reduction. Eventhough the framework represents an important commitment from countries to achieve a more integrated aproach to disasters involving all levels of authorities, the management of macroeconomics and how to prepare and protect it from disasters still unclear - governance, resilience and preparedness also requires macreconomic policies to stabilize economy when a external shock presents itself.

Natural disasters cause volatility in economic activity and affects multiple fronts of macroeconomics; it can increase budget deficits, domestic expenditure, interest rates and cause currency appreciation leading to a decline in competitivenes, while enhancing the trade deficit and slowing the growth of national income. Considering the Sustainable Development Goal target 17.13, which approaches the Global Macreconomic Stability and its importance to economic development and social welfare, specific policies to build resilience and rapid recover of economic activity should also be considered in the realm of disaster risk reduction.

The present thesis aims to contribute to the debate of the macroeconomic aspect of natural disasters in monetary policy. Various monetary policy frameworks are capable of absorbing of the external shock impact on economic activity, contributing to the quick and sustainable recover on the long-run. Previous studies have found that inflation target and floating exchange rate are monetary mechanisms that can contribute to avoid spillover effects of natural disaster in GDP (Fratzscher, et al., 2017; Keen & Pakko, 2011; Ramcharan, 2007). This thesis tests this hypothesis for Latin American countries checking whether these frameworks associated to natural disasters contributes positively to GDP growth.

To reach the goal, this work is divided in four main sections. The first reviews the literature related to economics of natural disaster, specifically studies that explicitly reveal the relations between estimated damages caused by disasters and the impact in growth and monetary policy factors. This also includesinvestigate studies which seek to understand if monetary policy and flexible exchange rate are regimes that really benefit developing countries when dealing with external shocks.

Next, the second section deals with the actions of the Central Banks towards disaster comprehensive policies and the independence of the authority. An assessessment of Central Banks in the region is analyzed to indicate whether they are aware of the spilover effects natural disasters can cause in the economy, and if there are any policies to mitigate these effects from a monetary framework standpoint. From previous studies (Andersen, et al., 2014; Carrière-Swallow, et al., 2016; Dreher, et al., 2010; Fratzscher, et al., 2017), it is essential to note that without proper independence and hard inflationtargeting, monetary policy has very limited absoptive capaty when facing an exogenous shock. Therefore, the hypothesis of independence and strict compliance to inflation target is tested..

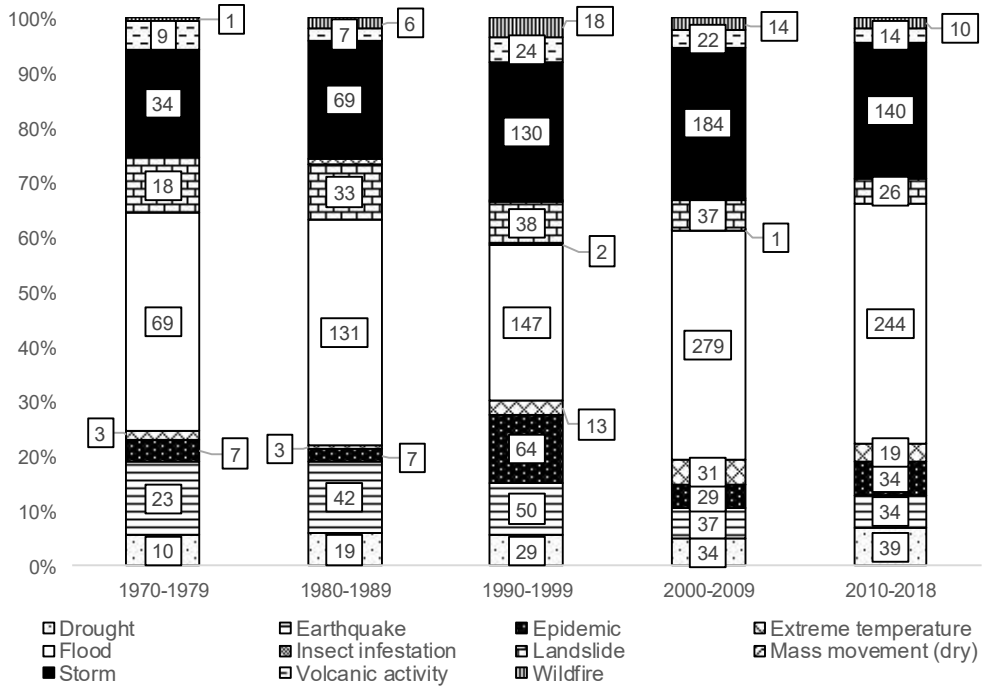
The third section first describes the theory on the economics of natural disasters in order to explain how natural disasters produce damages that affect production and employment; the channels through which natural disasters impact macroeconomic variables are also explicited according to the theorical framework. Later,stylyzed facts on natural disasters, human development and macroeconomic variables are explored; we seek first to understand what characteristics determine the size of damage caused by a disasters.Among the tested variables include number of events, amount of people affected, area, territory characteristics and its capacities to cope with disasters,and level of human development. In the second stage, an assessment is arranged to inidcate whether a correlation is present between macroeconomic variables and damage caused by natural disasters.

Lastly, the final section holds an empirical study on monetary policy and natural disasters in Latin America. The aim of this test is to understand if monetary framework adopted by countries in Latin America helps or hinders the absorption of spillover effects after natural disasters on economic growth. The sample contains a study of27 countries between 1970-2017. The panel follows specifications presented in previous studies on the topic (Noy, 2009; Parikoglou, 2016; Fratzscher, et al., 2017). Additionaly, cuts are made in the sample to test if results change according sub-regional levels, countries with independent Central Banks, human development and income levels.

2. The Economics of Natural Disasters: State-of-Art

Between 1970 and 2018, 2.242 natural disasters[1] took place in Latin America and Caribbean[2], leaving more than USD 320 billion in damages, 295 million of people affected and 509 thousand deaths. Generally, disasters are considered as exogenous shocks; an event coming from outside of the system that have a great impact in social and economic terms. If we look to disaggregated data in Latin America, there is very low correlation between type of disaster, damage, number of affected/deaths or a country more affected in one of described areas. Additionally, there is no clear trend along the years showing higher/lower incidence of disasters or higher/lower impact on damages/affected/deaths. However, natural disasters impose costs to countries in human and capital terms, and this can be determinant in a developing region in the sense that disasters can have a long-lasting effect.

Figure 1: Natural Disasters in Latin America by Type of Disaster and Period

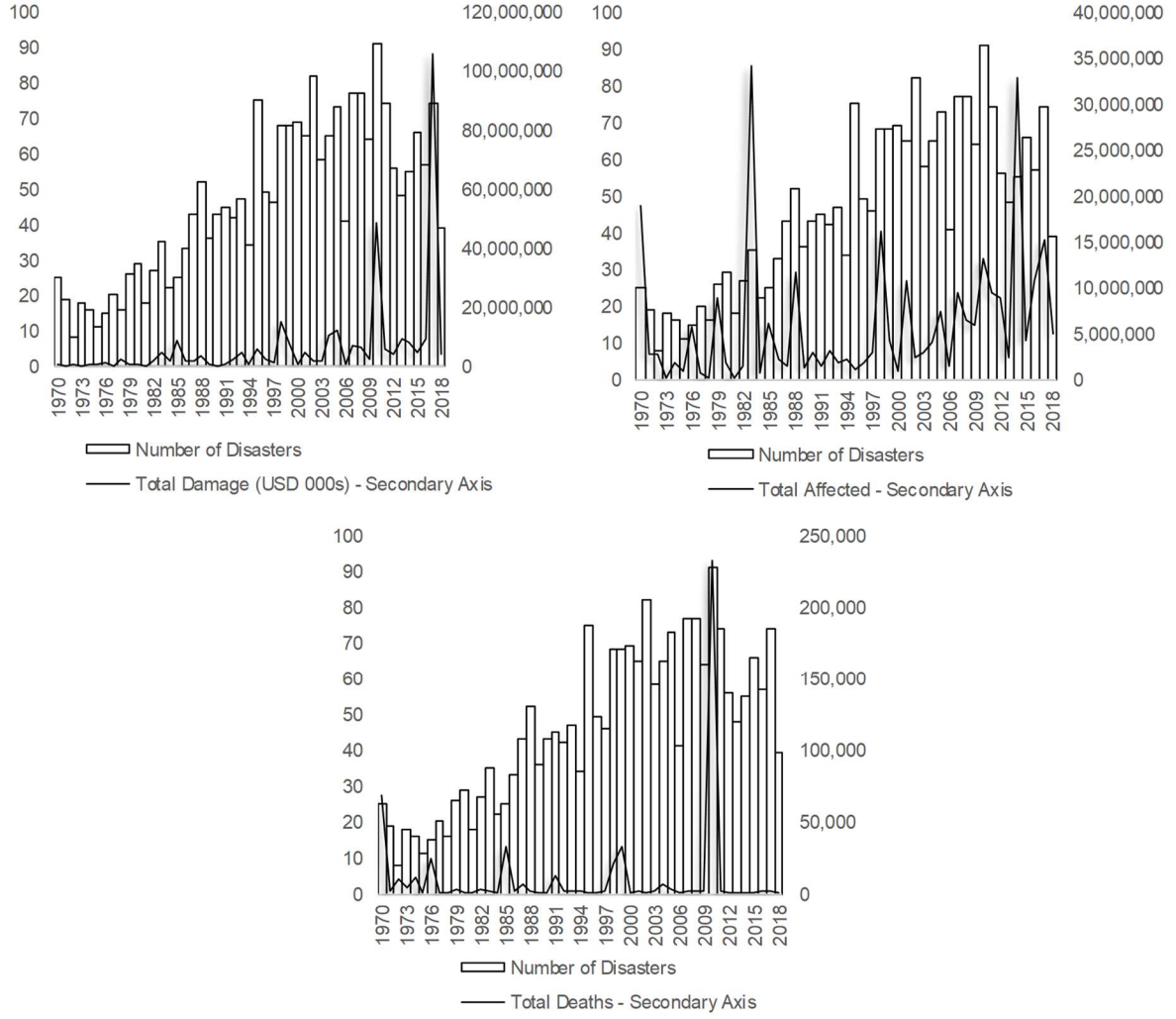


Source: EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) – CRED

[1] Characterized by droughts, earthquake, epidemic, extreme temperature, flood, insect infestation, landslide, mass movement, storm, volcanic activity and wildfire

[2] Region composed by Anguilla, Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Cayman Island, Chile, Colombia, Costa Rica, Cuba, Dominica, Domenican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico,Saint Barthlemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and Grandines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay,Venezuela and Virgin Island.

Figure 2: Number of Disasters x Total Damage/Total Affected/Total Deaths in Latin America



Source: EM-DAT: The Emergency Events Database - Universite Catholique de Louvain (UCL) – CRED

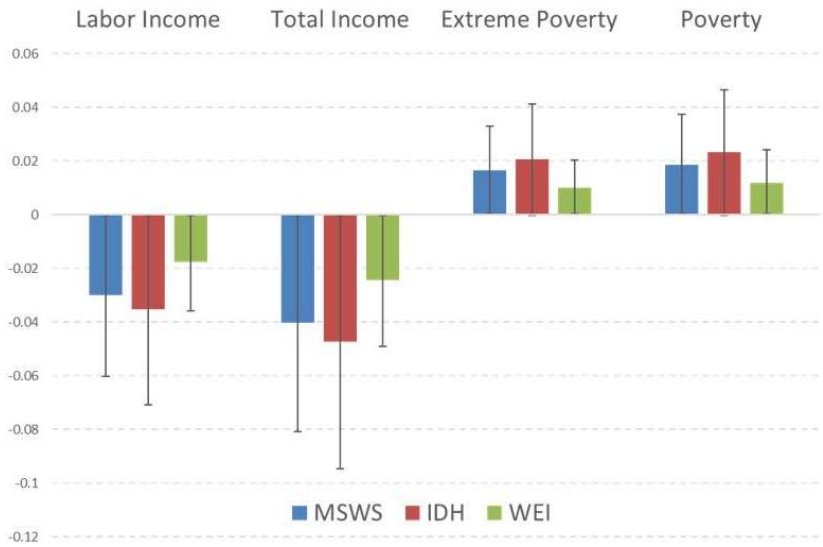
Latin America is an area prone to disasters and, the World Risk Report 2018 (Mucke, et al., 2018) show us that region also lacks coping and adaptive capacities, which may lead families and countries to a "poverty trap".

> "poor regions have a limited capacity to rebuild after disasters; if they are regularly affected by disasters, they do not have enough time to rebuild between two events, and they end up into a state of permanent reconstruction, with all resources devoted to repairs instead of addition of new infrastructure and equipment; this

> obstacle to capital accumulation and infrastructure development lead to a permanent disaster-related under-development". (Hallegatte & Przyluski, 2010, p. 15)

In a study measuring the impact of windstorms and hurricanes on poverty and economy in Central America, Ishizawa (2017) brings the effect in labor income and poverty according different measures: maximum sustained wind speed (MSWS), Index of Hurricane (HDH) and Wind Exposure Index (WEI). As figure 3 shows, the disasters decrease income and increase poverty.

Figure 3: Windstorms impacts on Labor income and Poverty



Source: Ishizawa (2017)

Building resilience is key to mitigate disaster impacts not only to avoid traps on micro-system but also in macroeconomic terms. The Sustainable Development Goal target 17.13 talks about global macroeconomic stability and reducing vulnerability to external shocks; with the motivation to contribute to more macroeconomic stable environment this thesis aims to investigate if different monetary policy framework (inflation targeting and exchange rate regime) contributes to smooth impacts of natural disasters on growth in Latin America.

In this chapter we will describe the existent literature relating macroeconomics factors and how it is affected by natural disasters in Latin American countries. We will start describing impacts on GDP and afterwards we will have an overview about how monetary policy mechanisms, such as inflation targeting, interest rate and exchange rate regime are affected or how these mechanisms influence growth adjustments after disasters.

2.1 Natural Disasters and the Economic Growth

A natural disaster represents an adverse shock supply on a macroeconomic point of view – this means it affects output and employment (Adam, 2013), however there are divergent opinions on the impact in economic growth.

In one of the first studies on the field, Albala-Bertrand (1993) analyses a set of disasters between 1960-1979 in a before-after methodology and finds that GDP increases after a natural disaster; this is a counterintuitive finding, however its grounded on neoclassical growth models which understands that external shocks have temporary effects and reconstruction and investment occurring after the shock can move the production function by enhancing technological progress. In Japan after World War II, as for example, the savings rate increased and even presented the highest annual average among the OECD countries between 1949-1980, two changes in technological progress and a well-above G-7 average total factor productivity (Valdés, 2003). When studying natural disasters and GDP growth in the Caribbean, Rasmunssen (2004) also reports that "recorded events divided by land area and the percentage of the population affected are both positively correlated with GDP growth" (Rasmunssen, 2004, p. 11).

In a study involving more countries, disaster types and robustness checks, Noy (2009) estimates the costs of natural disasters focusing on ex-post impact on the macro-economy. The author tests impact of the amount of property damage caused by natural disaster in GDP and finds significant evidence that the shock affects negatively macroeconomy, mainly in developing countries and small economies. Factors that are linked to resilience appears to be key on determining the size of the impact

> "… countries with higher literacy rates, better institutions, higher per capita incomes, larger governments and higher degree of openness to trade appear to be better able to withstand the initial disaster shock and prevent its effects spilling deeper into the macro-economy. Financial conditions also seem to matter. Countries with less-open capital accounts, more foreign exchange reserves, and higher levels of domestic credit appear more robust and able to endure natural disasters with less spillover to GDP growth rates." (Noy, 2009, p. 229)

A recent study using impulse response functions when correlating weather shocks on economic activity finds that increases in temperature have adverse impact mainly in hot countries (Acevedo, et al., 2018), which is the case for most of Latin American countries. Furthermore, this study finds the channels of impact, pointing that a rise in temperature reduces agricultural output, labor productivity and investments; with the rise in temperatures by 2100 low income countries may lose 9% of its respective GDP (Acevedo, et al., 2018).

By using night lights Ishizawa, et al. (2017) seeks to quantify the causal effects of hurricane windstorms on economic growth in Central American countries. The study finds mix results for short and long-term; during the 12 months after hurricane strikes the income growth on local level declines between 2.6 and 3.9 percent. Within the second year and the first half of the third year the authors find a positive effect of post-disaster recovery of between 2.5 and 3.6 in income growth (Ishizawa, et al., 2017).

It is consolidated in recent literature on the topic that natural disasters have a negative impact on economic growth in the short-term, and the decline on GDP can be even deeper and longer in developing world. This may reflect the fact that poorer countries are not able to adopt counter-cyclical fiscal policies that can pay for reconstruction and this factor can turn these countries more vulnerable in future disasters occasions (Cavallo & Noy, 2010). The inability to adopt counter-cyclical policies may also arise in the monetary pillar; according to Adam (2013) economies tend to fall in a twin-deficit situation in a natural disaster occasion, which means that the increase in the budget deficit enhance currency appreciation resulting in growth of imports, trade deficit and slower economic growth. If exchange rates are fixed or works with a very narrow boundaries of fluctuations, speculations in the medium-term, generating a currency crisis and constraining coping mechanisms. Furthermore, the inflation can spike by two means: disruption of production or appreciated exchange rate; if Central Banks are not highly committed to purchase power stability, high inflation may undermine recovery.

In the next section, studies linking monetary policy and natural are described in order to understand how these mechanisms may smooth or worse the adjustment capacities.

2.2 Natural Disaster and Monetary Policy

As Cavallo and Noy (2010) suggests, there is little research on the monetary aspect of natural disasters. Central Banks mandate often includes ensuring stability of the currency's purchasing power – in other words, keep inflation stable. Hyper inflation haunted Latin America during 80's and until nowadays it is not fully stabilized, lightening alerts whenever a minor risk present itself. A natural disaster can be a production shock and create a real challenge for monetary authorities.

In a research covering 212 countries, Parker (2016) studies how different type of disasters affect consumer price inflation in different development level countries. For developed countries the author finds no significant effect and, when there is any, the magnitude is negligible. In the other hand the impact in less developed countries "is more marked, with significant effects on headline inflation persisting even three years post-disaster" (Parker, 2016, p. 25). According to the study, disasters have an inflationary effect on food prices and disinflationary effect in housing and other subindexes. Regarding the effect of speciffic disasters, i) earthquakes significantly reduce CPI inflation excluding food, housing and energy, ii) storms

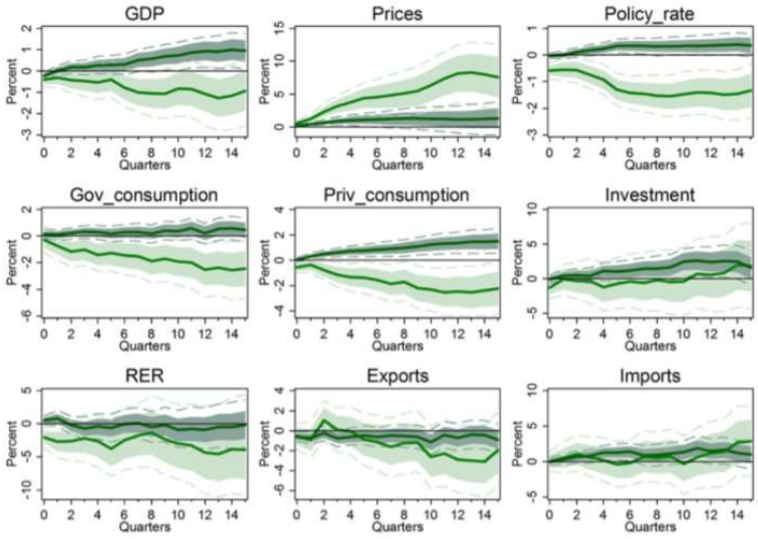
have an immediate short-term positive impact on food prices, iii) floods increase the headline of CPI in the short-term in middle and low income countries and, iv) droughts increase headline inflation for a number of years (Parker, 2016).

In its estimations on disaster' socio-economic and environmental effects, ECLAC (2003) claims that a "before-after disaster" comparison of inflation levels is not justifiable, but it is important to monitor

> "how supply limitations –arising out of the destruction of crops, manufactured goods, sales channels, transportation routes, etc.– might affect the price of certain goods and services that would have to be supplied by alternative means. The influence of these variables on general and relative prices must be estimated and included among macroeconomic effects" (ECLAC, 2003, p. 17).

Usually, when relating natural disasters and macroeconomics one might consider only the impact on fiscal policy, but monetary policy should be as much considered as fiscal policy in a disaster incidence. Central Banks can implement policies to absorb potential price shocks in essential services and food prices, preventing families to fall in food insecurity or poverty traps and avoiding further macroeconomic implications. One possible policy to avoid spillover effects of natural disasters is inflation targeting: Fratzscher, et al. (2017) developed a panel analysis covering 76 countries between 1970 and 2015 assessing the inflation targeting as a shock absorber in response to natural disasters. The authors report important difference in macroeconomic indicators dynamics under inflation targeting and under non-inflation targeting countries to large natural disaster shocks. The rationale behind this result is that inflation targeting is not only linked to lower inflation but also with predictability and credility of policy makers and, more predictability lows volatility in output, consumption, prices and investments. Lower volatility, in turn, leads to smaller interest rate and more stable exchange rate (Fratzscher, et al., 2017). The results represented below corresponds to responses in GDP growth, CPI price index, core central bank interest rate, government consumption, private consumption, gross capital formation, real effective exchange rate index, exports and imports, respectively.

Figure 4: Level effect of large natural disaster shocks in targeting and non-inflation targeting economies



Source: Fratzscher, et al., 2017, p. 2

We could testify in previous sections that natural disasters have a negative impact in GDP on short-run and positve in longe-run; Fratzscher et al (2017) also find this result in their sample, however, for countries adopting inflation targeting (IT) the initial decline is smaller and the subsequent recovery is stronger and faster. The results for inflation are also important as the authors finds a difference in non-inflation targeting countries consumer price of about six percentage points after four years while the increase is significantly less for targeters.

The results are robust when authors estimates the model by OECD and non-OECD samples, but with some remarks

> "The difference in output performance largely vanishes, but prices remain lower in IT countries despite the initial relative easing of monetary policy. We conclude that both developed and developing economies tend to benefit from an improved macroeconomic performance under IT, but the baseline results seem to be mainly driven by the OECD sample." (Fratzscher, et al., 2017, p. 28)

It is also important to highlight that these results are more visible in countries adopting hard inflation targeting – in other words, maximum time spell of consecutive recordings of inflation rates outside of the target corridor. To summarize, the important results for this study, and the ones taken into account to build our own model, are:

> "First, predominantly hard targeting stabilizes the economy, while soft targeting has only limited effects on macroeconomic

> dynamics. Second, our results suggest that a tougher stance on inflation does not only reduce consumer price fluctuations but also real exchange rate movements, which translates into a better adjustment of the economy through the external sector. Third, the findings indicate that IT, by reducing also the volatility of public and private interest rates, increases the effectiveness of monetary policy by lowering credit risk and term premia." (Fratzscher, et al., 2017, p. 35)

Another monetary policy mechanism that can be affected by natural disaster is interest rates. Keen & Pakko (2011) conducted a study after Hurricane Katrina in USA; according to the authors there were expectations that the Federal Reserve would cut interest rates as a respose to the disaster, however the Federal Open Market Committee anounced an increase of 25 basis points on fed funds rate in 20th of September 2005, suggesting monetary policy did not respond to the disaster. Using a dynamic stochastic general equilibrium to investigate the optimal response of monetary policy to disasters they find that

> "… monetary authority should raise its nominal interest rate target following a disaster. This prescribed increase in the federal funds rate clearly runs contrary to the conventional wisdom following Hurricane Katrina. The press and financial markets based their beliefs on an assumption that the Federal Reserve is motivated to dampen the fall in output caused by a disaster. When conducting monetary policy within a Taylor rule framework, however, the nominal interest rate responds primarily to higher inflation rather than to lower output." (Keen & Pakko, 2011, p. 974)

As a counter-example, in 2011 Japan faced an earthquake and a tsunami, causing serious damages in the eastern part of the country. The loss in capital stock and productivity is followed by expansion of output gap, resulting in inflation (Okano, 2013). However, on Japan's case the inflation wasn't affected and the Bank of Japan did not increase interest rate. Using a New Keynesian model, Okano (2013) finds that "monetary tightening for inflation stabilization does not necessarily have better performance in aftermath of a disaster shock" (Okano, 2013, p. 1). Another interesting finding of this study, and that should be observed when constructing our model, is that floating exchange rate has an important impact role to absorb fluctuations in relative prices (Okano, 2013).

Niemann (2011) seeks to assess optimal fiscal and monetary policies in disasters shocks contrasting policies under commitment and discretion in an institutional context, and he concludes that

> "A government that can commit to its policy plans relies heavily on debt to smooth the adverse effects of large shocks over time. Lack of commitment seriously limits the government's ability to use debt as a shock absorber. Under discretion, an increase in debt leads to an increase in inflation expectations and therefore higher nominal interest rate distortions. Hence, the discretionary

> government keeps debt in close vicinity of its steady-state level, and the response of taxes, inflation, and interest rates to shocks is much more pronounced under discretion than under commitment." (Niemann, 2011, p. 75)

As policies are often subject to discretion in Latin America, this finding indicate that we should consider a institutional quality variable in our model when measuring the impact of natural disasters in monetary policy.

In a more qualitative approach, White (1997) points that interest rate cuts may avoid a confidence crisis providing more liquidity to financial system. The author understands that reconstruction costs may offset inflation, but this should be a temporary effect "as the supply of items in short supply was re-established, or responded to meet the increased demand, prices could be expected to fall back toward pre-disaster levels" (White, 1997, p. 1).

A study that comprehends a panel data 251 countries between 1970 – 2012 seeking to answer if monetary policy is affected by natural disasters was developed by Parikoglou (2016). The author first develop an equation with interest rate as dependent variable and inflation, output gap, determinants of monetary policy and measurement of disasters.

Parikoglou (2016) doesn't obtain any significant result of natural disasters on monetary policy, however when controling by other factors the results changes. First the author disaggregates the disaster measurement in great disasters and finds that "other things constant, an additional large disaster event per square meter leads to an increase of discount rate to 0.68%" (Parikoglou, 2016, p. 29). Additionally, when spliting the sample between fixed and floating exchange rate, the author finds that in countries with floating rate the interest rate is likely to fall due to the impact of disaster on inflation. Parikoglou (2016) report very contrasting findings regarding the impact of natural disaster on interest rate for developed and developing countries: he reports an increase of 12% in interest rate in the case of a natural disaster in developed countries. Moreover, the author states that

> "The strongest evidence was found when the sample was divided into OECD and non OECD countries. In all four specifications natural disasters affected significantly the discount rate setting. Taking the above in consideration, it is concluded that natural disasters is an important determinant in countries with floating exchange rate regime, developed or OECD countries." (Parikoglou, 2016, p. 57)

In line with Keen & Pakko (2011) conclusions, the explanation for more likely changes in interest rate in developed countries may be that monetary policy in those countries is more strict and central banks

more reliable; without political interference, Central Bank's can act independently in guaranteeing the currency stability – even if it means unpopular measures such as hikes in interest rates.

Parikoglou's also highlights the that floating exchange rate is linked to adjustment in monetary policy; a similar finding was reported by Ramcharan (2007). Using data on natural disasters such as windstorms–hurricanes, tornadoes, typhoons–and earthquakes, the author estimates variant of equation, while controlling for the exchange rate regime and its interaction with the disasters to assess the contrasting theoretical predictions about the exchange rate regime and the economic adjustment to real shocks. Ramcharan (2007) finds that flexible exchange rate regime works as a cushion that smooths the disaster's negative impact on growth.

According to Andersen, et al. (2014) countries adopting inflation target and flexible exchange rate obtaing presents superior macroeconomic results when facing crisis and shock than countries adopting fixed exchange regime – this effect can be credited to better exports performance during initial periods of crisis as currency depreciates. But is flexible exchange better for developing countries? This question arises from the fact that developing countries in Latin America offers weak fiscal conditions, relatively low reserves and high volatility in economic conditions and, therefore, it is often target to speculations and massive outflows when risk perception deteriotes leaving countries with limited resources to cope with shocks enhancing procyclical policies. Kan (2007) affirms that flexible exchange arrangements constraints countries with limited access to financial markets while fixed arrangements or narrow fluctuations bands is source of speculative attacks.

> "The most promising alternatives for most emerging markets would therefore seem to be the two new intermediate schemes. This is not to suggest that they are equally attractive, however. The MFP (Managed Floating Plus) exchange rate regime would have to be viewed as the more promising because it combines the desirable features of a flexible exchange rate regime (i.e., monetary policy independence and shock-absorbing properties) with a framework designed to address the major problems that have complicated the implementation of such a regime in emerging markets (i.e., lack of a nominal anchor and vulnerability to sudden exchange rate movements)." (Kan, 2007, p. 13)

Additionally, the author highlights that more than the choice of which framework to use evolving in terms of institutional quality is the key for a more resilient macroeconomic context in emerging markets (Kan, 2007). In fact, credibility plays a bigger role than the determination of regime *per se* and it can be determinant when countries face exogenous shocks as volatility arises from expectations of individuals on authorities' reactions and level of commitment with adopted frameworks. This applies for both, floating and fixed exchange rate; for fixed exchange rate, for example, Guisinger & Singer (2010) argues that

> "… the official exchange rate regime is one of the most important signals of a government's economic policy preferences. When a government makes a *de jure* public commitment to a fixed exchange rate, it sends a signal to domestic and international markets of its strict monetary-policy priorities. In contrast, a government that proclaims a floating exchange rate signals a desire to retain discretion over monetary policy, even if it has implemented a *de facto* fixed rate." (Guisinger & Singer, 2010, p. 4)

We can therefore conclude that in order to exchange rate framework and inflation target works in favor of macroeconomic adjustment in case of exogenous shocks, one important factor must be observed: credibility of Central Banks. If monetary authority is not reliable, acting quickly and observing its mandate and commitments without external political interference, it is unable to reduce volatility in prices and exchange rates and, therefore, investments outflows increases with any signal of risk creating more volatility and negative impact on macroeconomic variables.

We can settle, from previous studies exposed early in this chapter, that natural disasters can cause a long-term impact on macroeconomic factors disrupting production in certain sectors (depending on the intensity of disasters and size of the country, it can destroy the totality of production and the capacity of countries to produce), increase government expenses, reduce government income, increase prices, disturb exchange rate volatility and deficits in trade balance due to currency appreciation. Central Banks should therefore to be prepared to act as soon as a disaster is detected or even before, if the effects of disaster is already known; this can only be achieved if monetary authority is fully independent to implement the policies that matches its mandate and framework. As Fratzscher, et al. (2017) states after finding that inflation target improves macroeconomic performance after disasters mostly due to stronger response of monetary and fiscal policy under inflation target framework, "… only hard, but not soft targeting reaps the fruits: deeds, not words, matter for successful monetary stabilization." (Fratzscher, et al., 2017, p. 1).

In order to analyze if Central Banks in Latin America are complying with its duties and mandates and if its policies are in line with the ones associated to better performance after natural disasters, we dedicate one chapter only to regional Central Banks: first we analyze the authorities actions and studies towards natural disasters, then we analyze if Latin American Central Banks are independent and if they are soft or hard inflation targeters (when applicable).

3. Central Banks, Monetary Policy and Natural Disasters

Countries as Argentina, Brazil, Chile and Mexico are big exporters of raw materials and food; therefore, its economies are very exposed to international market prices. A natural disaster, such as droughts, can cause serious damage to national production, and increase inflation. Not only disasters happening inside the country affects inflation – a disaster happening in Asia, for example, may trigger a hike in commodities prices and push up internal prices.

Not surprisingly Central Banks in Latin America are monitoring the impact of climatic events not only in their own countries but also in the world, sometimes even incorporating natural disaster measures in its decision-making models. This section is dedicated to highlight how Central Banks in Latin America are dealing with natural disasters and if it is taken into account in decision-making process.

According to the Caproasia Institute (2017) the Central Bank of Brazil (hereafter, BCB) is the 7th most influential Central Bank in the world. The institution adopted the inflation target in 1999 – CPI of maximum 10% and minimum 6% - and recently the target reached its lower (upper bound for CPI of 3,75% in 2021).

The mention to disasters is often in monetary policy statements[3] as it affects directly food and energy prices (70% of energy consumption comes from hydroelectric power plants in the country) which have a high weight in overall inflation. In 2014 the country experienced a major drought causing a damage of more than USD 5 bn; BCB published in its quarterly inflation report a special box with the impacts of climatic events on Brazilian economy – an inflationary impact was reported in grains (soy, corn and coffee), milk and cattle production and, additionally, a rise energy prices (Banco Central do Brasil, 2014). In 2015, another special box was released by the institution studying the impacts of El Niño and atypical rain patterns in inflation:

> "Based on the evidence presented, the El Niño phenomenon pressures the prices of *in natura* food, with developments over the CPI. This impact should be more pronounced at the beginning of 2016. The El Niño phenomenon may also create conditions for changes in the energy tariff, with favorable effects on inflation. The net effect of these two channels on the CPI tends to be neutral or, depending on the evolution of electric energy tariffs, favorable to the inflation path in 2016." (Banco Central do Brasil, 2015, p. 29, *author's translation*)

[3] See for example: Monetary Policy Committee Statement – 169th Meeting (paragraphs 1 and 29), 115th meeting (paragraph 47) and 113th meeting (paragraph 43)

Finally, in order to capture the impact of unusual climate condition on prices fluctuation, BCB introduced in 2018 variables such as the Oceanic Niño Index (ONI) in one of its models used to policy decision on interest rate (Banco Central do Brasil, 2018).

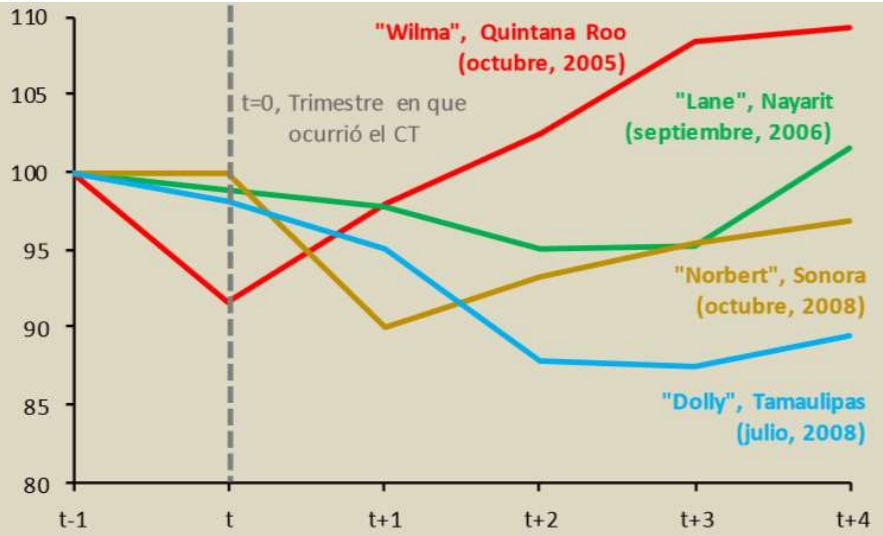
In 2010, Chile faced a major earthquake that destroyed 3% of its net capital stock (Banco Central de Chile, 2010). Considering this event, the Central Bank of Chile developed a special study to understand if earthquakes are inflationary in the short-run. The study finds inflationary pressure after earthquakes in Turkey (1999), Indonesia (2004) and Japan (2004) but, it also find evidence of deflationary forces in Taiwan (1999), Japan (1995) and USA (1994) – the researchers clarify that

> "Among the factors that could be behind these differences are: the magnitude of the earthquake, the affected area, and damage to infrastructure. Other factors that must be considered are those related to the capacity and speed of reaction of the authorities to restore the normal supply of goods and services; the role played by the monetary authority to stop a possible rise in prices; the existence of insurance against this type of disaster; commercial opening; fiscal situation and financing options for reconstruction, among others." (Muñoz & Pistelli, 2010, p. 118, *author's translation*)

In a research published in 2018, the Bank of Mexico analyzed the impact of tropical cyclones in economic activity of coastal municipalities in Mexico. The research finds that a cyclone with the "*Índice de Poder de Disipación*"[4] one standard deviation above the mean, the economic activity of a coastal regions could reduce its growth by 0.9 percentage points in the quarter of the event; this effect tends to dissipate two quarters after the event. Additionally, the study finds that the third sector is the one most affected by tropical cyclones, mainly because coastal regions are more involved in tourism and commercial activities (Banco de Mexico, 2018). Figure 5 illustrates the impact of cyclones on economic activity along the quarters.

[4] Índice de Poder de Disipación is an approximation of the net emission power of a cyclone that uses the maximum sustained wind speed $Vmax$ to capture the physical energy that these atmospheric phenomena radiate over a territory

Figure 5: Economic Activity Before and After the Occurrence of a Tropical Cyclone



Source: Banco de Mexico, 2018, p. 36

This small sample of selected studies from the main Central Banks in Latin America shows that monetary authorities are aware of their responsabilities on controling the macroeconomic scenario in a disaster event. However, as climatic events become more frequent and the effects of climate change in the economy still unclear, Central Banks should promote preparedness policies into their institutions. More than measuring post-disaster effects in economic activity and inflation, monetary authorities should be able to quickly identify unsual events affecting production and react to them as soon as they identify it, smoothening spillover effects along the production chain.

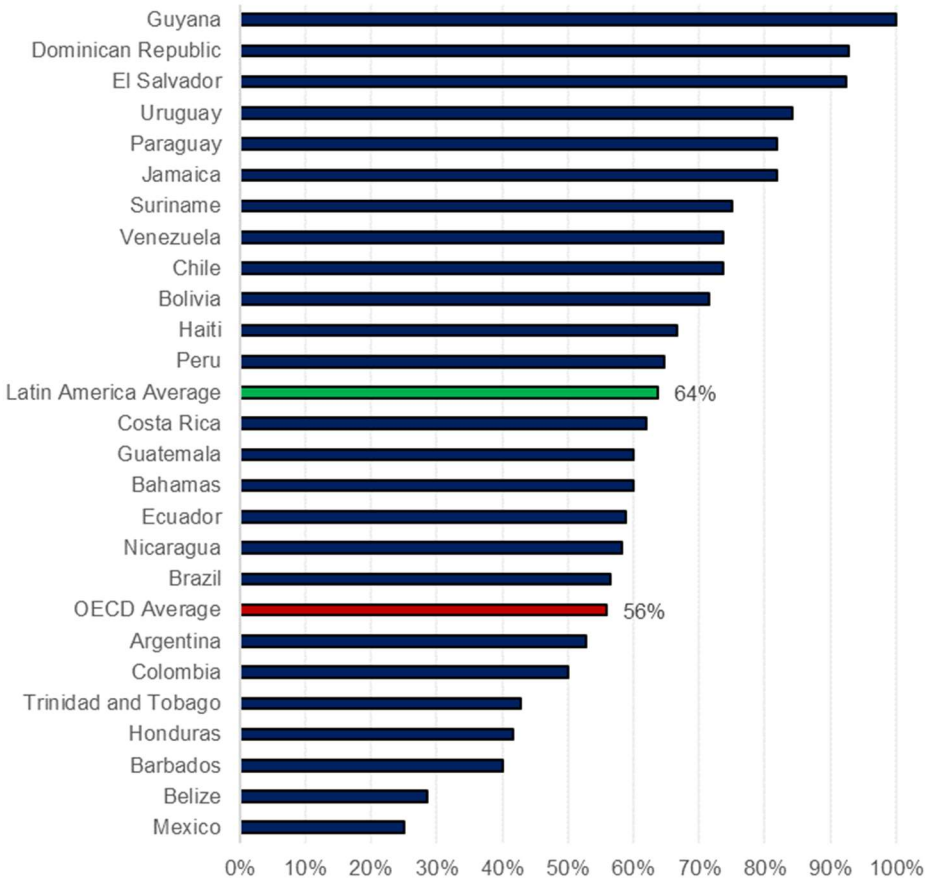
In order to react accordingly to negative shocks Central Banks needs to guarantee its indenpendence as political interference may enhance misleading policies and forcing the monetary authority to not comply with its mandate. In the next section, the authonomy of Central Bank in Latin America is analyzed to understand if institutions are capable of implement consistent measures to cope with shocks.

3.1 Central Bank Independence in Latin America

To approach the independence of Central Banks in Latin America and how monetary policy is conducted in the region, two qualitative variables were analyzed: i) central bank governors irregular turnovers and, ii) exchange rate arrangement and iii) inflation target compliance. The choice of these variables is based on to previous studies relating Central Bank independence and macroeconomic output (Andersen, et al., 2014; Dreher, et al., 2010; Dreher, et al., 2008; Fratzscher, et al., 2017; Guisinger & Singer, 2010)

The data on Central Bank governors is available at KOF Swiss Economic Institute[5] and it's the result of studies lead by Dreher, et al. (2010), Dreher, et al. (2008) and Sturm & Haan (2001). Irregular turnovers are replacements before the legal mandate period is over or reappointments not foresseing by law; remembering that high levels of turnover are often associated with lower independence. Below, trends the irregular turnovers as share of total turnovers for a sample of countries in Latin American countries are exposed and contrasted with OECD countries level.

Figure 6: Irregular Turnovers as share of Total Turnovers for Central Bank Governors



Source: author's calculation with data from KOF Swiss Economic Institute

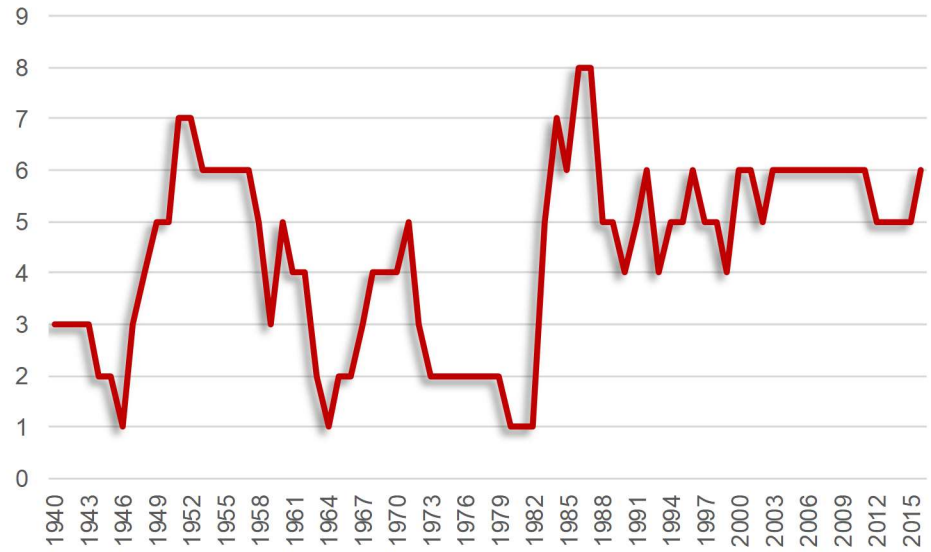
Only few Central Banks in Latin America display a lower irregular turnover rate than OECD countries; it may indicate that monetary authorities in the region are under political influence and its ability to guarantee currency stability is compromised. In the context of a natural disaster, knowing that it will

[5] See more details at: https://www.kof.ethz.ch/en/data/data-on-central-bank-governors.html

have a negative impact on economic activity in the short-run, politicians may persuade Central Banks to hold or decrease interest rates even if hikes in inflation arises.

As seen in the previous chapter, countries with flexible exchange rate regimes can cope better with the spillover effects on economic activity generated by natural disasters; the regime is linked to better adaptive capacities (Ramcharan, 2007). No country in Latin America exhibits a freely floating exchange rate regime; intermediary regime is more common with oscillation bands, in line with Kan (2007) findings. Figure 7 shows the number of countries adopting floating exchange in Latin America with data from Ilzetzki, et al. (2017). The following arrangements were considered as floating exchange rate arrangement: i) Pre announced crawling band that is wider than or equal to +/-2%, ii) Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time), iii) De facto crawling band that is narrower than or equal to +/-5%, iv) Managed floating, v) Freely floating.

Figure 7: Number of countries adopting floating exchange rate in Latin America

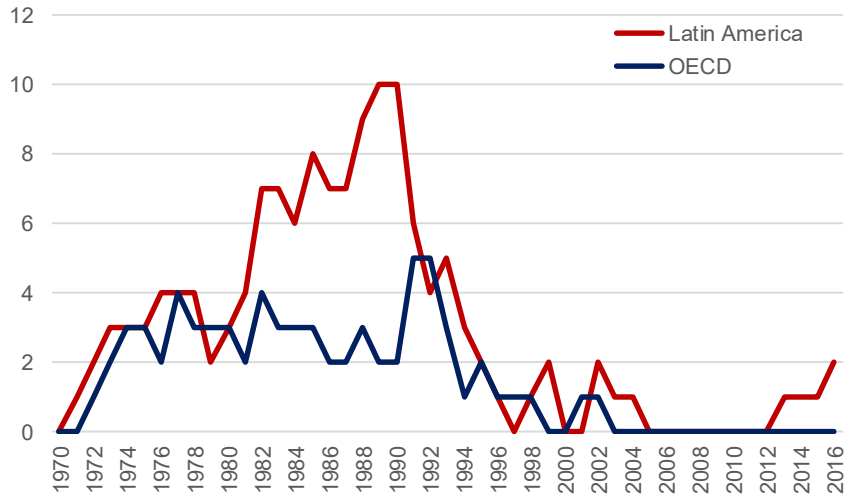


Source: author's calculation with data from Ilzetzki, et al. (2017)

From the 26 countries belonging to Latin America included in the database, only 6 could be considered as floating exchanging rate adopter in 2016; most of countries still adopting pegged systems. If we consider previous results that floating exchange rate arrangement are superior (Ramcharan, 2007; Fratzscher, et al., 2017; Noy, 2009; Parikoglou, 2016) in terms of macroeconomics adjustments in a disaster shock, this represents a worse output performance for Latin America as its capacities to control spillover effects through exchange rate are constrained.

It is important to remember that Latin America has in its past two waves of financial and currency crisis; the first in earlies 80's with the Mexican default (1982) and the second that started (again) with Mexico (1995), Brazil's currency crisis (1998-99) and Argentina's massive external default (2001) (Damill, et al., 2011). Hyper-inflation and currency instability marked the region between 1980 and 2000; in 1989, for example, in 10 from 26 countries the exchange rate was classified as "freely falling" on Ilzetzki, et al. (2017) database – which categorizes countries with chronically collapsing currencies that accompany very high inflation. In 2016, two countries in the region were categorized in freely falling exchange rate arrangement: Argentina and Venezuela. Figure 8 contrasts the number of countries in freely falling currency situation in Latin America versus OECD countries.

Figure 8: Number of Countries under "Freely Falling" Exchange Rate in Latin America and OECD - 1970-2016

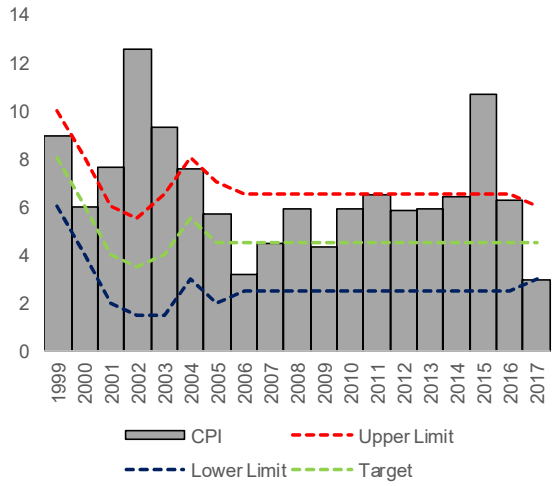


Source: author's calculation with data from Ilzetzki, et al. (2017)

In the end of 90's, when inflation achieved a stable path and flexible exchange rate started to be implemented in the region, Central Bank's in Latin America started to adopt inflation target systems with two main objectives: i) preserve price stability gains and ii) introduce elements of transparency and accountability (Carrière-Swallow, et al., 2016). Brazil was the first in the region to adopt the framework in June 1999, followed by Chile (September/1999), Colombia (October/1999) and Mexico (January/2001). Peru (2002), Guatemala (2005), Uruguay (2007) and Paraguay (2011) are recent adopters (in the monetary framework terms) of inflation targeting, summing up nine countries in Latin America in inflation target scheme, according to the Annual Report on Exchange Arrangements and Exchange Restrictions (IMF, 2018)

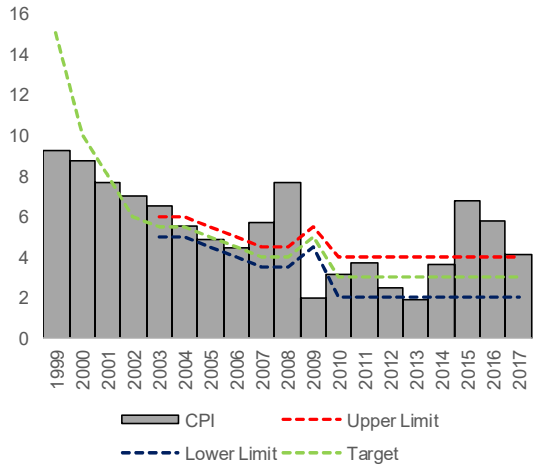
According to Fratzscher, et al. (2017) inflation target strict compliance is one determinant factor for the mechanism to absorb the negative impact cause by natural disasters on macroeconomic factors; the author states that "there is only limited evidence that countries which have introduced inflation targeting, but deviate from their target for a prolonged period of time, reap the fruits of an enhanced conditional macroeconomic performance" (Fratzscher, et al., 2017, p. 4). The idea is that if Central Banks deviate from the target repetitively, it means the target is not relevant for monetary policy, instead, political forces should play a bigger role in the decision-making process. The charts below display the targets for Brazil and Colombia, Chile, Mexico, Peru, Uruguay and Paraguay[6] with the actual CPI.

Figure 9: Inflation Target and Actual CPI - Brazil



Source: Banco Central do Brasil

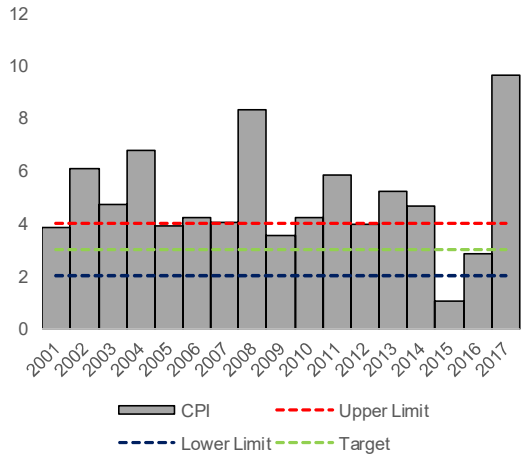
Figure 10: Inflation Target and Actual CPI - Colombia



Source: Banco de la Republica - Colombia

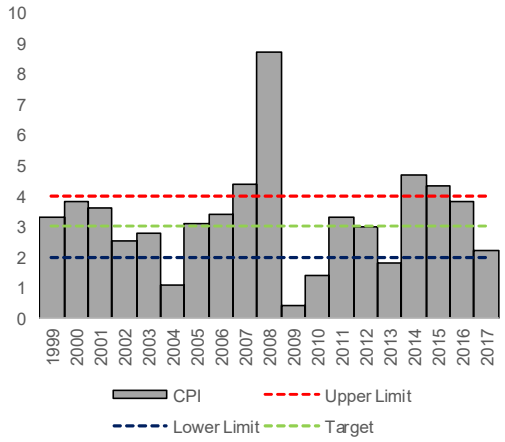
[6] Information for Guatemala wasn't possible do access

Figure 11: Inflation Target and Actual CPI - Mexico



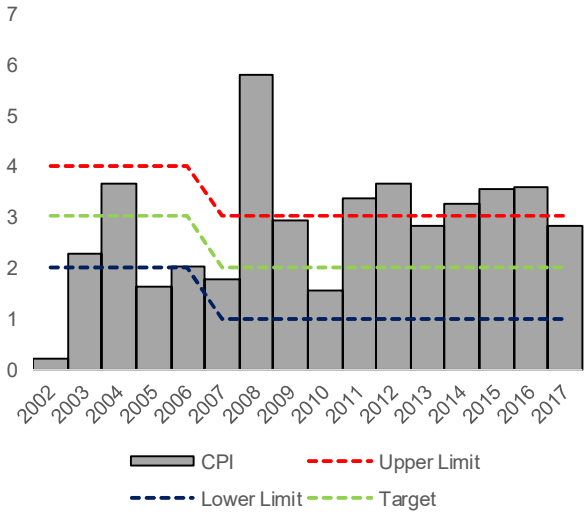
Source: Banco de Mexico & INEGI

Figure 12: Inflation Target and Actual CPI - Chile



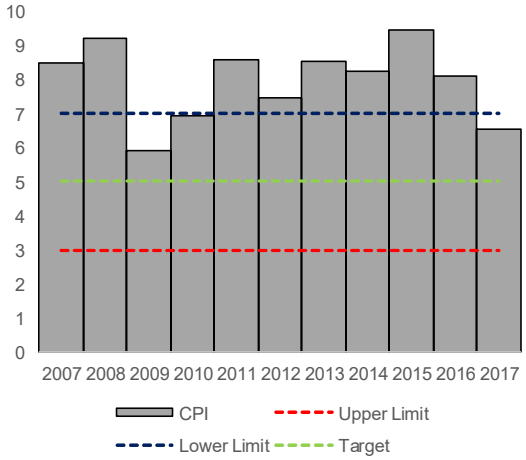
Source: Banco Central de Chile & World Bank

Figure 13: Inflation Target and Actual CPI - Peru



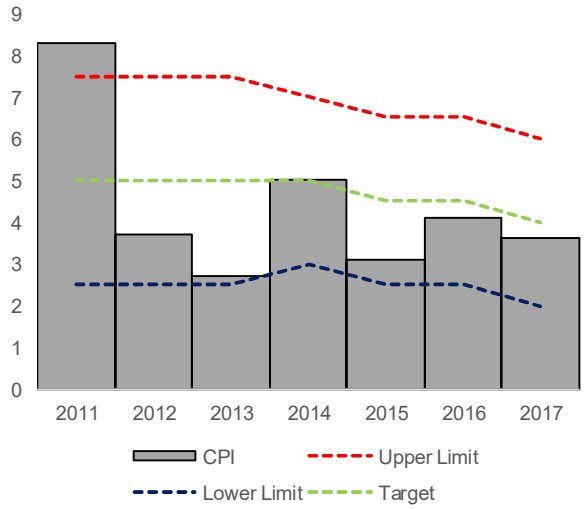
Source: Banco Central de Reserva del Peru

Figure 14: Inflation Target and Actual CPI - Uruguay



Source: Banco Central del Uruguay & Instituto Nacional de Estadisdica Uruguay

Figure 15: Inflation Target and Actual CPI - Paraguay



Source: Banco Central del Paraguay & World Bank

If we consider only the target (green line), consumer prices rarely display variations similar to the stablished target for the majority of countries (exception made to Paraguay). Instead, it is more likely that inflation ends the period close to the upper limit or above. In Fratzscher, et al. (2017) methodology, countries with a maximal one deviation from target of more than 11.4 percent of the total number of periods under IT are declared as soft IT counties. Following this logic, all countries showed above – with exception to Paraguay – can be categorized under soft inflation target regime.

It is also important to consider that markets expectation on inflation is key for actual inflation; firms and households take into consideration future prices when making consumption decisions, therefore if agents expect prices to rise it is likely that prices actually increase due to pricing and wage negotiations based on future inflation expectations. In our specific case, agents may expect prices to rise after a natural disaster due to production disruption and currency appreciation that follows the event. The table below brings statistics for inflation and expectations for inflation on target observance and asymmetry for Brazil, Chile, Colombia, Peru and Uruguay, which is presented in Gianelli & Licandro (2013) study.

Table 1: Percentage of Observations inside the range

		Brazil	Chile	Colombia	Peru	Uruguay
Jan/01-Oct/11	Inflation	70%	52%	31%	52%	31%
	Expectations	91%	88%	78%	72%	47%
	Range	4.26	2.00	1.20	2.00	3.08
Sep/07-Oct/11	Inflation	91%	27%	21%	38%	29%
	Expectations	100%	71%	65%	50%	35%

Range	4.00	2.00	1.44	2.00	3.42

Source: *author's translation and adaptation on* Gianelli & Licandro (2013)

Notes: Only considered periods with actual range; Range refers to the amplitude (average in the period) of the tolerance interval for the target.

Table 2: Asymmetry in the misalignment regarding the target

			Brazil	Chile	Colombia	Peru	Uruguay
Jan/01-Oct/11	Inflation	More than targeted	30%	22%	34%	28%	47%
		Lower than targeted	0%	25%	35%	20%	22%
	Expectations	More than targeted	8%	7%	15%	19%	45%
		Lower than targeted	0%	0%	4%	9%	0%
Sep/07-Oct/11	Inflation	More than targeted	9%	42%	42%	48%	70%
		Lower than targeted	0%	38%	38%	15%	0%
	Expectations	More than targeted	0%	25%	25%	42%	55%
		Lower than targeted	0%	8%	8%	8%	0%

Source: *author's translation and adaptation on* Gianelli & Licandro (2013)

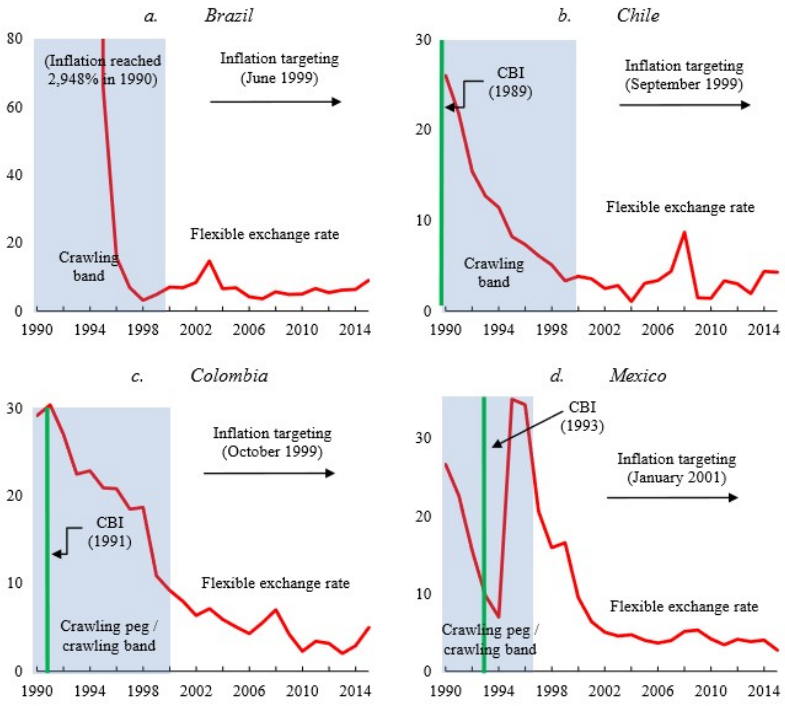
Note: Only considered periods with actual range

The time countries in this sample did not comply with inflation target and the asymmetries regarding the target are very high; in table 1, we can notice that Uruguay and Colombia only registered inflation inside its targeted range 31% of the time. Brazil is the country with more observations inside the agreed range, however, whenever deviations occurred, it was always superior above the boundary. It is also possible to notice that expectations were in all cases more optimistic than the observed inflation, but when it deviated it was more likely to be above the limits than below.

Upwards volatility in prices marks Latin America because of its hyper-inflation past combined with high risk and often inobservance to targets. It is true, however, that some progress were made since the region major crisis during the 80s-90s: 14 countries presented reforms regarding Central Bank independence between 1992 and 2002 and in all cases the Central Bank Index[7] showed superior performance post-reforms (Carrière-Swallow, et al., 2016). Figure 16 relates Central Bank independence with exchange rate regime and inflation for Brazil, Chile, Colombia and Mexico. It is clear that inflation ceased as Central Banks became independent (exception made for Brazil – which never approved legislation that grant Central Bank independence), inflation target defined, and flexible exchange rate adopted, but inflation levels still high and moments of peak are not uncommon.

[7] The index of central bank independence is based on the legal provisions of central bank laws and related legislation. The overall value of the index fluctuates on a continuous scale from zero to one, with higher values indicating stronger legal central bank independence. (Carrière-Swallow, et al., 2016)

Figure 16: Inflation, central bank independence, exchange rate regime, and inflation targeting - Brazil, Chile, Colombia and Mexico

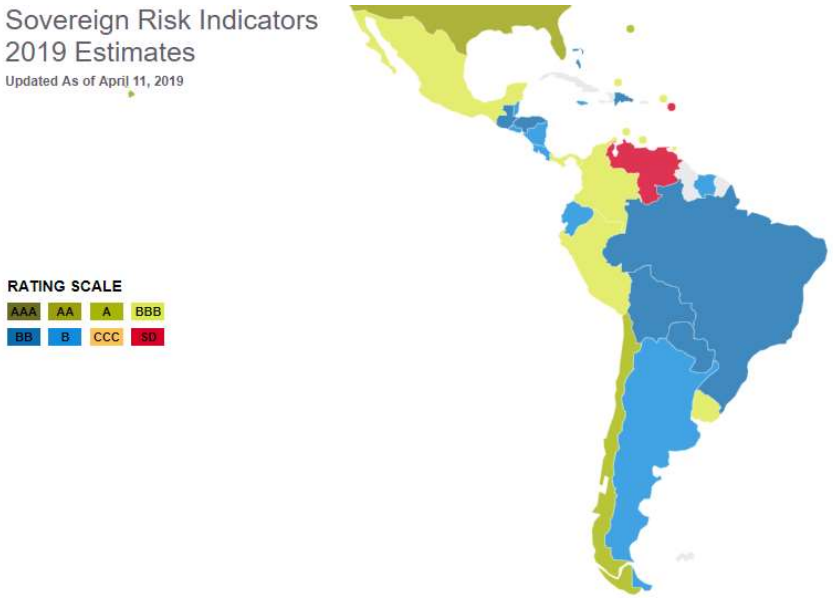


Source: Carrière-Swallow, et al. (2016, p. 8)

Even though countries have been notably working in provide more consistent and predictable policies and, also, perfecting its institutions quality, a lot of work must be done in order to change risk perception on the region – which still critical. Figure 17 shows the rating scale for Latin American countries according to S&P Global Ratings; countries signalized under the classifications BB, B and CCC are considered to be speculative or "junk" grade. A large part of region's country is classified under speculative grade, which means that the perception on its countries is that they are less likely to repay its debts due to economic fragility and high volatility. It is important to have in mind that many institutional investors with capacity to bring long-term investments requires a minimum grade of BBB for a country to receive its funds.

This factor can be detrimental in a disaster occasion; monetary policy in the region experience limited capacities as Central Banks are subject to political forces (sometimes even if laws grants it independence the monetary authorities still bound to discretion), causing more macroeconomic instability possibly with higher inflation. Moreover, financial means are also limited by speculative grade, which constraints financial possibilities to reconstruction and recovery.

Figure 17: Sovereign Risk Rating - S&P Methodology



Source: S&P Global Ratings, 2019

With high rate of irregular turnover of Central Bank governors, low adherence to floating exchanging rate and high number of countries classified with speculative grades, Central Banks in Latin America may not be fully independent and, therefore, the absorptive capacity of its monetary mechanisms may be rather limited – however an empirical test still needed. In the next chapter we bring stylized facts on the variables related to disasters, human development and macroeconomics. A theorical explanation on the economics of natural disaster is also presented; we seek to understand through which transmission channels a natural disaster can impact macroeconomic variable and economic growth.

4. Economics of Natural Disasters: Theory and Stylized Facts for Latin America

The Sustainable Development Goals contains 17 goals and an extensive list of targets to achieve a better and more sustainable future for all. The Goal number 17 is named "Partnerships for Goals" and it talks about the importance of government, private sector and civil society to actively participate in the development agenda sharing responsibilities for each step of the agenda. More specifically, the target 17.13 approaches Global Macroeconomic Stability. The description given to this target can be found on the Development and Globalization: Facts and Figures (UNCTAD, 2016), and it says

> "…high macroeconomic instability is strongly detrimental to economic development and social welfare. Indeed, it inhibits or distorts long-term economic decisions related to productive investment, employment creation and innovation. In addition, large swings in economic activity, volatility in exchange rates and financial markets and boom-and-bust episodes entail large economic and social costs: excessive credit and misguided investment decisions during expansions generate unsustainable debt levels, leading to credit crunches, firm bankruptcies, fiscal constraints, job and income losses, and increasing poverty during recessions. The resulting losses in productive and human capacities may take a long time to be reversed, when they are not irreparable." (UNCTAD, 2016, p. 178)

As exposed in the previous chapter, natural disasters are a big source of macroeconomic instability and it can lead to underdevelopment. Authorities should consider disasters in their decision-making process not only in post-disaster occasions, but also adjust their policies to enhance preparedness and resilience to such shocks. Droughts, for example, can seriously increase food prices, impacting inflation, creating additional volatility to markets, increasing exchange rates, affecting economic growth and ultimately enhancing poverty through unemployment, hunger and lacking coping mechanisms.

This chapter seeks to stablish relations between economics, monetary policy and natural disasters. The first part analyzes the theorical approach, meaning the macroeconomics channels through which a natural disaster affects macroeconomics. The second part brings stylized facts on economics, development and natural disasters in Latin America; first disaster incidence and its impacts are analyzed, then relations between disaster impact and human development/macroeconomic indicators are stablished.

4.1 Economics of Natural Disasters: Theory

In order to understand how natural disaster affects macroeconomic stability - including monetary policy - it is important to recognize the channels through which the impact occurs. Some studies explain

the relations between the macroeconomy and natural disasters; this section brings the highlights found in these studies.

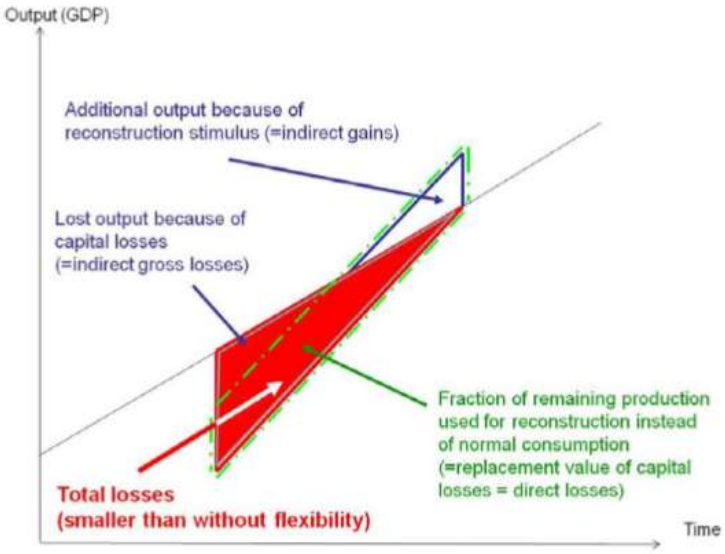
When a natural disaster hits a country, depending on the severity and level of preparedness, it may lead to disruption of infrastructure, markets, institutions, communications and enhance migration. Therefore, on the short-run the GDP is expected to decrease as a result of degradation of productive capacity in the economy (Adam, 2013; Cavallo & Noy, 2010). The reconstruction phase (medium/long-term) determines the output growth after the disaster; if there is no flexibility among production factors inside the economy the remaining productionis is not enough to meet reconstruction need and it has to crowd out consumption and investiments. In this scenario, the reconstruction leads to a no-disaster counter-factual scenario – meaning the output should go back to the level pre-disaster (Hallegate & Przyluski, 2010).

Figure 18 shows a a scenario with limited flexibility in the production proccess; in flexible production terms, natural disaster may even enhance gross indirect gains[8], as reconstruction effect may stimulate further production:

> "…capital destruction leads to a reduction in output; but unaffected capital may increase its own production to compensate this reduction, for instance through an increase in work hours by workers at unaffected factories and business." (Hallegate & Przyluski, 2010, p. 6)

[8] Indirect gains/losses are those "not provoked by the disaster itself, but by the consequences of it" (Hallegate & Przyluski, 2010, p. 3)

Figure 18: Output losses (direct or indirect) due to natural disasters considering limited flexibility in the production process



Source: Hallegate & Przyluski, 2010, p.9

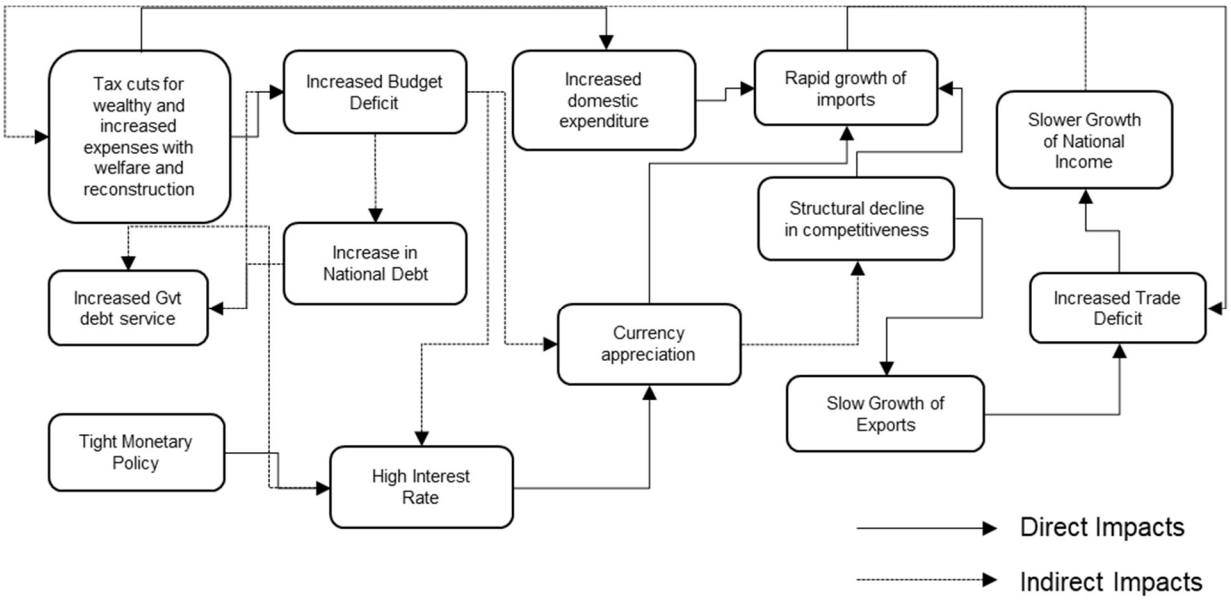
Other three main variables may be immediately affected by a natural disaster: (i) current account, (ii) employment and, (iii) fiscal policy. Right after the disaster, in order to compensate the decrease of suppply resulting from degradation of production capacity and to attend reconstruction needs, the imports immediately grows while exports decline (due to destruction of productive capacity, market infracstructure and/or scarcity of labor force). The result is a sharp degradation of current account through balance of payments (Adam, 2013, p. 102).

The labor supply is reduced in two different ways depending on disaster's severity: in a large disaster case, the labor supply is affected due to high mortality, while a disaster with more soft impact may enhance migration tightening the labor market in the short-run. This reaction may create a deflationary effect on the supply side. On the fiscal side, government expenses tend to rise in order to address immediate needs of affected population, reconstruction of vital services and support to damaged firms. In the other hand, revenues decline due to reduced demand for goods and services (less taxes are payed on income and consumption) and tax reliefs. More expenses and less revenue translated to rise of debts and higher risk-premium (Adam, 2013, p. 103).

> "The net effect of a natural disaster will therefore tend to confront the economy with a sharp incipient deterioration in the economy's 'twin deficits', the fiscal deficit and external current account deficit." (Adam, 2013, p. 103)

The twin deficits theory reveals a direct relation between expansionary fiscal policy and current account as the rise in expenditure may trigger the demand for imported goods. It is also important to highlight the effect on monetary mechanisms: the use of debt mechanism to finance the public deficit may put pressure on internal interest rates, atracting foreign capital and causing currency appreciation. Figure 19 shows all the relations between macroeconomic variables in a twin deficit case.

Figure 19: The trade and budget deficits in a natural disaster scenario



Source: *Adapted from* Blecker (1992)

In this scenario, even if the expansion of public expenditure enhance GDP growth in the reconstruction fase, this effect is not sustainable in the long-run as interest rate hikes, decline in exports and increasing debt service puts pressure in the rise of national income growth.

Of course, we are making big assumptions to define this model: perfect capital mobility, governments being always capable to finance their deficit and adopt counter-cyclical policies and reliable intitutions. In developing countries (which includes Latin America) the growth that might be generated due to reconstruction effect is contrained as governments have limited financing capacities, which may result in roll-over of existing debt and ultimatly in structural adjustment programmes (which means contraction in expenses, debt and, sometimes, recession).

Latin America faces many financing contrainst as the region hosted a major debt crisis in the 80s-90s followed by hyper-inflation and a decade of recession. By having limited capacity for adopting counter-cyclical policies, not only growth is contrained, but also human development. Countries in the Caribbean

may suffer a serie of disasters in a short period, or even every year. In this case, reconstruction process is compromised leaving population in bad living condition and precarious economic situation as investment is too risky. In the next section, we analyze the impact of natural disaster in terms of human and economic development.

4.2 Economics of Natural Disasters: Stylized Facts for Latin America

In order to measure the advances on global macroeconomic stability, UN uses a defined dashboard including important indicators covering the external, financial, fiscal, and real sectors; the indicators are published on World Bank website. In this section we seek to understand possible correlations between natural disasters, its impact's variables and macroeconomic indicators. We focus mainly in indicators that affect monetary policy.

The next subsection describes the impact data available on natural disasters in Latin America – this section is important to understand how disasters impacts the region in terms of number of events, damage, people affected and killed. The subsection 4.2.2 describe how these variables interacts with macroeconomic variables such as GDP, unemployment, government expenditure, foreign investment and etc.

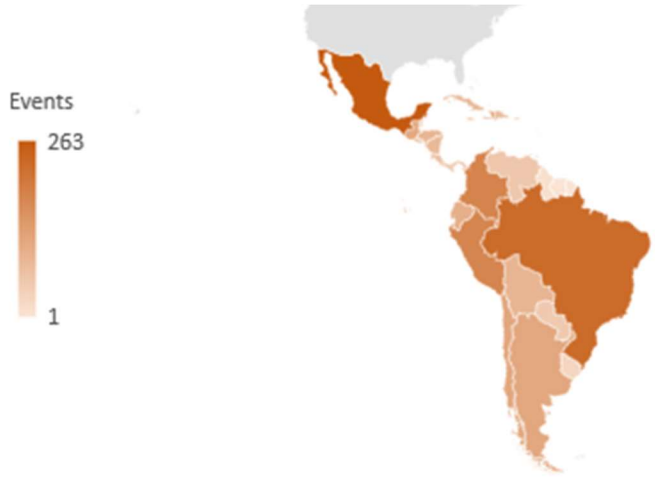
4.2.1 Disasters and its impacts

The data on natural disasters come from The International Disaster Database (EM-DAT) managed by the Centre for Research on Epidemiology of Disasters of the Catholic University of Louvain. To be considered a natural disaster and be counted on the database, at least one of the following criteria must be followed: i) ten or more people are reported killed, ii) 100 people are reported affected, iii) a state of emergency is declared or, iv) a call for international assistance is issued. Moreover, the database counts with four types of disasters: i) hydrological, ii) landslides and avalanches, iii) geophysical and iv) biological. There are three ways to measure impact of disasters using EM-DAT data:

- Total affected: People requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance.
- Total Deaths: Number of people who lost their life because the event happened.
- Estimated Damage: the amount of damage to property, crops, and livestock. For each disaster, the registered figure corresponds to the damage value at the moment of the event.

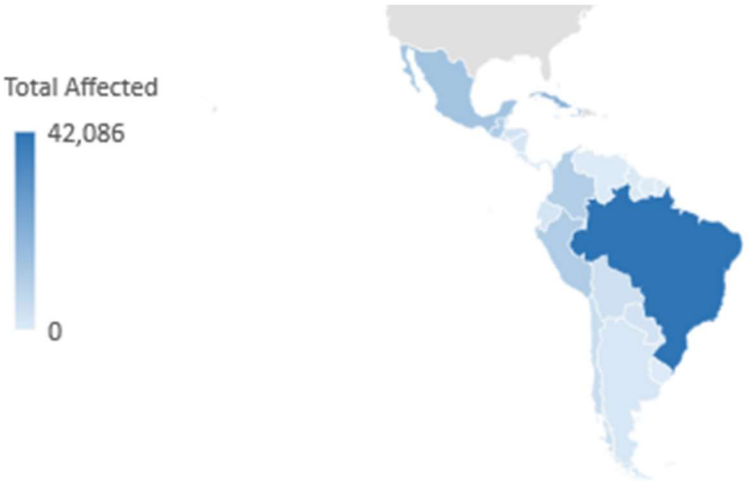
Data for all types of natural disasters were extract from 1900 to 2019 to all countries in Latin America in order to obtain stylized facts about the events in the region. The results for total of events and affected are plotted in the graphs below.

Figure 20: Number of Disasters per country in the Latin America and the Caribbean (1900-2019)



Source: author's calculation with data from EM-DAT

Figure 21: Total Affected (in thousands of people) per country in the Latin America and the Caribbean (1900-2019)



Source: author's calculation with data from EM-DAT

During the mentioned period, 2.527 events were registered in the region. The five countries with more incidence of events are Mexico (263), Brazil (229), Colombia (182), Peru (179), Haiti (125) and Chile (117). In terms of total affected people Brazil leads the ranking with 42 million people, followed by Cuba (20 million), Mexico (13 million), Haiti (12 million) and Peru (11 million). In terms of total deaths, Haiti is by far the country with more accumulated deaths in the period (237 thousands); the next country with

more deaths caused by natural disasters in the period is Peru, however it corresponds to only 1.6% (around 3 thousand) of the number of death in Haiti.

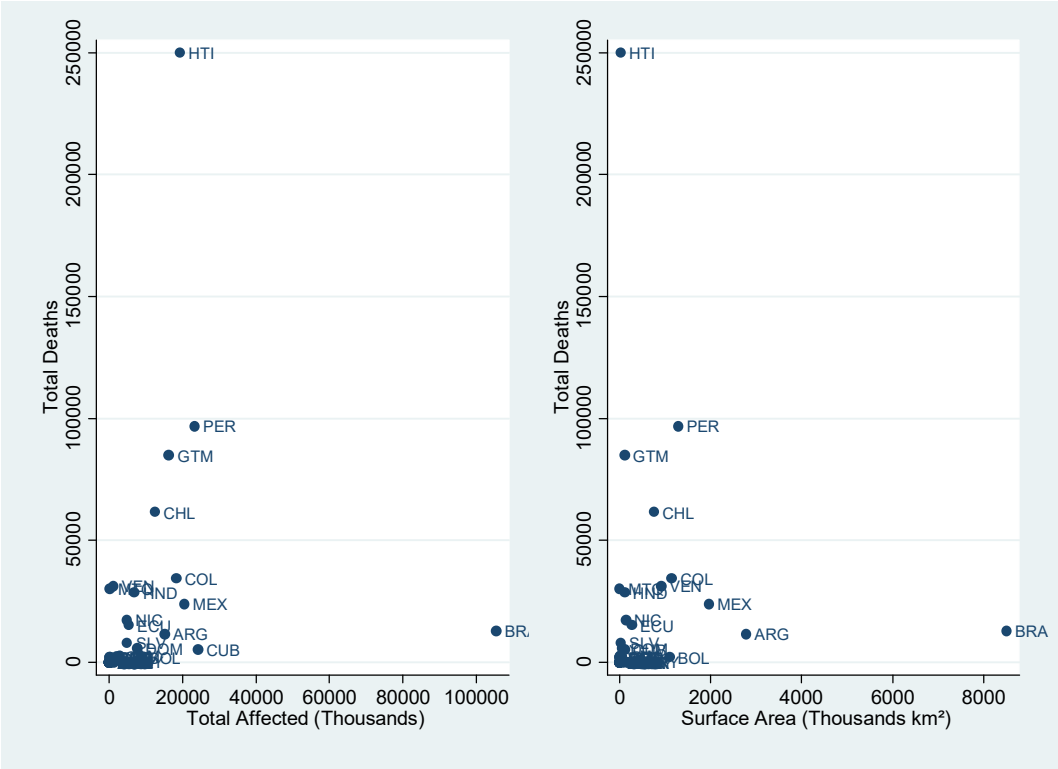
The correlation table below shows that the number of events is more related to total affected and surface area than death or damage. It is also interesting to notice that total deaths are very poorly correlated to surface area, indicating that small countries may face more fatal disasters than big countries.

Table 3: Correlation among disaster variables and surface area

	Number of Events	Total Affected	Total Deaths	Damage/GDP	Surface Area
Number of Events	1.0000				
Total Affected	0.7207	1.0000			
Total Deaths	0.4478	0.2513	1.0000		
Damage/GDP	0.4942	0.3326	0.1507	1.0000	
Surface Area	0.6503	0.9282	0.0547	0.2967	1.0000

Brazil is a good example to illustrate the results above - it is the biggest country in the region in terms of land and population and also the one with more events and people affected during the period analyzed, but the figure changes when we compare total deaths – only 3,259 deaths were registered in the country. Disasters seems more severe in terms of death in Haiti, Peru, Guatemala and Chile. We can also notice with the graphs below that number of affected does not always correlates to total deaths; Haiti, for example, has almost the same number of affected as Colombia and Mexico, but much more deaths occurred in Haiti than in later countries.

Figure 22: Plots for Total Affected, Deaths and Area



Estimated damage is the main measure used in studies seeking to relate macroeconomics and natural disasters. An important remark on this measure is that losses generated by natural disasters can be direct (losses with observed prices) or indirect (losses that are not provoked by the disaster but by its consequences) (Hallegatte & Przyluski, 2010). Therefore, the impact in macroeconomic variables are considered indirect losses.

From table 3, one can observe that damage measure does not hold strong correlation with the number of affected or deaths – the variable that seems to be more correlated is the number of events. To better analyze the damage measure, plots were generated relating it with the other impact measures plus surface area and GDP in constant 2010 US Dollars. By looking at the Figure 23 it is possible to notice that the damage size of a disaster has little to do with how many times a country is affected by a disaster (events), the size of country (surface area), how many people disasters affect and how many deaths it caused (severity of disasters occurred).

Figure 23: Plots for Damage (USD Million)

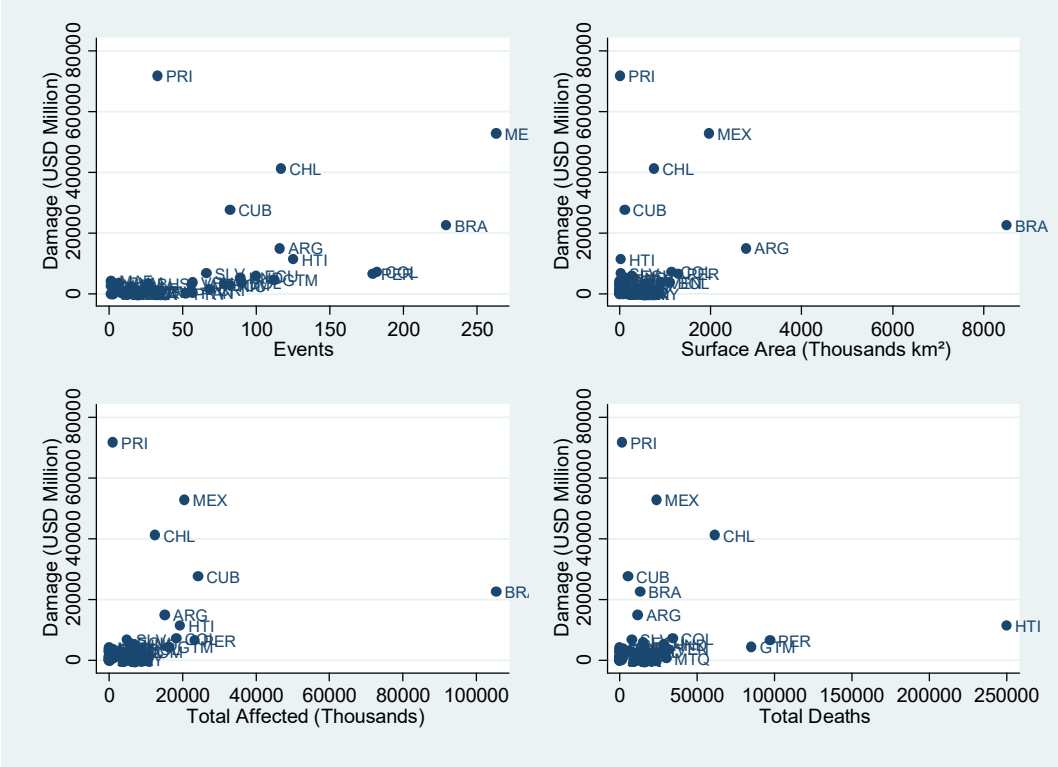
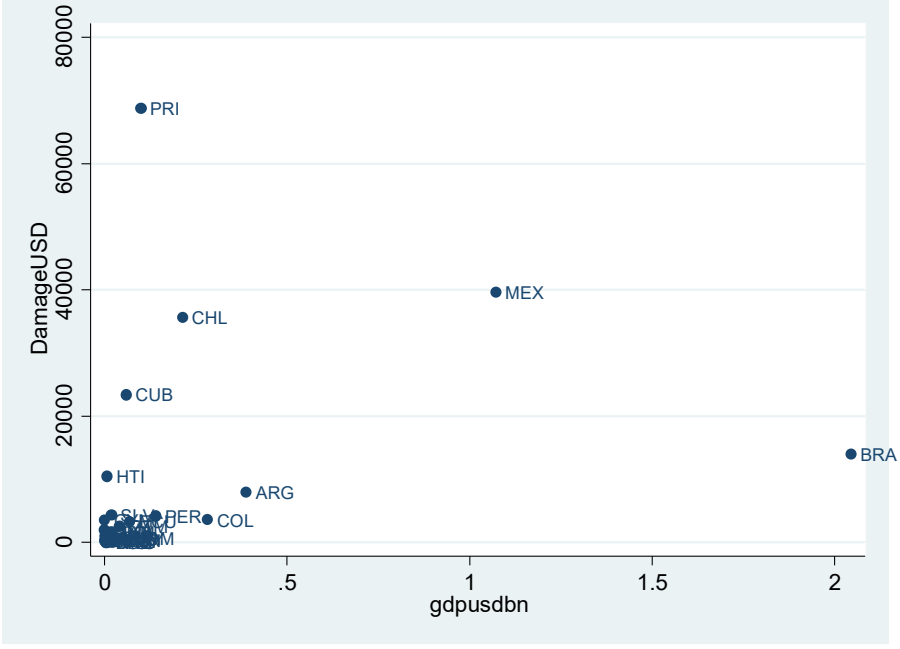


Figure 24: Plot for Damage (USD Million) x GDP (Constant 2010 USD, Billions)



Surprisingly, the damage measure also doesn't seem to be related with the economy size (measured by GDP), as can be observed in Figure 24. Cuba, for example, has a very small economy size, but suffered more damage than Brazil – which is the largest economy in the region in term of GDP in constant 2010 US Dollars and figures among the countries with larger number of events. This might entail that damage is more correlated to other indicators than the size of economy; in the next section, we explore how disaster impact measures responds to development, exposure, vulnerability and susceptibility.

4.2.2 Disasters, Risk and Development Indicators

Since 2011 the Bündnis Entwicklung Hilft – an alliance between eleven relief organizations, including Oxfam – publishes the World Risk Index. The index measures the disaster risk for 172 countries considering indicators of exposure, vulnerability, susceptibility, lack of coping capacities and lack of adaptive capacities; the higher the score more risk the country face in the front analyzed. By contrasting these indexes with disaster measures we seek to access how much of the impact a disaster generates is due to external factors, such as level of development and risks that country are exposed.

For comparison reasons the sample of disaster statistics analyzed in this section is a sum of events beginning in 2001 and ending in 2019. The indexes form the World Risk Index corresponds to the results published in 2018.

We compared the volume of events, total affected as share of population and the average of affected people each year divided by the population of that year. The damage is expressed in terms of GDP; the average of damage occurred each year divided by the GDP (constant 2010 USD) of that year. The results obtained are exposed below.

Figure 25: Number of Disaster Events x World Risk Indexes

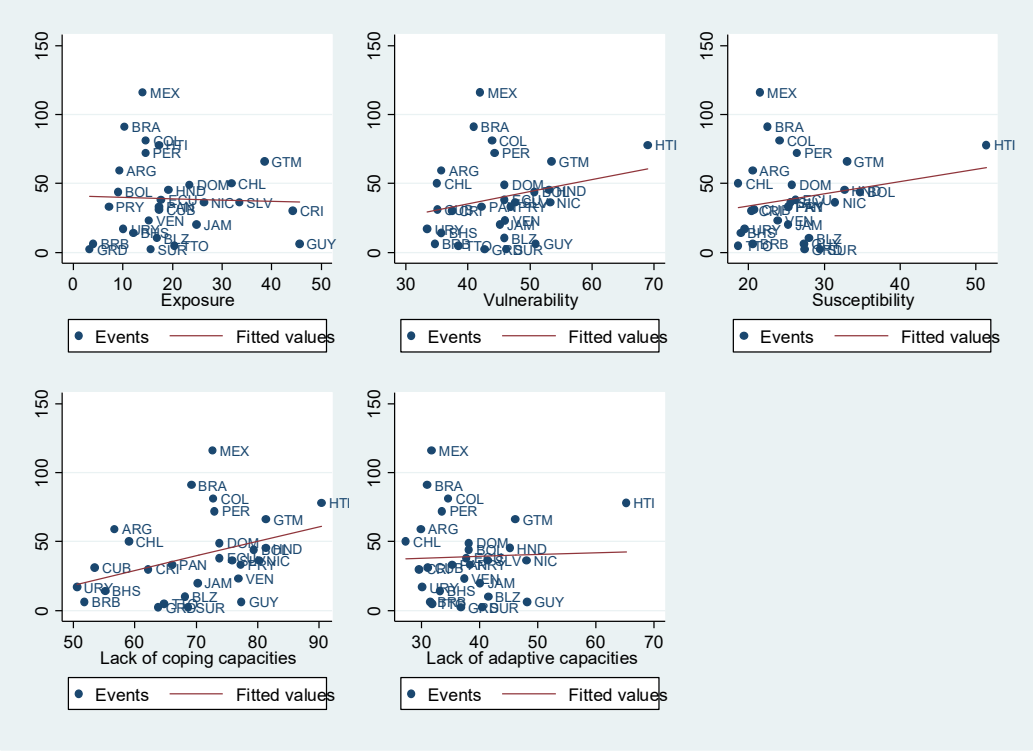


Figure 26: Total Affected/Population x World Risk Indexes

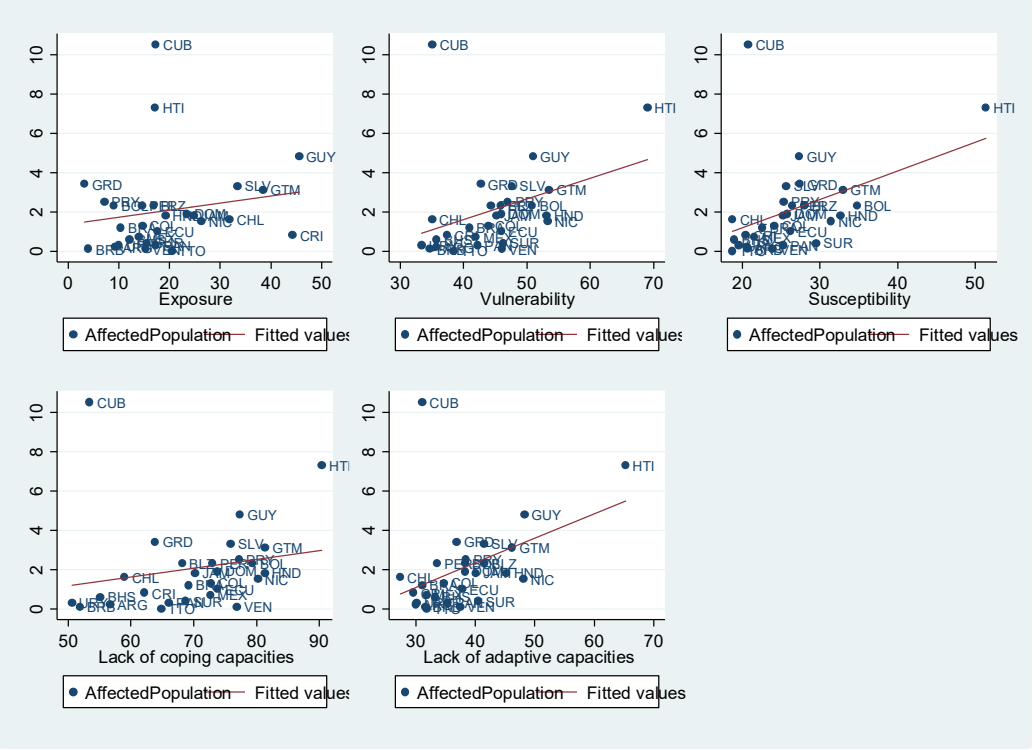
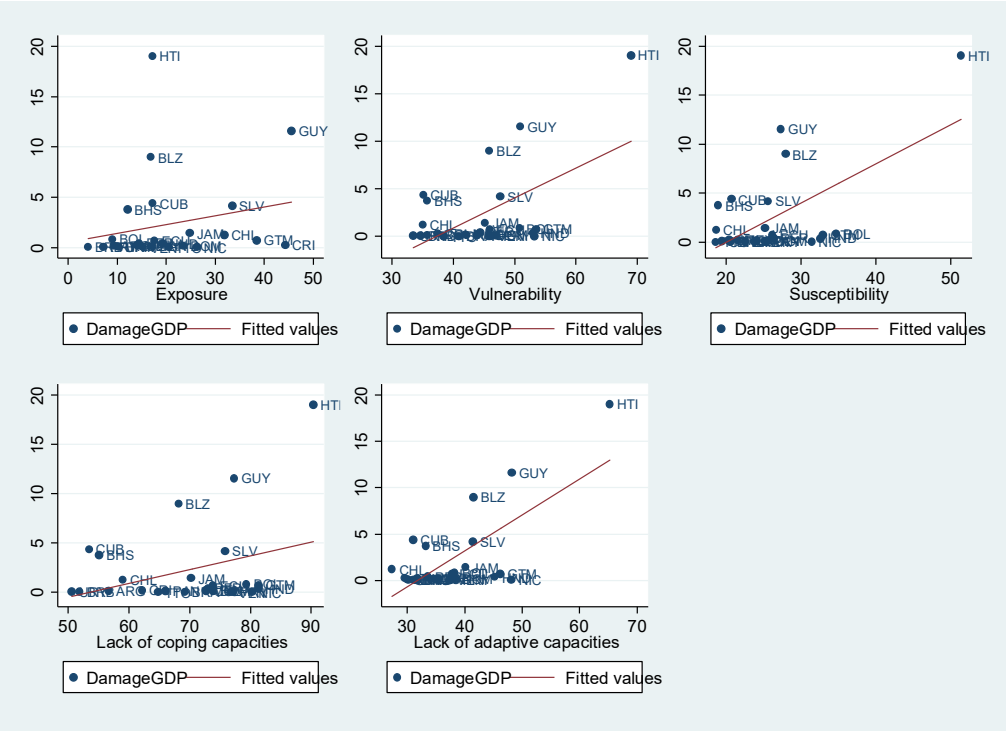


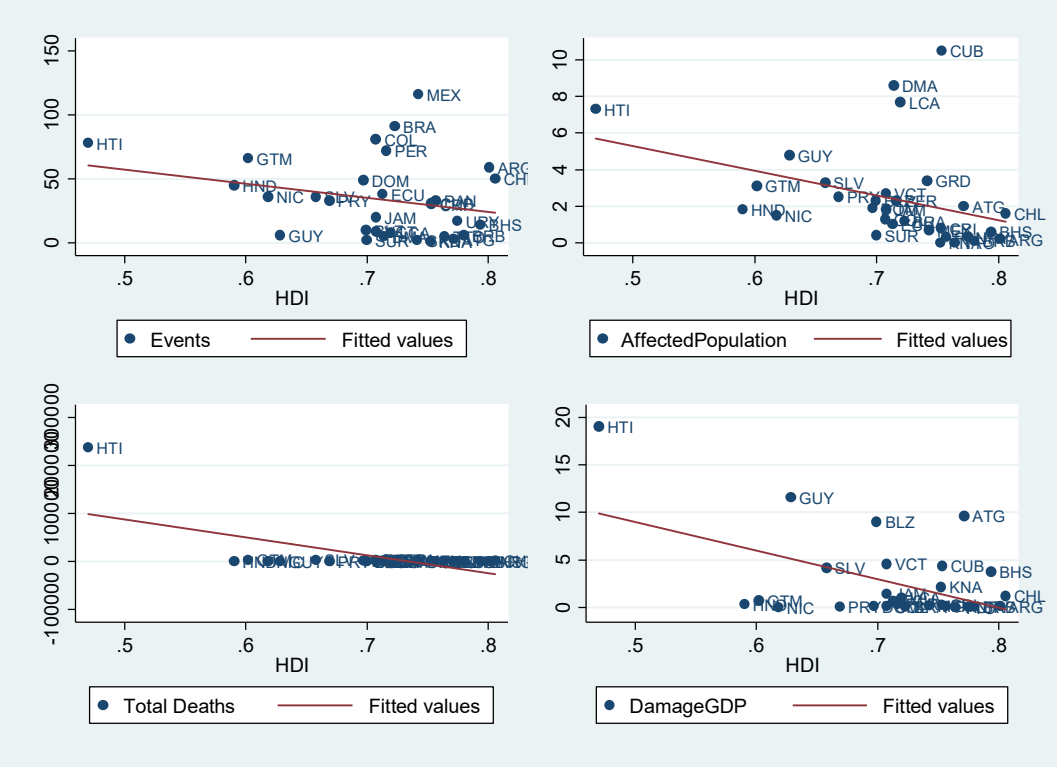
Figure 27: Damage/GDP x World Risk Indexes



While countries such as Mexico and Brazil show low scores of exposure, they faced the larger amount of disasters occurring on the 21st century. No clear trend can be identified when relating amount of disaster events with World Risk Indexes, as can be noticed on Figure 27. As for number of affected people, vulnerability, susceptibility and mainly lack of adaptive capacities appears as relevant contributors to the impact measure in Latin America – the variables are positive correlated with results of +35%, 42% and 43%, respectively. The damage caused by disaster is also strongly correlated to vulnerability (+56%), susceptibility (+62%) and lack of adaptive capacities (+71%).

As many human development indicators compose the scores of vulnerability, susceptibility and lack of adaptive capacities, below we test the disaster measures with the Human Development Index, in order to understand how disasters influence the development in Latin America. The following results were generated:

Figure 28: Human Development Index x Disaster Statistics



While there is no clear relation between event and HDI, some negative correlation appears to occur between the Human Development Index, affected population and damage – lower results of HDI means more affected population in disasters and higher damages.

4.2.3 The Damage of Disasters and Macroeconomic Indicators

This section analyzes the damage caused by disasters as share of GDP and its possible correlations with macroeconomic variables used by SDG Target 13.17 to measure Macroeconomic Stability and variables related to monetary policy. A division was created to better analyze the variables:

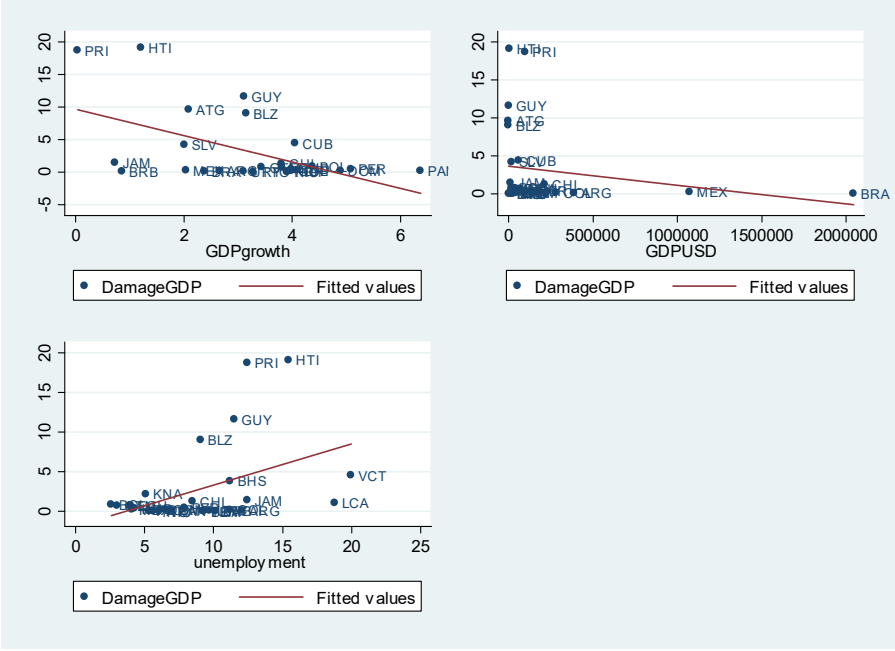
- Productivity related variables: GDP growth (annual %), GDP (constant 2010 US$) and Unemployment (% of total labor force)
- Public Sector related variables: Central government debt (% of GDP), Revenue, excluding grants (% of GDP), Net ODA received (% of central government expense)
- Monetary Policy related variables: Inflation, consumer prices (annual %), Total reserves minus gold (current US$), Domestic credit provided by financial sector (% of GDP) and Broad money (% of GDP)

The source of all macroeconomic indicators is the World Bank Data. An average of all variables was taken to the timeframe of 2001 until the last availability. Below it is possible to find the correlation matrix and plots:

Table 4: Correlation Matrix: Damage/GDP x Macroeconomics' Variables

	Damage/ GDP	GDP 2010 US Dollars	GDP Growth	Inflation	Debt	ODA	Reserves/ GDP	Unemployment	Revenue	Credit	Broadmoney
Damage/GDP	1.0000										
GDP in USD	-0.2982	1.0000									
GDP Growth	-0.1947	-0.1222	1.0000								
Inflation	0.4638	-0.0323	-0.1712	1.0000							
Debt	0.4461	0.0243	-0.7494	0.3667	1.0000						
ODA	0.4239	-0.1890	0.3252	0.4023	0.0422	1.0000					
Reserves/GDP	0.0259	-0.3672	0.3056	0.1562	-0.3103	0.4250	1.0000				
Unemployment	-0.0578	0.1946	-0.5557	-0.0977	0.6438	-0.6414	-0.4631	1.0000			
Revenue	-0.3353	0.0754	-0.4672	0.2210	0.3536	-0.4065	0.2451	0.5404	1.0000		
Credit	-0.1778	0.5653	-0.5859	0.0946	0.5923	0.0007	-0.4727	0.3305	0.2758	1.0000	
Broadmoney	-0.0937	0.2195	-0.6992	0.1695	0.5576	0.1535	-0.1044	0.1004	0.3626	0.8500	1.0000

Figure 29: Damage (%GDP) x Productivity Related Variables

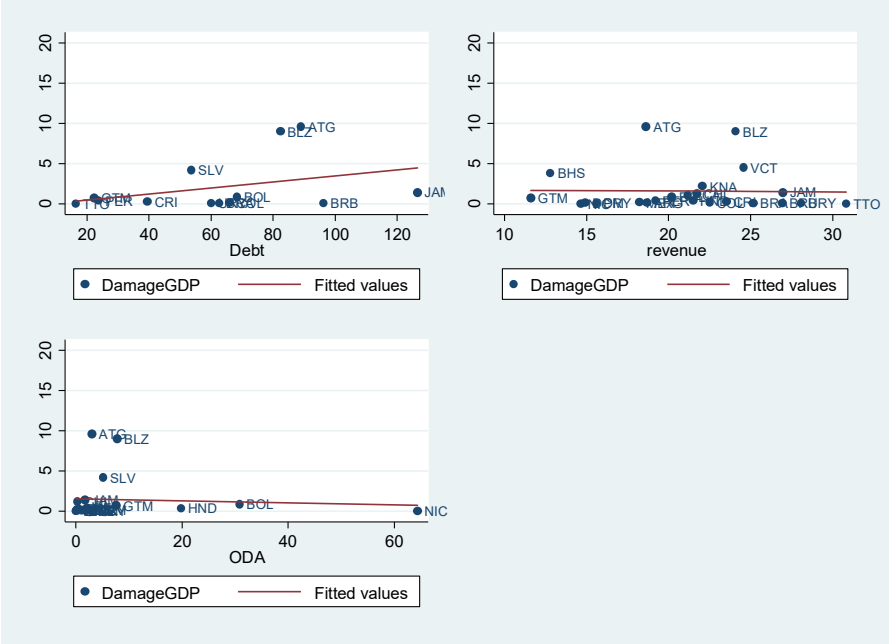


It is important to highlight that no direct correlation can be concluded – the factors affecting these variables are more than simply disasters - but results encourage further investigation. It is possible to notice a negative association between GDP growth and damage – higher the damage as GDP share suffered in the century lower the average GDP growth rate. Average unemployment rate also might keep a positive correlation with damage caused by disasters – big damages may result in higher unemployment. Even

though the GDP in constant 2010 USD has a stronger negative correlation with damage, the presence of outliers such as Brazil and Mexico make the relation less clear.

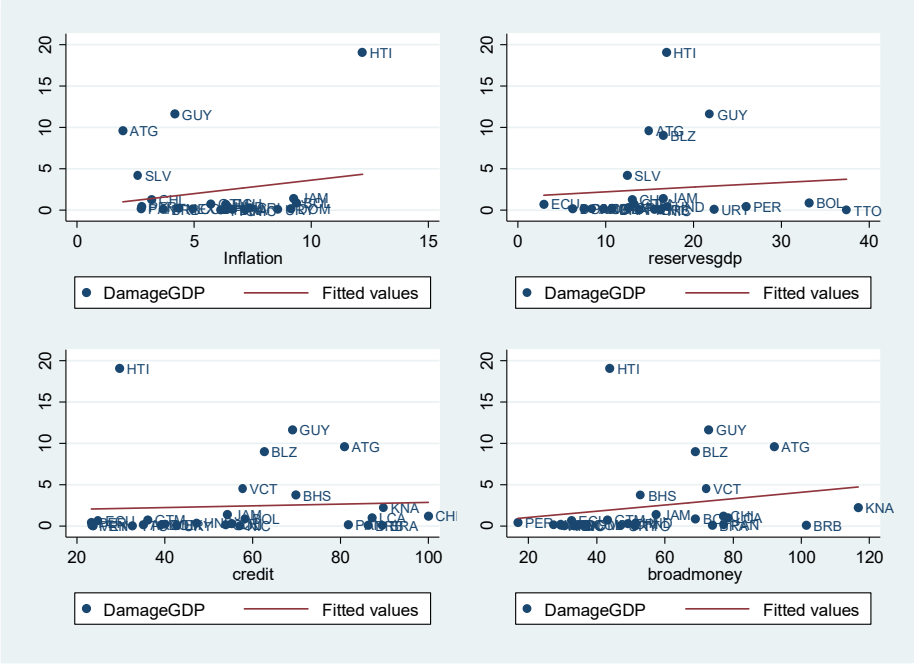
The same unclarity can be noticed when plotting public sector variables. While we can notice some positive relation between damage and the average of public debt within the 21st century, the revenue and ODA received are not impacted by damage caused through natural disasters.

Figure 30: Damage (%GDP) x Public Sector Related Variables



Finally, Figure 31 shows plots from monetary policy related variables. It is interesting to notice that inflation displays a significant positive correlation with damage, but the relation is not clear on the graph. The other variables also don't allow any early conclusion.

Figure 31: Damage (%GDP) x Monetary Policy Related Variables



5. Monetary Policy and Natural Disasters in Latin America: Empirical Evidence

Countries in Latin America have been adopting inflation targeting system and floating exchanging rate after its crisis in the 80s. In this chapter we seek to evaluate the absorptive capacities of monetary mechanisms when interacting with a natural disaster; previous literature found that inflation target and floating exchanging rate contributes to a quicker recover after disasters, however Latin American countries have political and financing constraints that may lead to different results even if these frameworks are adopted. In this sense, this investigation aims to understand if inflation target and floating exchange rate helps or hinders the absorption of spillover effects after natural disasters on economic growth.

The next section describes the data used followed by methodology description, results and limitation of the model.

5.1 Data

As expressed in chapter 2, the data on natural disasters is collected in the EM-DAT database; it is held by the Research on the Epidemiology of Disasters (CRED) and it contains essential core data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to the present day.

The variable characterizing a disaster in the model is Estimated Damage. Following Noy (2009) and Parikoglou (2016) methodology, we weight the estimated damage according to its onset month; a disaster happening on January is more likely to impact the current year GDP growth than a disaster happening in November or December. Therefore, our disaster measure is calculated as the equation below where DM stands for the estimated damage and OM stands for onset month:

$$DMS = DM(OM - 12)/12$$

In a second step the variable is treated as a share of the GDP registered in the previous year, as the result of same year GDP might be contaminated by disaster effects.

Due to lack of data, not all Latin American countries could be included in the sample. The model counts with 27 countries with data comprehending the period of 1970-2017. All countries are listed in the table below.

Table 5: List of Countries used in the analysis

Argentina	Dominican Republic	Panama
Bahamas	Ecuador	Paraguay
Barbados	El Salvador	Peru
Belize	Guatemala	Suriname
Bolivia	Guyana	Trinidad and Tobago
Brazil	Haiti	Uruguay
Chile	Honduras	Venezuela
Colombia	Jamaica	
Costa Rica	Mexico	
Dominica	Nicaragua	

Two dummies were created to capture the monetary framework adopted by countries: i) dummy for countries adopting inflation targeting system, ii) dummy for countries with a floating exchange rate regime. Countries were flagged as an inflation target adopter in the year of adoption; 9 countries in Latin America were identified inside this framework[9]. This information was taken from the Annual Report on Exchange Arrangements and Exchange Restrictions (IMF, 2018).

The floating exchange rate dummy was created based on Ilzetzki, Reinhart and Rogoff (2017) work, which creates a new measure of foreign exchange restrictions with more than 194 countries. Based on their score, countries were aggrouped in the two distinct categories: floating (assuming the value of 1) or fixed exchange rate arrangement (assuming the value of 2). The arrangements change along the period, and so does the dummy.

[9] Brazil (1999), Chile (1999), Colombia (1999), Guatemala (2005), Mexico (2001), Peru (2002), Paraguay (2011) and Uruguay (2007).

The control variables used in previous studies assessing impacts of natural disasters on growth were also included. Table 6 lists all variables inside the model and its sources, while the correlation matrix can be found on Annex I.

Table 6: Data Sources

Variable	Definition	Source
DAMGDP	Damage caused by Disaster (% GDP)	EM-DAT and WB
D_INFTAR	Dummy for Inflation Target	IMF
D_EXCFLO	Dummy for Floating Exchange Rate Arrangement	Ilzetzki et al (2016)
POPDEN	Population density (people per sq. km of land area)	WB
URBPOP	Urban population (% of total)	WB
GOVEXP	General government final consumption expenditure (% of GDP)	WB
INFCPI	Inflation, consumer prices (annual %)	WB
CAPFOR	Gross capital formation (% of GDP)	WB
IMPGDP	Imports of goods and services (% of GDP)	WB
EXPGDP	Exports of goods and services (% of GDP)	WB
CURACC	Current account balance (% of GDP)	WB
REER	Real effective exchange rate index (2010 = 100)	WB
CREPRI	Domestic credit to private sector (% of GDP)	WB
BROMON	Broad money (% of GDP)	WB
POL4	Political Regime	Polity IV Project

5.2 Methodology

Our main goal is to identify the direction in which direction inflation target and floating exchange rate contributes to GDP growth when interacting with a natural disasters. For this purpose, we create two

different models: one considering inflation target (Equation 1) and another one considering floating exchange rate (Equation 2):

$$(1)\ y_{i,t} = \alpha_{i,t} + \beta DMS_{i,t} + \theta IT_{i,t} + \rho DMS_{i,t}IT_{i,t} + \gamma X'_{i,t} + \varepsilon_{i,t}$$

$$(2)\ y_{i,t} = \alpha_{i,t} + \beta DMS_{i,t} + \theta FLO_{i,t} + \rho DMS_{i,t}FLO_{i,t} + \gamma X'_{i,t} + \varepsilon_{i,t}$$

On equation 1 we have that $y_{i,t}$ stands for the annual GDP growth rate in the country *i* and time *t*, $DMS_{i,t}$ the damage measure weighted by period and as share of last year GDP, $IT_{i,t}$ the inflation targeting flag for the corresponding year, $DMS_{i,t}IT_{i,t}$ the interaction variable between the damage measure and inflation target and X'_i holding for the traditional control variables in short-term growth.

Equation number 2 follow the same logic but considering floating exchange rate ($FLO_{i,t}$) and its interaction term with natural disaster ($DMS_{i,t}FLO_{i,t}$). The interaction variables seek to measure if in external shock case the monetary framework is relevant for GDP growth. Our main variable of interest in both equations is the interaction term.

The model is estimated with random effects; this means that we assume that the explanatory variables are exogenous with respect to the error terms. The two-way error component model is used in this estimation, so we assume that there are factors that affects growth that are specific for each country and time. Additionally, by adopting random effects we assume that there is no general tendency for countries with high/low volume of estimated damage to have a large individual specific effect. The choice of using random effects is based on Hausmann Test, and it is in line with Songwathana (2017) findings that the random effect specification is more appropriate for capturing these interrelationships between natural disaster loss and economic development, since the specification considers both country and time characteristics.

Divisions were created in the samples in order to create more homogenous groups. We first split the sample in subregions, such as Central America and South America – results for the Caribbean were not

possible to obtain as the data availability is poor. Another cut was made by countries classified as High Income or High-Middle Income according to the World Bank.

Central Bank credibility is also a very important factor for monetary policy; if a Central Bank is not totally independent or does not comply with inflation target level it might be signal that monetary mechanisms are often subject of political discretion, and therefore not efficient to stabilize the economy in an external shock event. To check if results are different in countries with more reliable Central Banks in Latin America, we test countries with lower levels of irregular turnover when compared to OECD countries.

Another cut made on the sample concerns the stability of governments. We consider countries with moderate government stability[10] according to the ICRG methodology. The last cut in sample stands for countries with higher HDI level when compared to the region's level. A summary with the countries included in each sample can be found on Annex II.

5.3 Results

We split the results in two, as we have two different models; the first subsection describe results for inflation target and the second describe results obtained with the model considering floating exchange rate. The results bellow shows the response of the (log) GDP growth and were estimated with random effects.

5.3.1 Results for Inflation Target model

General results considering all the control variables are shown on the first column of table 7. In general, for Latin American countries, the model points to a significant negative impact of inflation target on growth in a natural disaster event (see interaction variable *DAMGDP*IT*). On the other hand, the interaction variable presents a positive impact for Central American countries (column 2). In South America (column 3) none of the variables of interest appears as significant.

[10] According to the ICRG methodology, a country in the 60%-70% range of total score can be considered as offering "moderating risk". See more in ICRG Methodology (PRS Group, 2001).

Table 7: Regressions General and Regional - Inflation Target

Variable	(1) General	(2) Central America	(3) South America
DAMGDP	0.081*	1.651***	0.357
D_INFTAR	-0.271	-0.491	-0.145
DAMGDP*IT	-0.107**	1.623**	-0.413
POPDEN	0.000	0.145***	-0.002
URBPOP	0.002	-0.085	0.022**
GOVEXP	0.020	-0.584***	0.093
INFCPI	-0.002***	-0.005	-0.002***
CAPFOR	0.031	0.482***	0.025
IMPGDP	0.017	-0.051	-0.043
EXPGDP	-0.020	0.049	0.049
CURACC	0.046	0.050	0.041
REER	0.000	0.031***	0.005
CREPRI	0.007	-0.008	0.007
BROMON	-0.007	0.035***	-0.023
POL4	0.045*	-0.105	0.070
_cons	0.009	-8.577	-2.413
Obs	83	24	47
R^2	0.36	0.84	0.51

Note: The table reports the change in log(GDP growth) resulting from natural disasters and inflation target framework and control variables. ***, **, * indicate the significant level at 1, 5 and 10%, respectively.

Table 8 brings the results for the other cuts in sample. For countries with lower levels of irregular turnover inside Central Bank (column 1) the interaction variable between damage measure and inflation target appears with a positive sign. This indicates that countries with independent central banks and adopting inflation target may recover growth after a natural disaster faster than other countries. This result is in line with the findings pointed in previous studies where better results for GDP growth and interest rate reaction were reported in developed countries; developed countries are usually associated as more committed to inflation target and monetary policy (Noy, 2009; Fratzscher, et al., 2017; Parikoglou, 2016).

Results goes in the opposite direction in countries with moderate government stability in Latin America (column 2). One possible explanation is that stable government not necessarily translates into independent and committed Central Banks inside the region. Other possibility is that inflation target is not the framework more adequate to the analyzed countries; there are evidence that monetary policy under inflation target reacts in a procyclical way enhancing a negative impact on growth (Libânio, 2010). However, the solution for the mismatching issue between inflation target and the its achievement in

developing countries is not abolishing inflation target, but strengthening institution; it should be highlighted that even the countries with more stable governments in Latin America still unstable when comparing to governments in developed countries – lower stability is translated in higher country risk on investors perception. The risk perception is crucial when facing a negative external shock (such as a natural disaster) as it may limit countries in getting financial means to cope and, ultimately, it may result in procyclical policies. In this scenario, monetary policy mechanisms are not of much help as it can't revert the impact by its own.

High and Higher-Middle income countries also display a significant negative impact in the interaction term. For countries with better score in Human Development Index, disasters and monetary policy are not significant in this model.

Table 8: Regressions for Qualitative Samples - Inflation Target

Variable	(1) Central Bank Turnover	(2) Government Stability	(3) HDI	(4) High Income Countries
DAMGDP	-1.453*	0.04	0.468	0.083
D_INFTAR	-0.525***	-0.843***	-0.454	-0.200
DAMGDP*IT	1.280***	-0.045**	-0.495	-0.110**
POPDEN	-0.229***	0.002	-0.012	0.000
URBPOP	0.202**	-0.005	0.009	0.003
GOVEXP	-0.059***	0.019	0.065	0.012
INFCPI	-0.043***	-0.041***	-0.002***	-0.002***
CAPFOR	0.100	0.033	0.02	0.032
IMPGDP	0.055	-0.073	-0.019	0.018
EXPGDP	0.192**	0.054	0.029	-0.024
CURACC	-0.018	-0.022	-0.012	0.012
REER	0.006	-0.007	0.006	-0.001
CREPRI	-0.024***	-0.006	0.005	0.010
BROMON	0.000	0.011	-0.016	-0.012*
POL4	-0.234***	-0.031	0.069	0.056**
_cons	-7.884	2.771***	-1.193	0.276
Obs	23	44	46	73
R^2	0.93	0.47	0.44	0.36

Note: The table reports the change in log(GDP growth) resulting from natural disasters and inflation target framework and control variables. ***, **, * indicate the significant level at 1, 5 and 10%, respectively.

5.3.2 Results for floating exchange rate arrangement

On table 9, the results found to the general model including all control variables and with no sample-cut (column 1) shows a negative impact on growth coming from the interaction between floating exchange rate and damage measure. As highlighted previously, no country in Latin America presents a freely floating exchange rate; the region is marked by intermediate exchange rate regimes and this factor may limit the ability of the mechanism to absorb the impact caused by a natural disaster.

If in one hand, the intermediate regime limits the impact absorption in case of an external exogenous shock, the model suggest that this type of monetary framework may have a positive effect in growth when not interacting with the disaster variable in South America. One possible explanation for this result can be the propensity of these countries to be often target of speculators, which requires more control on exchange rate in order not to fall in monetary crisis, however, this arrangement it still not exhibiting significant effects when interacting with the disaster measure, indicating it is not efficient for adjustments when dealing with external shock.

Table 9: Regressions General and Regional – Floating Exchange Rate

Variable	(1) General	(2) Central America	(3) South America
DAMGDP	0.077**	4.075	0.312
D_EXCFLO	0.038	-1.32	0.741**
DAMGDP*EXCFLO	-0.103***	-0.547	-0.368
POPDEN	0.000	0.147***	-0.022*
URBPOP	-0.001	-0.026	0.021*
GOVEXP	0.019	-0.687***	0.087
INFCPI	-0.002***	0.002	-0.001***
CAPFOR	0.024	0.673**	-0.007
IMPGDP	0.017	-0.161	0.007
EXPGDP	-0.019	0.159	-0.005
CURACC	0.043	-0.067	0.104
REER	0.002	0.037***	0.013**
CREPRI	0.007	-0.032	0.01
BROMON	-0.008	0.053***	-0.028
POL4	0.037	0.042	0.038
_cons	0.344	-17.393	-1.874
N	83	24	47
R^2	0.34	0.86	0.55

Note: The table reports the change in log(GDP growth) resulting from natural disasters and inflation target framework and control variables. ***, **, * indicate the significant level at 1, 5 and 10%, respectively.

For countries hosting central banks with low irregular turnover, the exchange rate also seems to be a significant positive contributor to GDP, at least when not interacting with a natural disaster. This result may bring more robustness to the previous explanation; more reliable central bank in Latin America may be efficient in defending their currency and preventing eventual attacks to affect growth, but the positive effect vanishes when disaster is present. For High and High-Middle Income countries in the region we again find a significant negative effect of exchange rate framework on GDP in a natural disaster event.

Table 10: Regressions for Qualitative Samples - Floating Exchange Rate

Variable	(1) Central Bank Turnover	(2) Government Stability	(3) HDI	(4) High Income Countries
DAMGDP	-3.156	0.026	0.238	0.080*
D_EXCFLO	0.630***	-0.829***	-0.170	0.122
DAMGDP*EXCFLO	3.040	-0.050	-0.269	-0.104***
POPDEN	-0.193***	-0.001	-0.014*	0.000
URBPOP	0.087	-0.020*	0.009	0.000
GOVEXP	-0.102***	-0.013	0.072	0.012
INFCPI	-0.032***	-0.039***	-0.002***	-0.002***
CAPFOR	0.072***	0.046	0.029	0.023
IMPGDP	0.117***	-0.122**	-0.015	0.017
EXPGDP	0.107	0.114*	0.034	-0.021
CURACC	-0.011	-0.138	-0.05	0.000
REER	0.004	-0.018***	0.006	-0.001
CREPRI	0.003***	0.001	0.005	0.010
BROMON	-0.018**	-0.010	-0.020*	-0.014*
POL4	-0.265***	0.017	0.051	0.047*
_cons	-0.286	5.262***	-1.258	0.539
N	23	44	46	73
R^2	0.93	0.43	0.41	0.36

Note: The table reports the change in log(GDP growth) resulting from natural disasters and inflation target framework and control variables. ***, **, * indicate the significant level at 1, 5 and 10%, respectively.

5.4 General Results and Limitations

Previous studies found that inflation target and floating exchange rate enhance faster recovery of economy in case of natural disasters (Fratzscher, et al., 2017; Ramcharan, 2007)– mainly in developed countries. However, this might be not entirely true to Latin America. The model shows mixed results for

the smoothening capacity of inflation target and floating exchange rate on GDP – while we cannot make any robust conclusion, some remarks may be useful for further research in the field.

The inflation target system in Latin America is rather young and a very limited number of countries adopted it. Even for adopters, the lack of Central Bank total independence may limit the mechanism to function at its full potential. In the same direction, no country in Latin America can be classified as a freely floating exchange rate adopter, which seems to limit the absorptive capacity of the currency in an adjustment process. Interventions on exchange rate are not uncommon in Latin America, mainly because the region is target for speculations, as risk is higher due to political instability and volatility of economic factors.

Such frameworks combined with lack of resources to cope with shocks and the additional risk the natural disasters represent to already unstable economies may enhance pro-cyclical policies influencing negatively the economic growth. This does not necessarily mean that inflation target and floating exchange rate are not suitable to control spillover effects of natural disasters in economic growth in Latin America; but it does encourage us to think that the way these mechanisms are managed in the region may not be ideal for dealing with exogenous shocks.

If it is true that climate change will increase the number and intensity of natural disasters, policies to strength macroeconomic resilience is crucial to avoid further underdevelopment in Latin America. It is therefore recommended that Central Banks implement monitoring mechanisms and encourages research on the topic to understand how monetary framework can contribute to maintain stability when dealing with natural disasters and how the institution can contribute to avoid spillover effects not only in economic growth but mainly in livelihoods.

5.4.1 Limitations

The first limitation of this empirical analysis presents is the lack of counterfactual model which allows us to compare and measure more precisely the magnitude of positive/negative impact of inflation

target and floating exchange rate in a disaster event in the complete absence of this frameworks. Another important limitation incurred in the present analysis and also other papers on the economics of natural disasters (Noy, 2009; Parikoglou, 2016) is the exogeneity assumption; we consider the disaster measures to be exogenous as until the present moment no appropriate instrument uncorrelated with any economic indicator is available as public source.

Another factor that limits the model is the choice to use one model for inflation target and another model for floating exchange rate which may create omitted variable bias as we miss the nature of exchange rate regime.

As each type of disaster may affect particular sectors of economy, further research on how monetary policy absorb shocks in macroeconomy factors considering single kinds of disasters should complement the already existent research . Another important aspect and may be consider in the future is the linkage between natural disasters, monetary policy and food security; if not managed in credible and rigorous way, monetary policy may fail in control prices putting people at risk of food insecurity due to limited resources to cope with shocks.

Conclusions

In this analysis, the inflation target and floating exchange rate was invistiaged to measure if these frameworks helps or hinders the absorption of spillover effects after natural disasters on economic growth. 27 countries were analyzed in the period between 1970 and 2017. Results obtained are mixed; generaly, we found a negative or not significant impact of inflation target and floating exchange rate when interacting with disaster damage measure. One possible explanation for these results is that even in the event of Central Banks adopting inflation target and floating exchange rate, the monetary authority indepence required by these mechanisms to work properly is not observed.

The last hypothesis is confirmed by countries which presents irregular Central Bank governor turnover similar/lower to the average of OECD countries, for these countries we find that the inflation target is a positive factor for GDP growth on a natural disaster in Latin America. It is essential to note that in the oposite direction of previous findings, inflation targets are negative for countries classified with moderate government stability and high/higher-middle income. This raises the possibility that neither more stable governments nor higher income level translates into improved monetary policy framework or central bank reliability/compliance in Latin America.

Floating exchange rate framework displays a negative effect when associated to natural disasters for high/higher-middle income countries. While the exchange rate in Latin American countries does not follow freely-floating arrangements, intermediary regimes with fluctuations bands are more common. Eventhough there is evidence that intermediary exchange rate regimes are actually better for developing countries (Kan, 2007), this kind of arrangement also open space for speculation since a natural disaster event correlates to less investment and less available capital for reconstruction, which inevitably negatively impacts economic activity.

Enough evidence in previous studies points to a linkage between the inflation target and the floating exchange rate with better economic outcomes in a natural disaster occasion for advanced economies. This is due to central banks quick response to changes in inflation even through unpopular measures, resulting in an increase in the effectiveness of monetary policy, stability in investments, and improvement in economic adjustmenets through the external sector to be reported (Noy, 2009; Fratzscher, et al., 2017; Parikoglou, 2016). However, Latin America is mainly composed by middle-income countries and, even for countries that showhigher development levels, challenges regarding institutional integrity, high debt level and partial democracies remain present.

Building resilience and coping mechanisms are often mentioned as authorities approach quality policies to mitigate effects of natural disasters. In this context, in order to build resilience and strenghthen policies to diminish the impact of natural disasters on the macroeconomy and a populations' livelihood, Central Banks should be aware of its responsibilities in maintaining macroeconomic stability in the event of an exogenous shock. For these purpose three policies are suggested: i) to strenghthen research on natural disasters to understand the linkages between each type of event and monetary policy mechanisms in an individual country's context, ii) guarantee full independence to Central Banks and, iii) implement hard inflation target regime by enlarging fluctuation bands for exchange rate in order for these mechanisms to gain absorptive capacities in case of exogenous shocks.

Macroeconomic factors are often little or not approached in disaster risk reduction frameworks due to its complexity and unclear linkages. However, by building more resilient and prepared macro policies – including the monetary pillar – it is possible to mitigate spillover effects reducing damages not only in economic growth but in human life and development.

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Annex I: Correlation Matrix

	GDPGROWTH	DAMGDP	D_INFTAR	D_EXCFLO	DAM*IT	DAMGDP *EXCFLO	POPDEN	URBPOP	GOVEXP	INFCPI	CAPFOR	IMPGDP	EXPGDP	CURACC	REER	CREPRI	BROMON	POL4
GDPGROWTH	1.0000																	
DAMGDP	-0.1712*	1.0000																
D_INFTAR	0.0585	-0.0659	1.0000															
D_EXCFLO	0.0521	-0.0505	0.4890*	1.0000														
DAM*IT	0.0046	0.1579*	0.2256*	0.1185	1.0000													
DAMGDP*EXCFLO	-0.0552	0.3640*	0.0514	0.2247*	0.5043*	1.0000												
POPDEN	-0.1619*	0.0624	-0.1012*	-0.1959*	-0.0304	0.0720	1.0000											
URBPOP	-0.0069	-0.0928	0.3421*	0.2707*	0.0956	-0.0382	-0.3816*	1.0000										
GOVEXP	-0.3066*	0.2086*	0.0107	-0.1326*	-0.0230	0.0377	0.0657	-0.1531*	1.0000									
INFCPI	-0.2090*	-0.0362	-0.0536	-0.0400	-0.0175	-0.0215	-0.0839	0.0488	-0.0423	1.0000								
CAPFOR	0.2292*	0.0303	-0.0905	-0.0938	-0.0064	-0.0078	-0.1452*	-0.0370	0.0918	-0.0761	1.0000							
IMPGDP	0.0092	0.2491*	-0.1931*	-0.3466*	-0.0116	0.0318	-0.2049	-0.4846*	0.3833*	-0.1482*	0.4353*	1.0000						
EXPGDP	0.0638	0.1984*	-0.1428*	-0.2810*	0.0290	0.0308	0.0911	-0.3436*	0.3201*	-0.1310*	0.3771*	0.8991*	1.0000					
CURACC	0.0908	-0.0186	0.1269*	0.1418*	0.0573	0.0651	0.0661	0.2569*	-0.3569*	-0.0307	-0.2460*	-0.4468*	-0.2058*	1.0000				
REER	-0.2585*	0.0240	-0.0835	-0.1085	-0.0016	0.0138	-0.1105	-0.2484*	0.4728*	0.2743*	0.1379	0.1247	0.0761	-0.3794*	1.0000			
CREPRI	-0.0582	0.1067	0.1590*	-0.0136	0.2237*	0.0879	0.0521	0.2213*	0.2393*	-0.0208	0.1637*	0.2871*	0.3298*	-0.0658	-0.1045	1.0000		
BROMON	-0.2199*	0.2934*	0.0934	-0.0932	0.1081	0.0429	0.2374*	-0.0220	0.5124*	-0.0716	0.1143*	0.4951*	0.4490*	-0.2059*	0.2408*	0.6457*	1.0000	
POL4	0.0183	0.0177	0.2496*	0.0537	0.0756	0.0316	0.1357*	0.3139*	0.0430	0.0468	-0.0162	0.1045	0.1352*	0.1968*	-0.3978*	0.2379*	0.2326*	1.000

Note: Legend for each variable can be found on table 6. * indicate the significant level at 5%

Annex II: Countries Included in Samples

General	Central America	South America	Central Bank Turnover	Government Stability	HDI	High Income Countries
Argentina	Belize	Argentina	Mexico	Bahamas	Argentina	Argentina
Bahamas	Costa Rica	Bolivia	Belize	Chile	Bahamas	Bahamas
Barbados	El Salvador	Brazil	Barbados	Colombia	Barbados	Barbados
Belize	Guatemala	Chile	Honduras	Dominican Republic	Brazil	Belize
Bolivia	Honduras	Colombia	Trinidad and Tobago	Jamaica	Chile	Brazil
Brazil	Mexico	Ecuador	Colombia	Mexico	Costa Rica	Chile
Chile	Nicaragua	Paraguay	Argentina	Trinidad and Tobago	Mexico	Colombia
Colombia	Panama	Peru		Uruguay	Panama	Costa Rica
Costa Rica		Uruguay			Trinidad and Tobago	Dominica
Dominica		Venezuela			Uruguay	Dominican Republic
Dominican Republic					Venezuela	Ecuador
Ecuador						Guatemala
El Salvador						Guyana
Guatemala						Jamaica
Guyana						Mexico
Haiti						Panama
Honduras						Paraguay
Jamaica						Peru
Mexico						Suriname
Nicaragua						Trinidad and Tobago
Panama						Uruguay
Paraguay						Venezuela
Peru						
Suriname						
Trinidad and Tobago						
Uruguay						
Venezuela						