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The impact of climate on farm inputs in developing countries agriculture

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RESUMEN

El éxito de la revolución verde ha propiciado que algunos analistas sugieran que ésta puede extenderse de manera generalizada a todos los agricultores pobres. Este trabajo sostiene que la presencia de condiciones naturales adecuadas es un prerrequisito importante para la agricultura de alto rendimiento. Al examinar las funciones de producción en China, se advierte que los resultados son altamente sensibles al clima. Por consiguiente, también las funciones de demanda de insumos son sensibles al clima. Los esfuerzos para intensificar la agricultura en regiones no desarrolladas deben centrarse en áreas con suelos y clima adecuados (en especial este último). Los resultados también sugieren que los agricultores modificarán parcialmente la intensidad de utilización de insumos para adaptarse al cambio climático.

ABSTRACT

The success of the green revolution has prompted some analysts to suggest it can be extended more broadly to all poor farmers. This paper argues that suitable natural endowments are an important precondition for high input farming. Examining production functions across China, we find that outcomes are very climate sensitive. It follows that we also find that input demand functions are climate sensitive. Efforts to intensify farming in undeveloped regions should focus on places with suitable soils and especially climate. The results also suggest that farmers will partially adapt to climate change by altering their input intensity.

Keywords: Adaptation, agriculture, climate change.

1. Introduction

In 1960, the yields per hectare of grains used to be quite similar in China and Africa. Currently, the yields in China are three times the yields in Africa. This is evident for both maize (Fig. 1) and rice (Fig. 2). This rapid growth in China and other Asian countries has been credited to the Green Revolution. Although the stimulus for this burst of productivity in Asia first came from advanced seed technology (hybrid varieties), the bulk of the increased production came from high intensity agriculture (Evenson and Gollin, 2003). The success of the green revolution in Asia has led to a call that it be used to help poor farmers around the world (World Bank, 2008).

This paper argues that the green revolution was dependent on favorable soils and climate. The regions in Asia that flourished from the green revolution had good natural endowments of soils and climates. The results suggest that high input agriculture would also work in other areas of the world with adequate natural endowments. However, many poor farmers live in places with inadequate soils and climate. In these places, high input agriculture cannot generate sufficient additional revenues to warrant the additional cost. Although some resource deficiencies

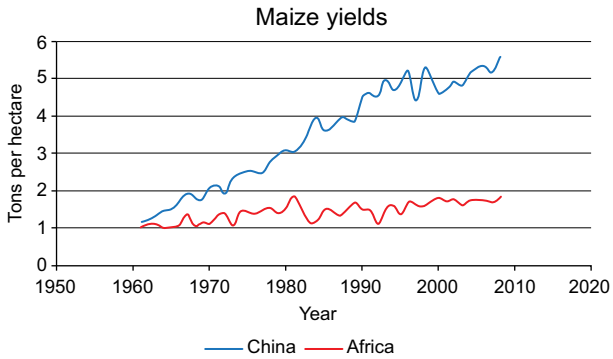

Fig. 1. Maize yields over time in China and Africa. Source: World Bank (2008).

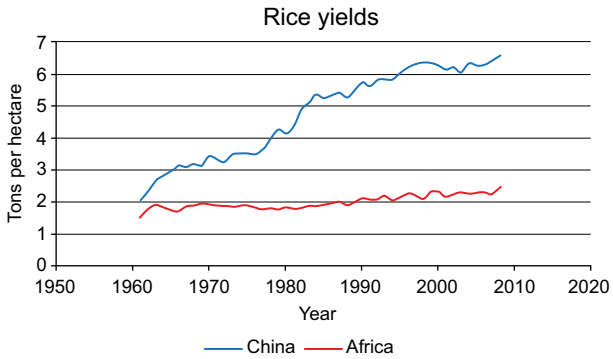

Fig. 2. Rice yields over time in China and Africa. Source: World Bank (2008).

can be readily overcome with more inputs, efforts to extend high input agriculture to low productivity sites will often be doomed to failure.

The paper begins with a theoretical model of a net revenue maximizing farmer. The paper argues that if climate and soils enter the production function for the farmer, they will also enter the input demand function. Clearly other constraints that would affect the production function would also affect the input demand function. We therefore test whether market access (Udry, 1995; Sachs et al., 2004; Goldstein and Udy, 2008) and knowledge also affect production. The intriguing prospect of these latter constraints is that policy could possibly free farmers from these limits.

We then conduct empirical analyses of Chinese agriculture. China is a good example of a country that benefited from the Green Revolution. We gather a sample of Chinese farmers from across the country to test whether climate, soil, market access, and knowledge played a role in the production functions for three products: rice, maize, and wheat. We find that climate and soils were very important to all three crops, even though the requirements for each crop were different. We then test whether the input demand function was also sensitive to climate and soils. We find that climate played an important role in the input demand functions as well. In fact, we find that these natural endowments played a larger role than both market access and knowledge in explaining outcomes across the country.

The results suggest that the Green Revolution was not equally beneficial to every farmer. Farmers with more suitable climate and soil conditions got a much larger productivity gain. These additional output gains made adding more inputs more profitable. As a result, farmers in more suitable climates were able to further intensify inputs. However, even in China, farmers with poor natural endowments tend to continue to rely on low input farming. There remain opportunities to intensify farming in undeveloped regions of the world. However, this opportunity is dependent on the underlying natural productivity of each region.

Finally, if the intensity of farm inputs is sensitive to climate, the results also have implications for climate change and adaptation. Climate change can alter the productivity of farmland. A great concern about climate change is that it might make large tracts of current farmland unproductive especially in low latitude semi-arid locations (IPCC, 2013). Farmers will likely change their input intensity in response to climate change. In places where climate makes land more productive, farmers should respond by adding more inputs. But in places where climate change makes land less productive, farmers may respond by adding even fewer inputs and thus causing yields to fall even further. Of course, if food becomes scarce globally, that will increase agricultural prices which will encourage more farm inputs globally.

2. Theory

We begin with a theoretical model to shed light on the link between climate and other constraints on the choice of input intensity in farming. The production function determines yield, Q, (output per hectare) given variable inputs chosen by the farmer (I) (technology, capital, labor, and fertilizer), exogenous factors to a farmer that are subject to government policy (X) (market access [roads] and knowledge), and natural endowments (Z) (climate and soils):