BANCO CENTRAL DE COSTA RICA

Macroeconomic Effects of El Niño in Costa Rica

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Conference on Climate Change and its Impact in the Financial System
CEMLA
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Effects of climate change on the actions of the BCCR

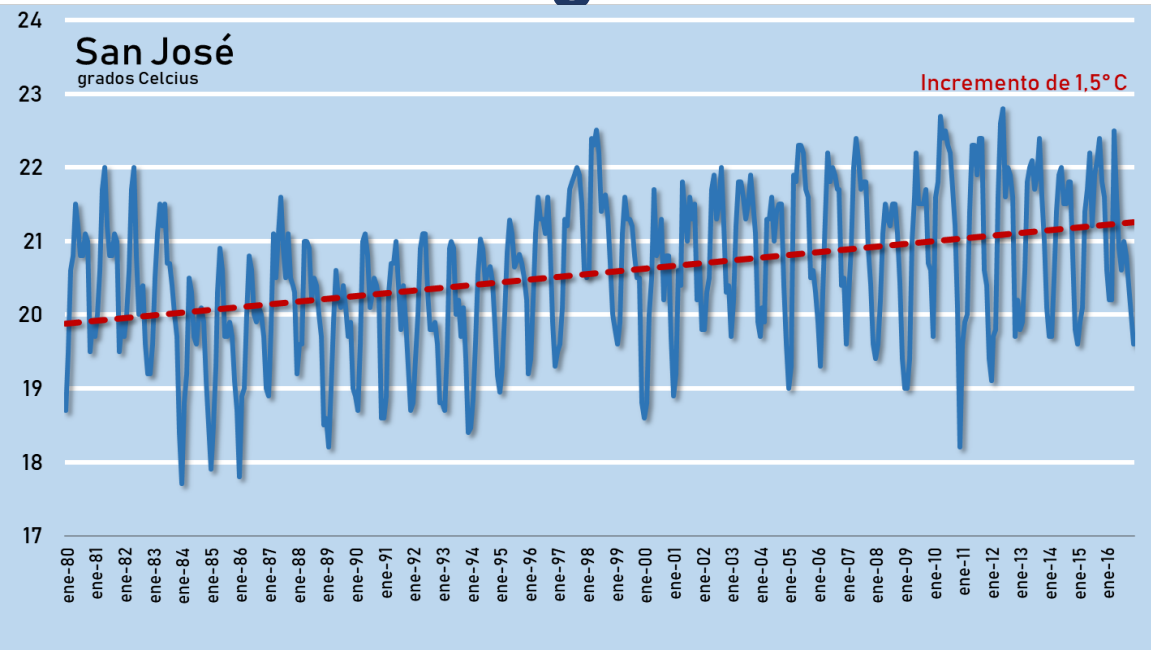
- Climate change affects, in the short and medium term, the fulfillment of the following strategic objectives:

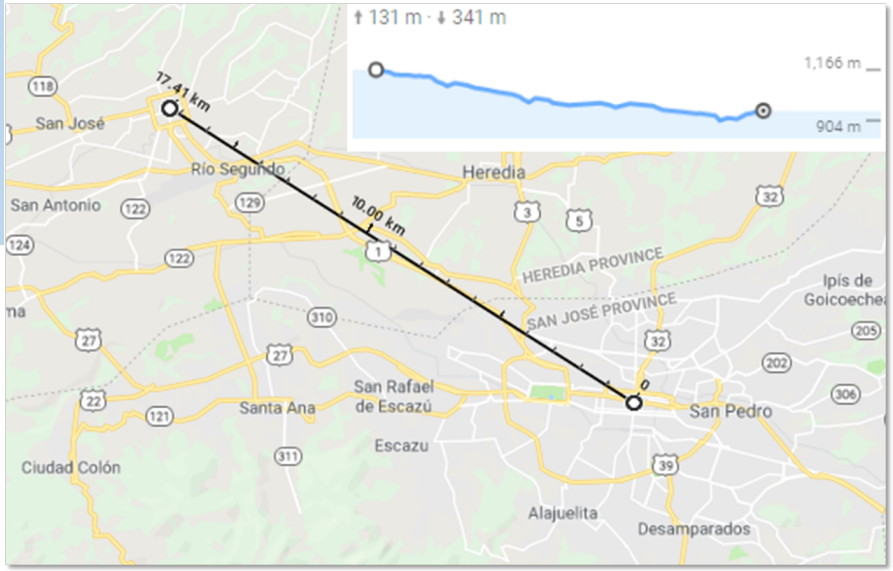
Objective 1	• Ensure that inflation falls within the target range.
Objective 3	• Promote a stable, efficient and competitive financial system.

- Mitigators that can reduce residual levels significantly are outside the scope of the BCCR.

- Climate change is transversal in the BCCR: it does not belong to a single agency.

Climate change in Costa Rica





1. Introduction

- This document explores the effects of the weather phenomenon known as El Niño Southern Oscillation (ENSO) on the evolution of prices and production in Costa Rica.

- The results obtained in this work prove that the climatic oscillation of El Niño has an effect on both prices and national production.

- The results allow a discussion of the climatic effects and their policy implications in the case of the national economy.

2. What is El Niño?

- The El Niño phenomenon is a climate cycle that has its origin in the Pacific Ocean, but has an impact on global weather patterns. The cycle begins when warmer waters located in the western part of the Pacific Ocean near Ecuador move eastward towards the coast of South America.

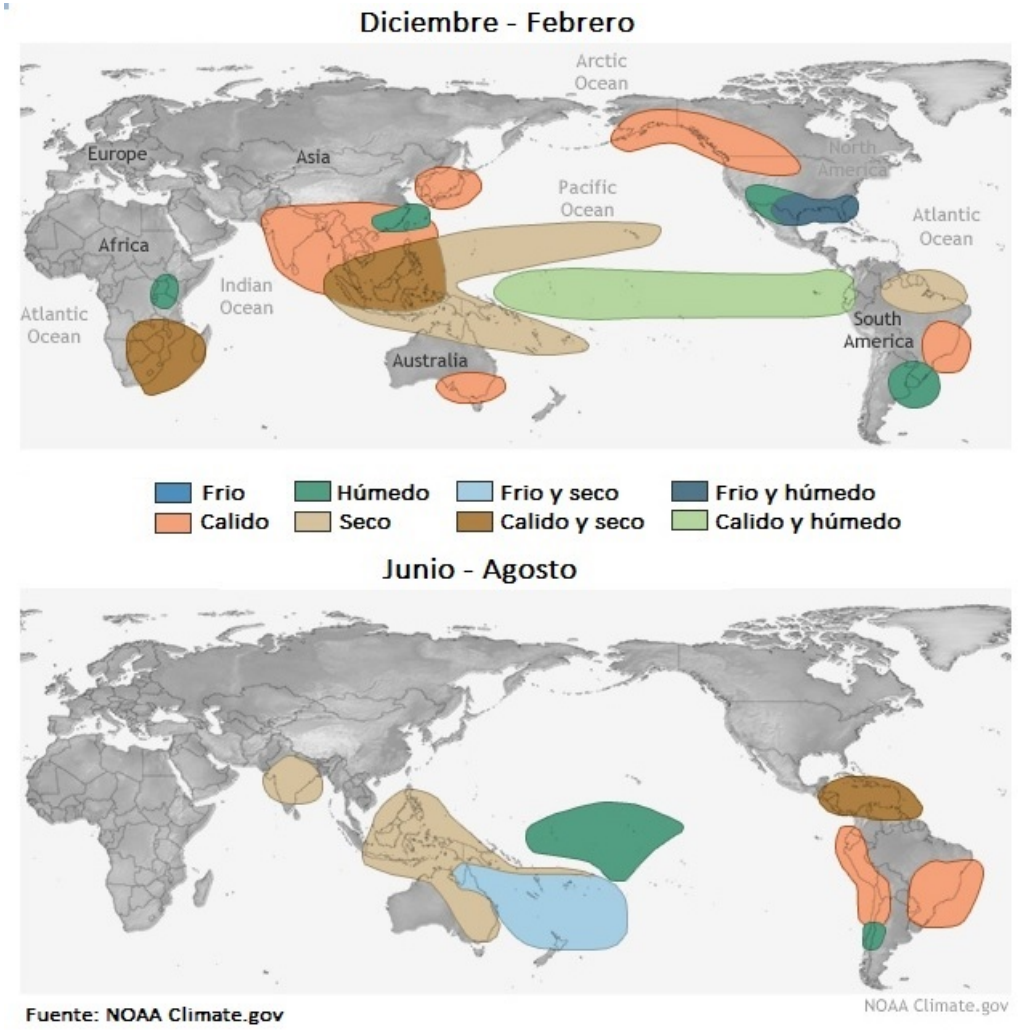
- There is the opposite phenomenon which is called La Niña. This refers to periods in which the eastern surface of the Pacific Ocean is colder than normal. Typically.

- El Niño and La Niña as a whole are part of an oscillation in the ocean and atmosphere called El Niño Oscilación del Sur (ENSO).

2. What is El Niño?

- The particular characteristics of its repercussions differ greatly from one episode to another, even in the case of similar variations and patterns in the Pacific Ocean.

- The effects on agriculture will depend decisively on the date on which El Niño occurs and the agricultural calendar of a given region

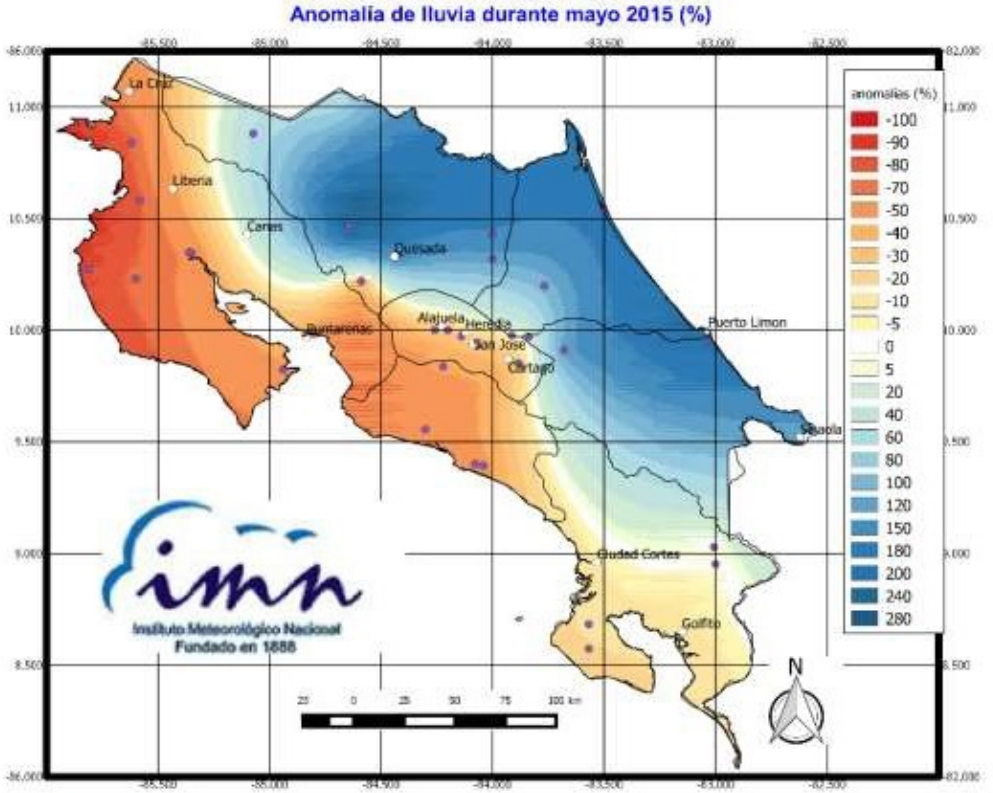


3. El Niño in Costa Rica

- There are well-defined effects: the Pacific slope tends to show lower rainfall, while the Atlantic slope shows higher rainfall.

- The phenomenon of El Niño does not present a homogeneous shock on the climate, that is, there is no drought or excessive rainfall throughout the country.

- This complicates the analysis, since in both aspects productive processes are carried out, both agricultural and livestock, fishing, tourism and hydroelectric production.



Fuente: IMN

4. How is El Niño measured?

- The internationally accepted measurement for El Niño comes from the “El Niño-Southern Oscillation” Index or ENSO. According to ENSO, the El Niño phenomenon occurs when the index values exceed the value of one, while the La Niña phenomenon is present when the values are less than less than one.

- There are several indicators to measure and monitor the ENSO. ONI (Ocean Niño Index), is the most common indicator, which is based on the surface temperature of the ocean. SOI (Southern Oscillation Index), measures the difference between atmospheric pressure at sea level in Tahiti and Darwin.

4. How is El Niño measured?

MEI (Multivariate ENSO Index), is based on observable variables in the tropical zone of the Pacific Ocean. These are:

(i) atmospheric pressure at sea level.

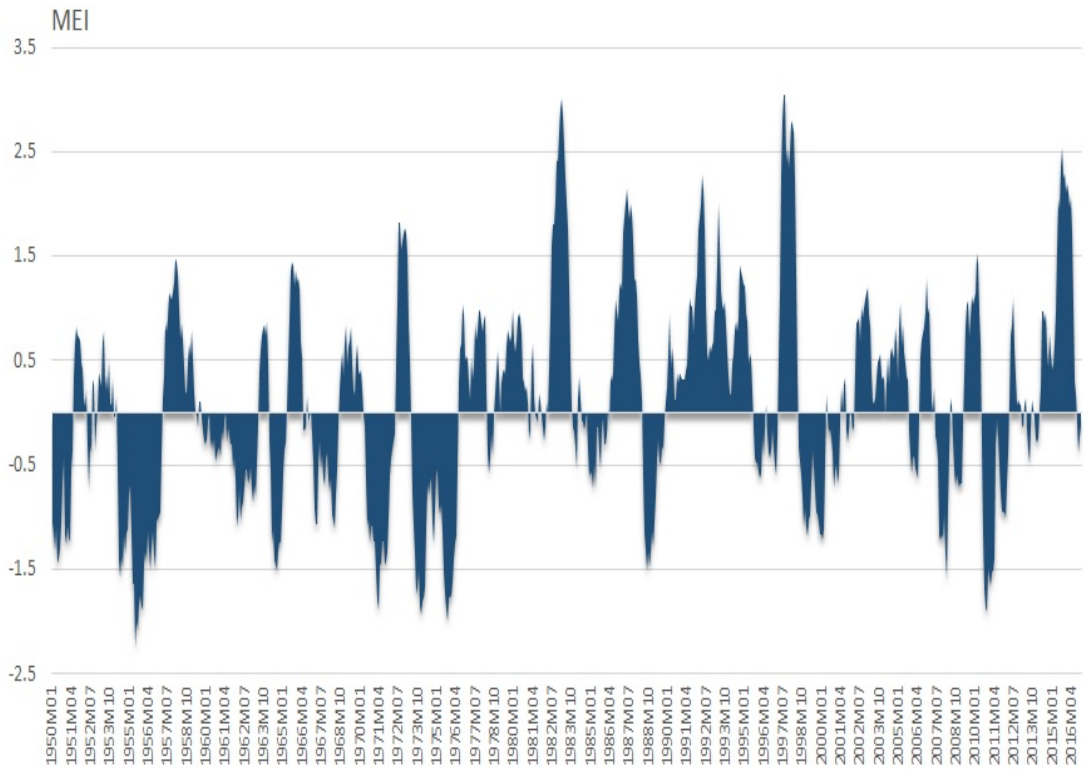
(ii) wind direction.

(iii) temperature on the surface of the ocean.

(iv) surface air temperature and

(v) cloudiness.

The MEI is calculated as the main component of all the combined observations.



5. Economic effects of El Niño

- The main economic impact of El Niño is on the agricultural sector. However, it should not be ruled out that fluctuations impact other economic sectors directly and indirectly.

- Among the most affected sectors, is the fishery because the change in ocean temperatures causes fish to migrate to other regions of the ocean.

- The energy sector is also affected, as El Niño is associated with warmer winters in the northern hemisphere, which reduces fossil fuel prices. On the other hand, countries dependent on hydroelectric power are affected by changes in rainfall patterns.

5. Economic effects of El Niño

- Funk et al. (2008), and Battisti and Naylor (2009) analyze the effects of fluctuations on agricultural production and thereby affect the food security of developing countries. In turn, these climate shocks on supply have consequences on the prices of commodities and food (Brunner 2002, Chen et al. 2008).

- Adams et al. (1999) show that extreme ENSO events generate losses in United States agriculture. They especially find that La Niña has a stronger impact than El Niño. Hsiang and Meng (2015) show that El Niño has a negative and statistically significant effect on agricultural production, yield and added value for a panel of tropical economies.

- Oduber and Ridderstaat (2016) find a relationship between climatic fluctuations with El Niño in tourism demand patterns by the United States, the Netherlands and Venezuela for Aruba.

5. Economic effects of El Niño

- Laosuthi and Selover (2007) studied the effects of El Niño in twenty-two countries and found that the effects on GDP growth and the Consumer Price Index are generally small, but these vary considerably between countries. The authors find that since El Niño has a redistributive effect on rainfall, it has both negative and positive effects on the economy. Therefore, the net effect is small.

- This result is especially true for diversified economies with large geographic areas. So small countries with little economic diversification and agriculture-dependent economies are the most affected by El Niño.

6. Theoretical model

- The effects and their magnitudes depend on the reaction that agents have in the presence of El Niño, modeled as a climate shock.
- In order for the model to be treatable and especially highlight the effect of a climate shock, the model is static for a closed economy, with two representative sectors and agents.
- The agents of the economy have a function of utility of elasticity of constant substitution (CES) given by the equation and with aversion relative to the constant risk (CRRA).

$$U(c_t) = \frac{c_t^{1-\rho}}{1-\rho} \qquad c_t = \left[\gamma^{\frac{1}{\theta}} c_{a,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} c_{n,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

6. Theoretical model

- Firms produce agricultural and non-agricultural goods in a market of monopolistic competition in each sector. There are two types of inputs: labor and capital. Both inputs are not specialized by sector.

- The production function for non-agricultural enterprises is Cobb-Douglas.

$$y_{n,t} = A_{n,t} k_{n,t}^{1-\alpha_n} l_{n,t}^{\alpha_n}$$

6. Theoretical model

- On the other hand, the production function of agricultural entrepreneurs differs in that their production depends on the weather conditions (η), and has the following functional form:

$$y_{a,t} = A_{a,t} k_{a,t}^{1-\alpha_a} l_{a,t}^{\alpha_a} e^{-\phi(\eta_t^2 - \epsilon)}$$

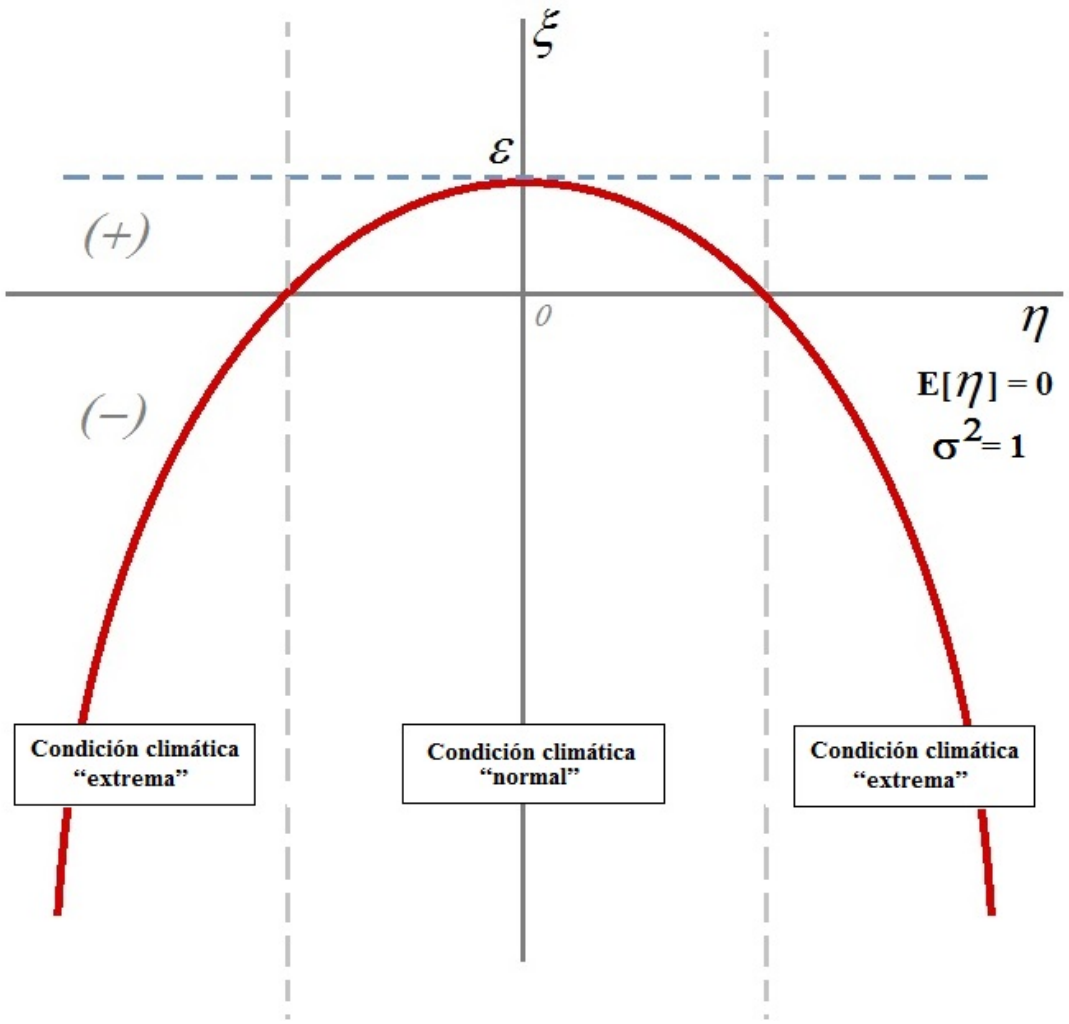
  - The function is constituted by η which is the standard deviation of the climatic conditions with respect to its average.
  - The parameter η is squared because both positive and negative deviations from typical climatic conditions will have a negative effect on production
  - The coefficient ϵ represents the breaking point where climatic conditions become adverse, ϵ is different from zero since it is assumed that agricultural products can tolerate a certain level of climatic fluctuation without this having negative effects on their productivity. Finally, parameter φ directly quantifies the effect of the average climate deviations in the region on productivity.

6. Theoretical model

- Climate shock can be defined as:

$$\xi_t = -\phi(\eta_t^2 - \epsilon)$$

Graphing ξ_t as a function of η_t it is possible to distinguish that normal conditions (ϵ, 0) have positive effects on agricultural production.



6. Theoretical model

- Solving the model it is obtained that the prices of the agricultural sector depend on the effect of the climatic shocks (ξ_t).

$$p_{a,t} = \frac{\theta}{1-\theta}\frac{1-\alpha_a}{\alpha_a} w_t \left(\alpha_a A_{a,t} k_{a,t}^{1-\alpha_a} l_{a,t}^{\alpha_a - 1} e^{-\phi(\eta_t^2 - \epsilon)}\right)^{-1}$$

- By log-linearizing the price function of the agricultural sector:

$$\hat{p}_{a,t} = \hat{w}_t - \hat{A}_{a,t} - (1-\alpha_a)\hat{\kappa}_{a,t} + \phi(\eta_t^2 - \epsilon)$$

- The price level of the economy is given by:

$$\hat{p}_t = \gamma \hat{p}_{a,t} + (1-\gamma)\hat{p}_{n,t}$$

6. Theoretical model

- Under the assumption that the salary is the same for both sectors and if the supply of inputs is perfectly elastic, companies have no reason to change the composition of the use of inputs.

- If the assumption that productivity shocks are identical in both sectors is also used, a simplified equation is obtained:

$$\hat{p}_t = \hat{w}_t - \hat{A}_t + \gamma\phi(\eta_t^2 - \epsilon)$$

6. Theoretical model

- In balance the demand and production of each one of the sectors must be equal, in turn the total production must be equal to the sum of the production / demand of the two sectors.
- Using the assumptions of the previous filmina the production is:

$$y_t = \left[1 + \frac{\gamma}{1-\gamma}\left(\frac{p_{n,t}}{p_{a,t}}\right)^{-\theta}\right] y_{a,t} = A_{a,t} k_{a,t}^{1-\alpha_a} l_{a,t}^{\alpha_a} e^{-\phi(\eta_t^2 - \epsilon)}$$

- Log-linearizing:

$$\hat{y}_t = \theta(\hat{p}_{a,t} - \hat{p}_{n,t}) + \hat{A}_t - \phi(\eta_t^2 - \epsilon)$$

7. Results

- ENSO effect on Inflation

Variable	coef.	t-stad.	coef.	t-stad.	coef.	t-stad.	coef.	t-stad.
c	0.083	10.5	0.039	3.9	0.061	7.0	0.062	6.8
π^*_{t-7}	1.070	6.5	1.104	6.7	1.069	6.5	1.155	6.7
$\dot{e}_{t-3}$	0.289	19.2	0.293	19.4	0.289	19.1	0.289	18.5
$\hat{y}_{t-15}$	0.628	2.9	0.606	2.8	0.629	2.9	0.481	2.2
ξ	0.023	9.4						
$niño$			0.058	9.2				
$niño^2$					0.023	9.3		
$niño_d$							0.081	7.6
$niña$			0.049	4.2				
$niña^2$					0.023	2.8		
$niña_d$							0.035	2.2
d	-0.066	-6.0	-0.065	-5.9	-0.066	-6.0	-0.063	-5.6
$R^2 Ajust.$	0.68		0.68		0.68		0.66	

Fuente: Elaboración propia.

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Fuente: Elaboración propia.

7. Results

- Cross effect of ENSO on Inflation

Variable	coef.	t-stad.	coef.	t-stad.
c	0.084	13.47	0.081	13.38
π^*_{t-7}	0.805	6.12	0.629	6.46
$\dot{e}_{t-3}$	0.296	25.03	0.242	26.67
$\hat{y}_{t-15}$	0.291	1.72	0.269	2.15
ξ	-0.011	-4.03		
$\xi * \overline{\pi}$	0.131	12.16		
$\xi * \hat{y}$	0.368	3.11		
$niño$			-0.038	-7.87
$niño * \overline{\pi}$			0.361	24.64
$niño * \hat{y}$			1.074	6.89
$niña$			-0.028	-2.13
$niña * \overline{\pi}$			0.364	3.82
$niña * \hat{y}$			-0.245	-0.48
d	-0.055	-6.33	-0.033	-4.72
$R^2 Ajust.$	0.80		0.89	

Fuente: Elaboración propia.

7. Results

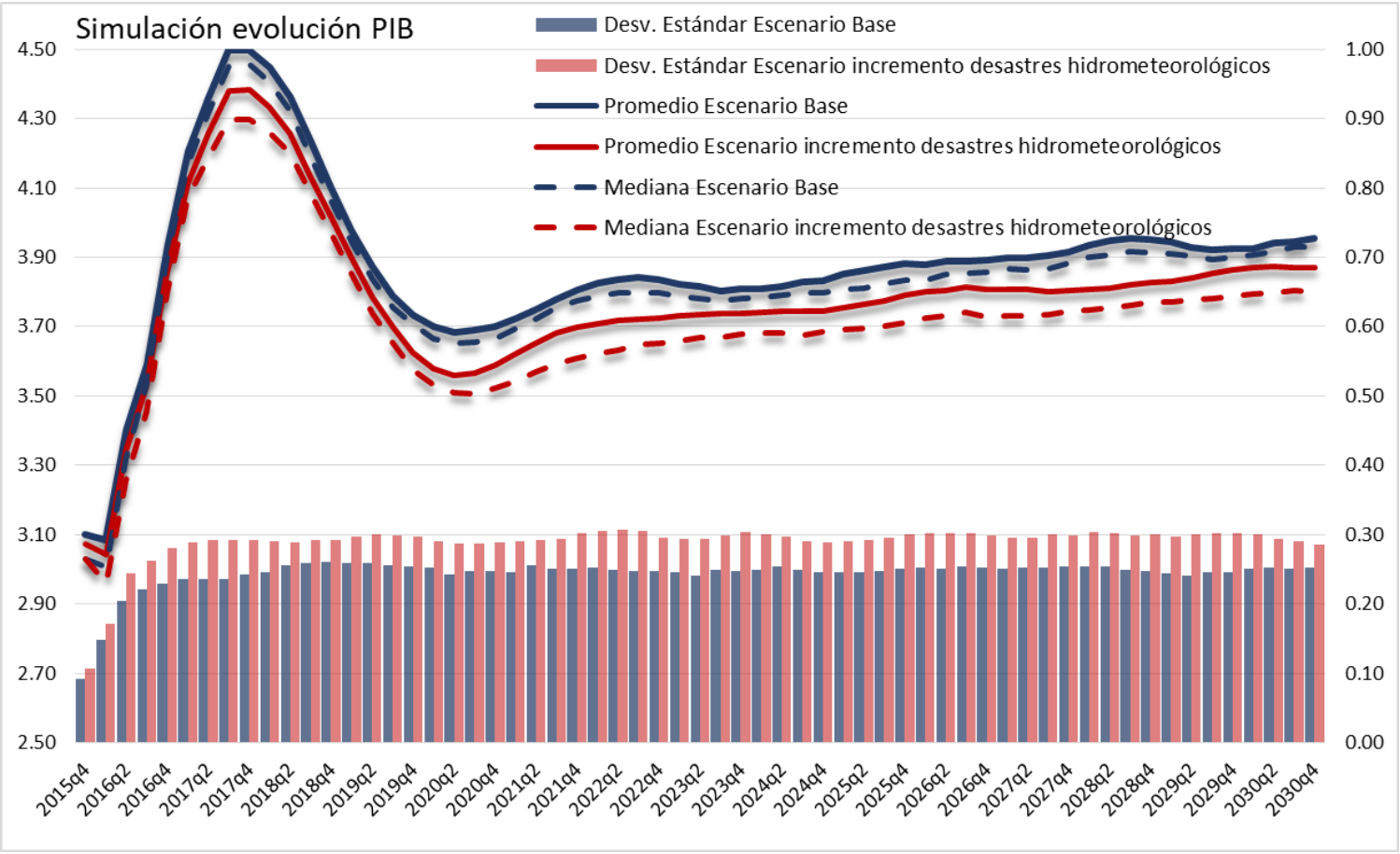
- ENSO effect on output gap

Variable	coef.	t-stad.	coef.	t-stad.	coef.	t-stad.	coef.	t-stad.
c	0.000	-0.2	0.001	1.0	0.001	1.1	0.000	0.3
$\hat{y}^*$	0.738	7.0	0.770	7.0	0.726	6.7	0.765	7.0
ξ	-0.001	-2.6						
$niño$			-0.002	-1.5				
$niño^2$					-0.001	-2.7		
$niño_d$							-0.003	-1.3
$niña$			-0.002	-0.8				
$niña^2$					-0.001	-0.3		
$niña_d$							0.001	0.3
$R^2 Ajust.$	0.13		0.12		0.13		0.12	

Fuente: Elaboración propia.

7. Results

Growth simulation



8. Conclusions

- The climatic shock shows a positive effect in all its specifications, and it is also statistically significant.

- El Niño has a marginally greater inflationary effect than La Niña, but both phenomena are inflationary. This confirms the theory that a negative shock on the products affected by the climate has affected the inflationary dynamics of the country.

- The intensity of the ENSO fluctuations approximated by the quadratic specification has an impact on inflation.

8. Conclusions

- The inclusion of cross effects suggests that the effect on inflation of ENSO fluctuations is increased by high levels of inflation, that is, in high inflation states, increases in costs due to climate changes are more easily transferred to The prices of these products, in turn, may have an effect on inflation expectations, which will cause this price increase to be transmitted via expectations at other prices within the consumption basket.

- El Niño and La Niña will be more inflationary if the economy is growing above its potential. From a monetary policy point of view, this suggests that in an overheated economy with high inflation, climate effects will have a greater impact on inflation.

8. Conclusions

- From a central bank perspective, the effects on the prices of the El Niño phenomenon must be observed as a climate shock of supply, so a restrictive monetary policy would only reduce production more, while an expansive monetary policy would increase prices without necessarily Increase production

- The contribution of a central bank to mitigate the effects would be to maintain low and stable inflation that allows agents to react to changes in relative prices, and at the same time does not allow these shocks to feed higher inflation expectations in the medium term.

- The central government in charge of carrying out infrastructure investment policies that reduce the effects of these climatic fluctuations.

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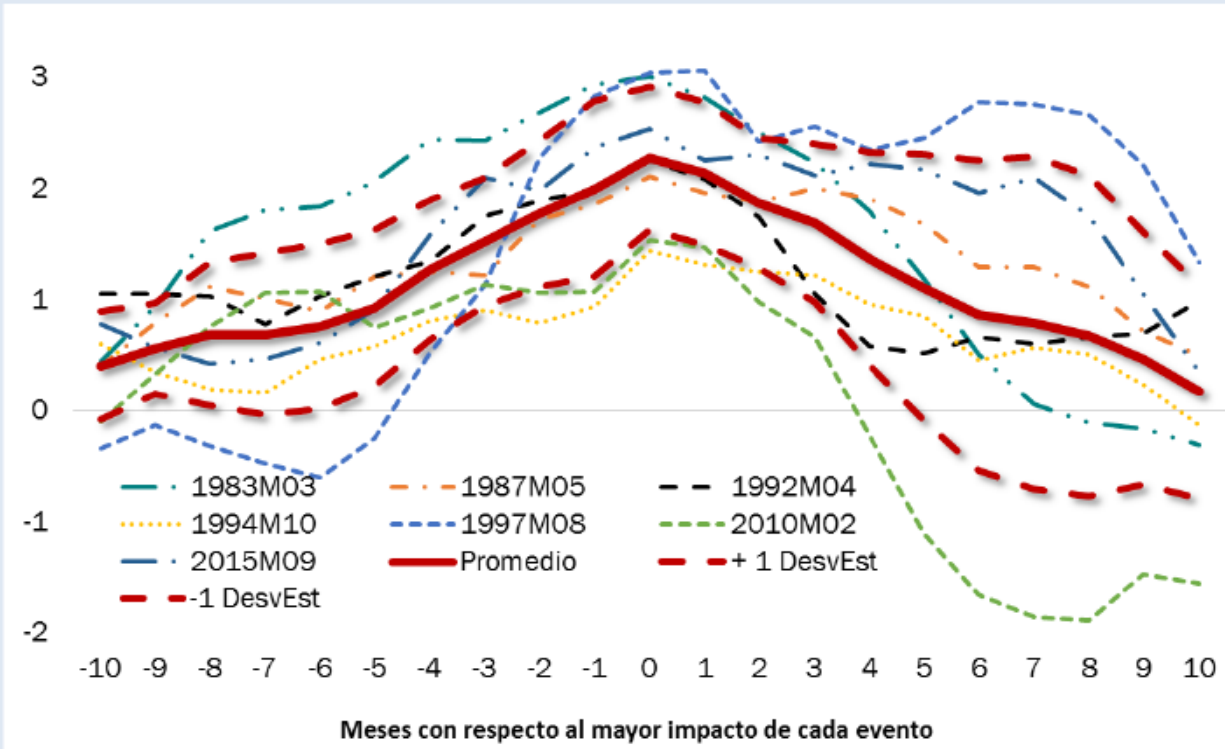
Recuadro 3. Estimación del impacto sobre la inflación del fenómeno El Niño Oscilación Sur (ENOS)

Informe de inflación
Diciembre 2018

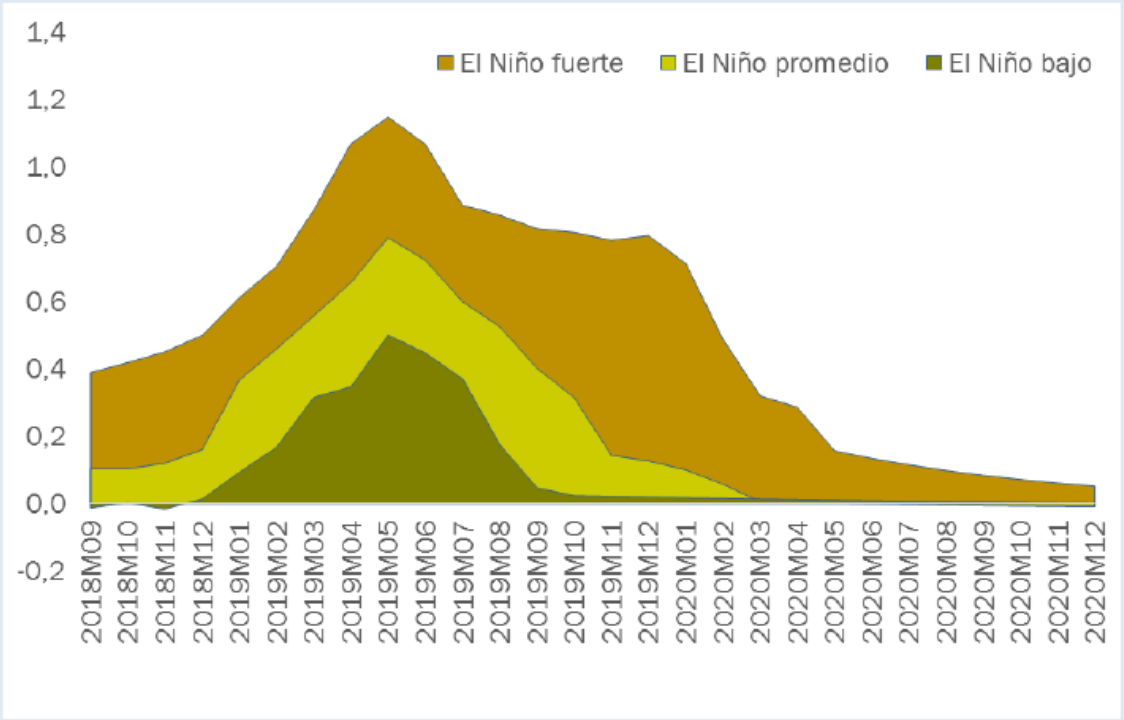
Gráfico 3.1. Eventos de El Niño en el periodo 1980-2015: Índice ENOS multivariado



Recuadro 3. Estimación del impacto sobre la inflación del fenómeno El Niño Oscilación Sur (ENOS)

Informe de inflación
Diciembre 2018

Gráfico 3.2. Proyección del efecto de ENOS sobre la inflación en el periodo 2018-2020
-en puntos porcentuales-



Fuente: Banco Central de Costa Rica.