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Measuring household vulnerability to climate change—Why markets matter

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ABSTRACT

Climate change and climate variability affect households in developing countries both directly through their impact on crop yields and indirectly through their impact on wages, food prices and the livelihoods of the poor. Therefore, vulnerable household groups cannot be identified without considering their position in and access to markets. I illustrate the effects – transmitted through markets – that are significant in household exposure, sensitivity and adaptive capacity to climate change by simulating productivity shocks to maize up to 2030 due to climate change in a computable general equilibrium model of Malawi. The results show that rural households with large land holdings may benefit from the adverse impact of climate change on maize yields as a result of increased maize prices. Urban poor and small-scale farmers are vulnerable to climate change due to the large portion of their incomes spent on food. Existing vulnerability measures that do not consider equilibrium effects and characterise all farmers as vulnerable may therefore be misleading.

1. Introduction

It is important to identify households that will likely be vulnerable to future climate change in order to effectively target adaptation policies. With this motivation, several approaches for measuring vulnerability have been developed across disciplines (Adger, 2006). This paper shows that these approaches largely ignore the second-order effects of climate change that are transmitted through prices of goods produced and consumed by households and, in particular, the potentially large impact of climate change on households in developing countries through food prices. To illustrate the importance of the indirect effects of climate change on households, a computable general equilibrium model of Malawi is used to assess household vulnerability to climate change by 2030. The model contains a detailed disaggregation of households that captures their position in agricultural markets. The results show that some agricultural households can benefit from climate change due to higher food prices. However, the majority of rural poor in Malawi are net buyers of food and are vulnerable to the adverse impacts of climate change. These findings are contrary to results from studies using indicator approaches and the Ricardian approach. The results of this study are also important in the context of existing computable general equilibrium models that assess the impacts of climate change. These models have often been too aggregated to make the important distinction between net sellers and buyers among agricultural households. In line with previous studies using computable general equilibrium models, I find that the urban poor are the most vulnerable to climate change due to the large share of their expenditures allocated to food. I also illustrate the importance of taking into account the impact of climate change on global food prices when measuring vulnerability by showing how adverse impacts on households are amplified when the price of imported as well as domestically produced food increases.

The next section discusses the existing literature on measuring vulnerability to climate change. Section 3 uses a computable general equilibrium model to measure vulnerability to climate change in Malawi. The results from this model are discussed in Section 4. Section 5 concludes the paper.

2. Literature on measuring vulnerability

The IPCC defines vulnerability to climate change as ‘the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity’ (Parry et al., 2007).

According to Hinkel (2011), measuring a theoretical concept such as vulnerability requires the use of a method for mapping vulnerability to something that is observable. One such method entails creating vulnerability indicators.

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The indicator approach measures vulnerability to climate change by combining indicators of biophysical impacts (exposure) with indicators of socioeconomic characteristics (sensitivity and adaptation) into an aggregate indicator of vulnerability (Gbetibouo et al., 2010). This approach has been used both at the global level (Brooks et al., 2005) and the national and regional levels (Gbetibouo et al., 2010; O'Brien et al., 2004). The latter two studies assume that access to markets increases adaptive capacity through access to agricultural input and output markets, as well as to outside employment opportunities. In addition, less dependency on agriculture is assumed to decrease vulnerability by decreasing sensitivity and increasing adaptive capacity. Neither of these assumptions takes into account the indirect effects of climate change through, for instance, food prices and agricultural wages or the exposure to indirect effects transmitted through markets in areas that are not directly affected by climate change. For instance, the vulnerability of the growing group of urban poor cannot be addressed without taking into account food price changes that may result from the effects of climate change on agriculture.

Another approach is to use poverty as a proxy for household welfare, and measure the degree to which households or individuals are susceptible to and unable to cope with the adverse impacts of climate change as a change in poverty status or a change in the depth of poverty. This is in line with the literature on vulnerability to poverty (Calvo and Dercon, 2005; Kamanou and Morduch, 2005; Ligon and Schechter, 2003). Household data are used to estimate either expected poverty measures or expected utility measures of vulnerability to a shock. A detailed description of these methods and the econometric issues related to them is provided in Hoddinott and Quisumbing (2003). In general, the approach is based on calculating the probability that the welfare of an individual or household will fall below a certain benchmark level in response to a shock or an exposure to risk. This approach is based on observed data. Therefore, the approach must rely on already observed climate variability to measure vulnerability to climate change. This method may therefore be more appropriate for looking at climate risk rather than at vulnerability to gradual change in temperature and precipitation.

A third approach that has been used to assess the potential impacts of climate change through agriculture and to assess the vulnerability of households based on these impacts is the Ricardian approach. The Ricardian approach uses cross-sectional data to estimate the impact of marginal temperature and precipitation change on land values. The analysis is based on returns to land under different climatic conditions, and assumes that farmers will adapt to climate change by switching to the available practices and crops that offer the highest return to their land. The impacts of climate change estimated using this method must therefore be seen as estimates of impacts in the long run, after all available adaptation has already occurred.

Mendelsohn (2008) summarises recent studies that have used the Ricardian approach. The impacts vary greatly depending on geographic location, access to irrigation and whether the focus is on mean climate change or climate variability.

Different authors have emphasised a number of weaknesses of the Ricardian approach. Hertel and Rosch (2010) provide a good discussion, pointing to the Ricardian approach's sensitivity to omitted variable bias and its lack of applicability to climates outside the observed range (i.e., impacts of non-marginal climate change). Additionally, they argue that the Ricardian approach does not address the costs of adaptation because it looks at impacts *after* adaptation has occurred.

Reilly (1999) adds that the Ricardian approach does not consider how changes in global food prices will affect farmers' adaptation and that the approach's results are therefore only valid if impacts on global food prices are small or if the research only examines the impacts on a closed economy.

Food expenditures constitute a disproportionate share of expenditures for the urban poor, and their livelihoods may be closely linked to those of agricultural households through food prices, labour markets and demand linkages between agricultural and non-agricultural sectors (Haggblade et al., 2007). This calls for the integration of methods for assessing impacts on crop yields with general equilibrium models in order to take into account the impact of crop yield changes on prices, supply and demand, and on the rest of the economy.

Many studies assessing the impact of climate change both globally and in specific developing countries have been conducted using computable general equilibrium models. For instance, Hertel et al. (2010) use the Global Trade Analysis Project (GTAP) model to assess the impacts of climate change by 2030 on poverty, and show that poverty impacts can be disaggregated into effects on the cost of living and on earnings. The positive impact on farm income from increased crop prices may outweigh the increased cost of living for some households. Thurlow et al. (2012b) use a similar approach at the national level to look at the poverty impacts of climate change and current climate variability in Zambia, while Arndt et al. (2012) look at impacts on food security in Tanzania using a recursive dynamic computable general equilibrium model. However, the previous studies have not focused on measuring household-level vulnerability, and the models are often too aggregated to distinguish between household groups according to the net seller or net buyer status of food crops. Pauw et al. (2011) look at disaggregated poverty impacts of droughts and floods in Malawi, and find that small-scale farmers in the country's southern region, as well as urban households, are vulnerable. A similar model is used in this paper, but the focus is on vulnerability to gradual climate change rather than extreme events, and also examines global food price changes resulting from climate change.

To measure vulnerability to climate change scenarios simulated in a computable general equilibrium model, some measure of household welfare is used as an indicator of vulnerability. The households' exposure to climate change is imposed through simulations, such as changes in crop productivity. Sensitivity is captured by the model, which describes the economic structure that determines how households are affected by exposure to climate change. Finally, the adaptive capacity of households is captured by the behavioural assumptions in the model, such as the assumptions that households maximise utility and producers maximise profits. However, as I will show, the computable general equilibrium model must distinguish between whether households are net food sellers or net food buyers to adequately assess household-level vulnerability to climate change because these characteristics determine the impact of food price changes on household welfare (Deaton, 1989).

3. An application – measuring vulnerability to climate change in Malawi

The severe impact of climate variability on households in Malawi became evident in 2001 and 2002 after local flooding slashed maize (the local staple crop) production by 32 per cent. The number of deaths from starvation and hunger-related diseases is estimated to be between 300 and 3000 (Devereux, 2002). Although the weather shock was relatively mild compared to previous shocks, the consequences for food security were severe (Dorward and Kydd, 2004).

The aggregate economic impacts of climate change and climate variability depend on the size of the agricultural sector in terms of GDP and employment, as well as on the links to the rest of the economy. Approximately 30 per cent of Malawi's GDP was