Climate Change, Food Production, and Welfare

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Background

The key objective of this paper is to trace the impacts of climate change on household welfare across different regions in the world. The paper examines the key interactions between temperature change and water scarcity and their impacts on yields in the context of a dynamic global economy. The paper aims to highlight the transmission mechanisms from climate change to households using a dynamic global computable general equilibrium model (Envisage).

A changing climate will change household welfare via different channels. Water scarcity and climate induced changes in crop yields will affect welfare by changing price of water, food prices, labor income, production costs, and trade patterns. When prices are rising, consumers with higher food share in total expenditure are more affected than those with lower food cost share. Labor wages are also affected as production revenue falls. The effects of climate change on water availability and crop yields are expected to be different across agricultural products and countries. Water requirements for crops are widely different across regions and crops. Some countries use more efficient technology for producing crops and use less water. In addition, changes in agricultural outputs will have indirect economy-wide impacts; change in price of agricultural products will affect prices and production in food industry and some manufacturing industries; change in labor demand in agriculture affects labor supply to other sectors; this will affect non-farm labor wages; due to change in prices and income, the optimum decision of farmers, produces, and consumer will change; the equilibrium price and quantity in labor market, capital market, and wide range of commodity markets will adjust accordingly. An accurate analysis needs to consider heterogeneity among regions, agricultural crops, and labor groups. Considering major general equilibrium impacts provides better insights of the consequences and it is more appropriate for policy recommendations.

Literature Review

Economic analysis of water scarcity has been improving over the past decade. IMPACT-WATER (IFPRI) is used for simulating world water and food to 2025 (Rosegrant et al. 2002); WATERSIM introduces integrated water and food analysis at the global and basin level (de Fraiture, 2007); IGSM-WRS is trying to model the global water resource system (Strzepek et al. 2010); IMAGE model, Integrated Model to Assess the Global Environment, consider water and temperature changes (Stehfest et al., 2014); and GTAP-BIO-W is used for analyzing the water availability and global land use change (Liu, et al. 2012 and Taheripour et al. 2013); It is also used for analyzing competition for land in the global bio-economy (Hertel et al. 2013). Interaction of climate change, crop yields, and water scarcity is also addressed in several studies (e.g. Willis et al., 2014 and Marshal et al. 2015, Taheripour et al. 2015). Our contribution to the literature will be to consider the dynamics of the impacts and decomposing their interactions. Our technical innovation will be using improved functional forms for land supply and households welfare introduced in Envisage (van der Mensbrugghe, 2015). We also consider some real world constraints on the supply of managed water. We assume a maximum level for irrigable land and exploitable water in each country. We also assume different supply elasticities of water for each region. Another important feature is introducing water demand for agricultural use, municipal use, and industrial use. Substitution of

water with land, capital, and fertilizer is considered. Several validation methods will be employed to assess the plausibility of the model.

Methods and Materials

This study will simulate the effects of climate change by employing Envisage, a dynamic global computable general equilibrium framework extended for water analysis. We will investigate how counterfactual scenarios of changes in crop yields and water resources affect different regions of the world. This study employs an improved dataset for water use and climate change. We will use the current estimates of changes in water and yields as it is done by climate scientists. Water shocks will be obtained from estimations of IWSRs (Irrigation Water Supply Reliability) between 2000 and 2030. This information will be obtained from the IMPACT-WATER model (Rosegrant et al., 2012). The changes in crops yields will be obtained from FAO GAEZ for high resolution grid cells. We will use GTAP 9 database as main inter-sectoral information. This database includes detailed energy and food industries, with rich information on production technology, interindustry relations, and international trade. It provides information on different crops and food commodities which is required for our analysis. It also provides sectoral labor information. We follow Taheripour et al., (2013) method to construct the database for 2011. Rain-fed and irrigated data is obtained from Siebert and Döll, (2010). This information will be matched to main database regions. Then we map information from river-basin-AEZ to national data.

Results

We expect to find regions in which climate change has severe negative impact on welfare and food production. This will help us to plan to reduce the vulnerability of people on those areas. Decomposing the changes in food production and welfare helps identifying which component part is more important. Then each region can decide to invest more on heat-tolerant crops or to preserve more water.

As an initial result, the following figure shows the impact of 20% decrease in water supply on outputs. The irrigated production declines while the rain fed production is substituted. The changes are bigger in the Middle East and in OECD America. (This scenario will be replaced with a more realistic scenario using estimates from climate scientists).

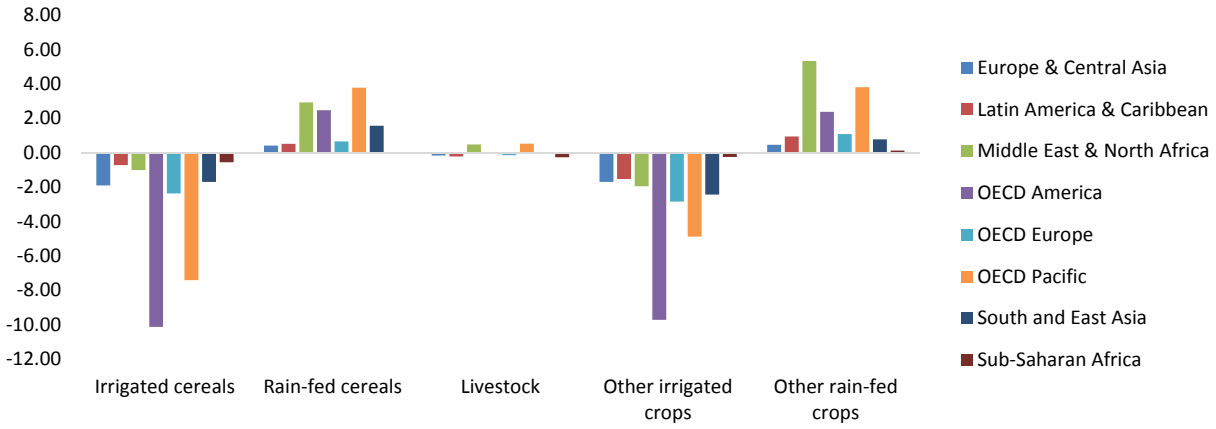

Figure 1: Percentage change in production of irrigated and rain fed crops by region (due to 20% decrease in water)

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