Revisiting the Historical Green Revolution: Impacts on Global Food Security

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I. Motivation and Research Questions

The historic rise in both crop production and yields over the past 50 years has been made possible by aggressive investments in agricultural research which led to the development of modern crop varieties. In turn, the adoption of these innovations opened the doors to the Green Revolution (GR) which contributed to around 20%-40% of the yield growth in developing regions over this historical period (Evenson, 2003).

Amongst the impacts of the Green revolution, its effect on food security is the most relevant but there is a lack of studies on quantifying the Green revolution’s role in improving nutritional outcomes. This study contributes to the literature and attempts to answer three key research questions:

- How much was the increase in average dietary energy consumption given the historical Green Revolution?
- With the GR, how many people avoided extreme caloric hunger?
- If a future African Green Revolution were to occur, what are its implications on food security outcomes?

II. Model and Methods (A)

Figure 1. The SIMPLE Model

We assess the food security impacts of both historical and future Green Revolutions at the global level using the Simplified International Model of Agricultural Prices, Land use and the Environment (SIMPLE). SIMPLE is a partial equilibrium economic model and as the name suggests, it is designed to be as parsimonious as possible.

The model has been demonstrated to faithfully reproduce long-run historic changes in crop production, cropland use and crop price at a global scale (Baldos & Hertel, 2013). More recently, SIMPLE has also been used in long-run food security analysis (Baldos & Hertel, 2014).

Consumer behavior

- Crop commodities are consumed directly as food and indirectly via the consumption livestock and processed foods.
- Demand response to income and food prices diminishes as per capita incomes grow.

Producer behavior

- Food sectors are defined for each region and are modelled using the Constant Elasticity of Substitution production framework.
- Crops are produced using aggregate land and non-land inputs.
- Crop and non-crop inputs are used in the livestock and the processed food sectors.

Further, the historical simulation includes a counterfactual simulation based on the Green Revolution (GR) and its impacts on food security.

III. Results and Conclusions

Historical Analysis (1961-2006): Baseline vs. no-Green Revolution

Figure 4. Increase in Average Caloric Consumption

Globally, the incidence of caloric malnutrition is lower by roughly 7% due to the Historical GR.

On average, Sub-Saharan Africa and South Asia experienced sharp reductions in the incidence of caloric malnutrition – by around 14% and 11%, respectively – given the productivity improvements from the historical Green Revolution. For China, the error bars suggest that it is uncertain whether the Historical GR led to the reduction of caloric malnutrition incidence in this region.

Without the Green Revolution, the average depth of caloric hunger would have been 13% higher compared to 2006 values.

The historical GR helped reduce the depth of caloric hunger – alleviating the intensity of hunger faced by malnourished persons – particularly in Sub-Saharan Africa, South Asia, Southeast Asia and China. These reductions are robust to parameter uncertainty.


Figure 8. Changes in Food Security Outcomes under an African Green Revolution

On average, we see improvements in food security outcomes both at the global level and for Sub-Saharan Africa. However, the impacts of a Future GR in Africa is quite sensitive to model parameters and shocks.

The impacts of a Future African Green Revolution on food security is ambiguous.

V. Model and Methods (B)

We employ the food security module developed by Baldos and Hertel (2014) and report not just changes in average dietary energy intake but also shifts in the caloric distribution within a region. The distribution of food calories is assumed to be log-normal following FAO (Neiiken, 2003).

We track the changes in three key metrics of food security:

- Caloric Malnutrition Incidence – the proportion of the population whose daily caloric consumption is less than the minimum caloric requirement
- Caloric Malnutrition Headcount – the number of people who are considered malnourished in terms of daily caloric consumption
- Depth of Caloric Malnutrition – reports the average daily caloric deficit faced by malnourished persons.

IV. Experimental Design

Figure 3. Coverage of the SIMPLE model

Historical Analysis (1961 to 2006)

We first simulate the baseline given the historical growth rates in population, per capita incomes and total factor productivity in the crop, livestock and processed food sectors.

A counter-factual scenario is then simulated by deducting the contribution of the Green Revolution to productivity growth through crop genetic improvements using estimates from Evenson (2003)

Future Projections (2006 to 2051)

Similar to the historical simulations, a future baseline is established given the future growth rates in population, per capita incomes, biofuel use and total factor productivity in the crop, livestock and processed food sectors.

An African Green Revolution scenario is then simulated using the historical estimates from Evenson (2003) as a guide.

References: