Climate change impact on America´s native grains production

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Introduction

Climatic change will increase temperature and rainfall variability, with the consequent increase in extreme weather events. In response, economic research has quantified the possible impacts of climate change on society.

Indeed, a growing body of country-level studies has confirmed that changes in precipitation patterns and warmer temperatures have negative impacts on agriculture, with most severe losses occurring in Africa, Latin America and India.

Methods and estimations

A semi-Ricardian approach using farmland net revenues as reflect of net productivity has been proposed.

An alternative strategy to estimate the impact of climate change is through panel data methods (fixed or random effects) to control for unobserved determinants of agricultural productivity (soil quality, farmers ability).

The impact of climate change on maize yields is then estimated from the predicted weather parameters and predicted changes in climate. Linear precipitation and temperature increase yields, but their squares (extreme temperature and rainfall) decrease yields. In quinoa´s yields case, there is only one production season, and rainfall and temperature decrease

Such estimations overstate the impact of climate change on stunting because households can mitigate the consequences of climate change migrating to more amenable municipalities or move across sectors within the same municipality.

Consider a production function for an average farmer (rural household) as follows: Yieldcrop = f (Tmt, Pmt, G, L, K), where T and P represent temperature and precipitation, respectively, G stands for inputs largely immutable such as geographical characteristics and soil type, L represents an input that can vary in the short run, which we shall call labor for concreteness, and K represents capital, an input that can only vary in the long run, and m represents our core unit of analysis – the municipalities. The farmer, taking prices, rain and temperature as given, solves the following program:

$$max\,Yielcrop = f(Tmt, Pmt, K, L, G)\,subject\ to\ c(m1, \ldots, mn)xm \in R \qquad (1)$$

Total costs c(.) are a function of maize produced, which in turn depends on weather, w, because precipitation and temperature affect yields directly [2, 29]. Solving this optimization problem would let us know for a given level of temperature and precipitation, soil and prices, the combination of labor and agricultural inputs chosen by the farmer that maximizes its corn or quinoa yield. Also, changes in agricultural productivity affect rural income in our simplified model and, consequently, food security.

Without full adaptation in the short-run, the impact of weather shocks on maize and quinoa yields in a regression framework becomes nonlinear; Other plausible determinants of agricultural yields such as soil quality and municipal location need to be included to avoid misattributing the impacts of climate shocks on yields.

Overall, we assess the historic effects of temperature and rainfall (and their projections due to climate change) on rain fed maize yields (in Mexico). We propose the following econometric model to estimate variations in yield for municipality (county) m at year t.

$$yield(w, hm, t) = \int_{h}^{\bar{h}} g(\phi w_{mt})\,\phi_{mt}(h)dw + \delta z_{mt} + c_m + \varepsilon_{mt} \qquad (2)$$

In equation 2 our dependent variable are average yields per hectare. Yield estimates were constructed as follows.

$$yield(w, m, t) = {}^{\pi_{xmt}}/_{H_{xmt}} \qquad (3)$$

Where π_{xmt} is total production (in tons) of production x in county m at year t and H are rainfed maize and quinoa hectares initially sowed.

Equation 2 g(w) represents cropping growth, which depends on climatic variables w (temperature, precipitation) and f_{mt} (w) is the average of rainfall for each growing season in municipality m and year t, and δ the behavior regarding production costs. The matrix z_{mt} includes average temperature and technologies employed (seed type, manual or mechanical rooter, and fertilizers and agrochemicals used) in municipality m and year t. The term cm represents municipal characteristics (i.e., soil type, latitude, longitude, and height above sea level).

Overall, the regression includes climatic, geographic and economic variables affecting maize productivity. As part of the geographic variables, we include location coordinates (latitude, longitude, altitude) and soil quality. For the economic variables influencing agricultural productivity we consider costs; and the climatic variables comprise linear and quadratic terms for seasonal precipitation and temperature means.

Given a mean model, μm, with variance structure, Vm, the estimating equation is formed as follows

$$U(\beta) = \sum_{m=1}^{N} \frac{\partial \mu_{mj}}{\partial \beta_k} V_m^{-1}\{Y_m - \mu_m(\beta)\} \qquad (4)$$

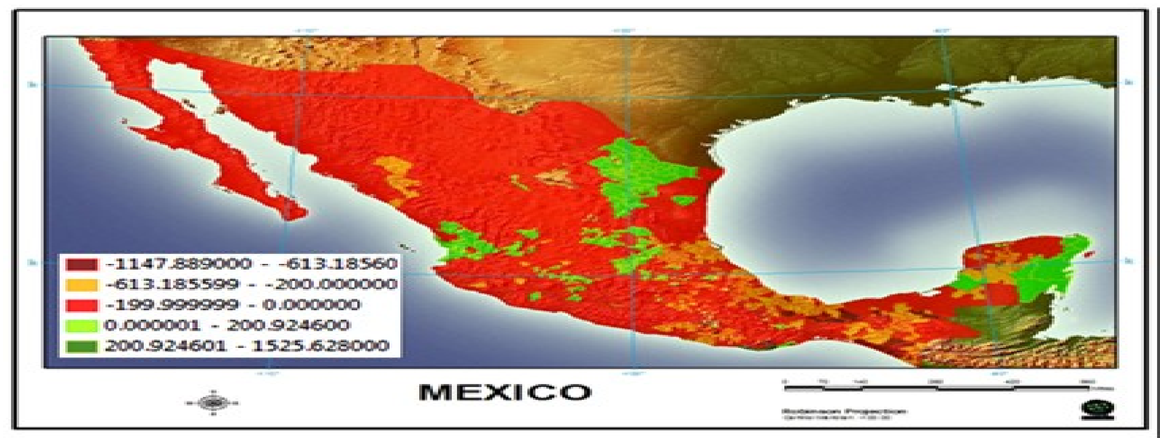
The parameter estimates B solve U(β)=0 and are typically obtained via the Newton-Raphson algorithm. The model chooses the variance structure (V) to improve efficiency. To correct for correlation, the variance matrix V changes by municipality, and minimizes the error {Ym-μm(B)} in equation 4. Once estimated the yield parameters, we obtain the economic impacts caused by climate change. Climate change modifies the mean and variance of rainfall and temperature. Various scenarios were finally constructed in terms of yields losses given decreases in rain and increases in temperature.

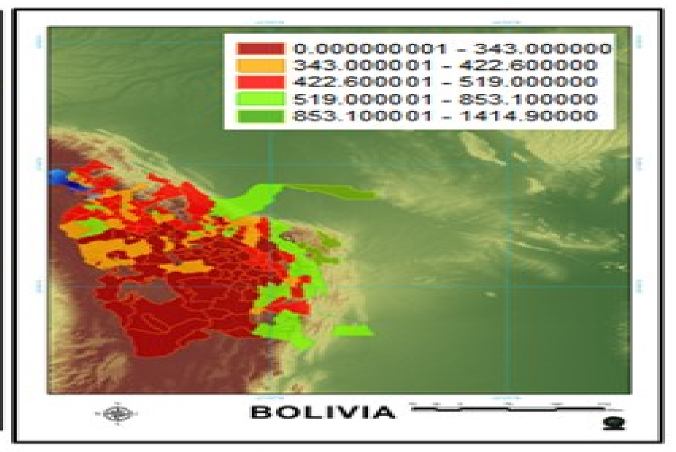
Results and Conclusion

As expected, linear precipitation and temperature increase yields, but their squares (extreme temperature and rainfall) decrease them. This confirms the existence of a non-linear relationship between temperature/rainfall and maize yields, where the lack of rain reduces agricultural productivity, as do heavy rains. This finding is consistent across specifications. According to our preferred specification, estimates show that a 1mm increase in precipitation raises gross productivity by 81 kilograms per hectare on average; and a 1 Celsius degree increase boosts productivity per hectare by 80 kilograms on average, in the maize case. The ensemble models predict increases in temperature and drops in precipitation.

Changes in precipitation

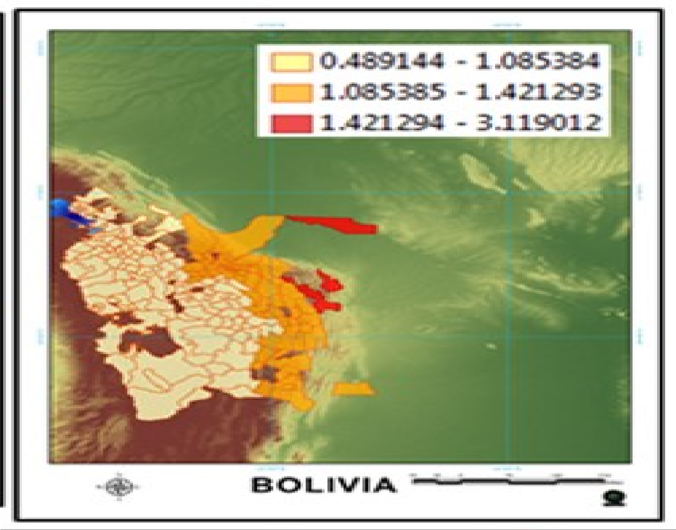
2005-2030





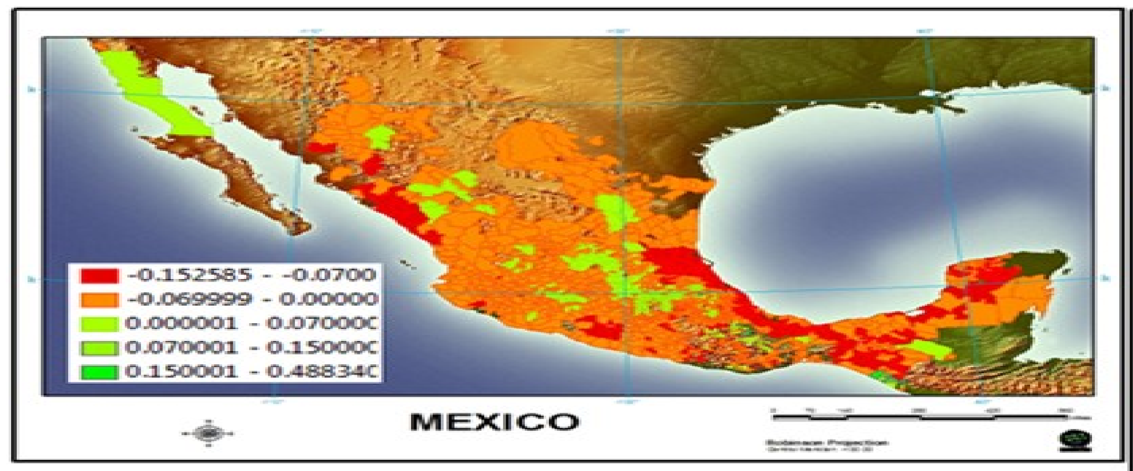
Changes in temperature

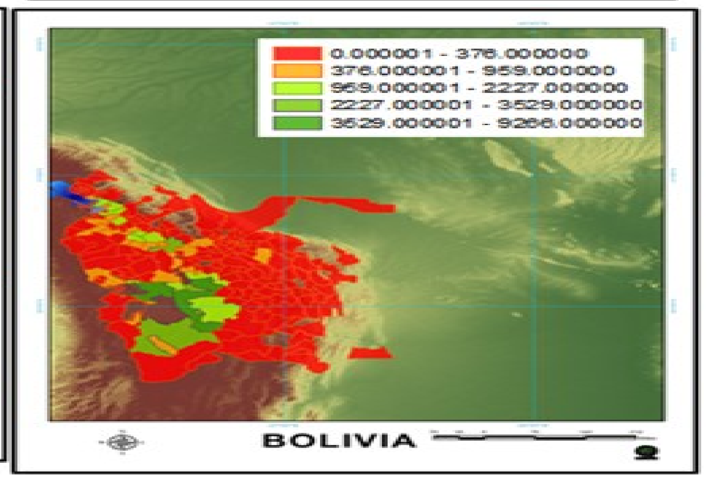
2005-2030



Percentage drop in maize yields

(tons per hectare) 2005-2030





As we can see, it's important for our future to develop more advanced and ecological techniques and knowledge to take advantage of these two grains production, optimizing its process and reducing the environmental impacts resulting from these activities, and also to create and apply more effective politic policies regarding farmers adaptation to help them to make the correct long-term decisions and face the impacts of climate change and it's also necessary to adapt to the future conditions.

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Poster design: Karolina Enriquez Ortiz 2018