World Development 112 (2018) 13–32

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Temperature shocks, short-term growth and poverty thresholds: Evidence from rural Tanzania

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ARTICLE INFO

Article history:
Accepted 28 July 2018

JEL classification:
I32
O12
Q12
Q54

Keywords:
Weather shocks
Climate change
Household consumption growth
Rural development

ABSTRACT

Using the LSMS-ISA Tanzania National Panel Survey by the World Bank, we study the relationship between rural household consumption growth and temperature shocks over the period 2008–2013. Temperature shocks have a negative and significant impact on household growth if their initial consumption lies below a critical threshold. As such, temperature shocks slow income convergence among households, at least in the short run. Crop yields and total factor productivity in agriculture are the main transmission channels. Extrapolating from short-term elasticities to long-run phenomena, these findings support the Schelling Conjecture: economic development would help poor farming households to reduce the impacts of climate change. Hence, closing the yield gap, modernizing agriculture and favouring the structural transformation of the economy are all crucial issues for adaptation of farmers to the negative effects of global warming.

1. Introduction

Poorer countries are generally found to be more vulnerable to climate change and weather variability. Many would suspect that poorer people are more vulnerable too, but research is scarce. As Tol (2016) notes, if the pattern of vulnerability observed between countries also holds within countries, this would strengthen concerns about climate change, but there is lack of quantification of the intra-country distributional implications of the impacts of climate change.

We shed light on the following questions: does weather and, by implication climate, affect the pattern of economic growth of farm households in a developing country? Is a weather- or climate-induced poverty trap plausible? To this end, we use the empirical tools and models of development economics to examine the link between short-term household welfare dynamics and temperature shocks in rural Tanzania. Specifically, we employ a micro-growth model (borrowed from the macro-growth literature) and test for convergence among households and for the significance of weather shocks as determinants of growth, while controlling for heterogeneity. Then, we test for the presence of consumption thresholds with respect to the impacts of temperature shocks. Finally, guided by previous theoretical and empirical literature, we test potential transmission channels, viz. agricultural productivity, crop yields and asset growth, that may explain heterogeneity of impacts and the lack of consumption smoothing.

This paper thus speaks to two distinct strands of research: the development literature on poverty traps, that investigates the issues of poverty persistence, growth divergence and multiple equilibria; and the emerging climate-economy literature that studies weather elasticities of growth. Our identification strategy looks at short-run weather variations to infer changes over longer periods, exploiting the tight linkages between short-run weather shocks and climate change (Dell, Jones, & Olken, 2014).

Tanzania is an appropriate setting for such a study for several reasons. It is commonly accepted that the future impacts of climate change will disproportionately affect poorer and hotter countries (Tol, 2018), and especially people living in rural, remote and scarcely populated areas, whose main source of income is agriculture. Sub-Saharan Africa, in particular, has been identified as one of the

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https://doi.org/10.1016/j.worlddev.2018.07.013
0305-750X/

most vulnerable parts of the world to climate change (Field et al., 2014). Tanzania is a poor and hot Sub-Saharan country, where in 2015 68% of the population lived in rural areas.[1] It is typically classified as a country under high risk from the impacts of future climate change: temperatures in the country are predicted to rise 2–4 °C by 2100, with warming more concentrated during the dry season and in the interior parts of the country (Rowhani, Lobell, Linderman, & Ramankutty, 2011). Ahmed et al. (2011) underline the importance of agriculture, which accounts for half of GDP and employs 80 percent of the labour force. Agriculture in the country is primarily rain-fed, with only two percent of arable land having irrigation facilities. Tanzania is also a country which exhibits quite large climatic diversity, varying from tropical at the coast to temperate in the highlands (Rowhani et al., 2011). Finally, there are good data: we use the Living Standard Measurement Survey (LSMS) – Integrated Survey on Agriculture (ISA) Tanzania National Panel Survey by the World Bank, a three-wave household longitudinal dataset covering the period 2008–2013.

The results show striking heterogeneity: temperature-induced consumption shocks only affect the poorest households. Rural households suffer from a negative and significant contemporaneous slowdown of growth due to temperature shocks, but only if their initial consumption level lies below a critical threshold. In other words, hot weather slows convergence among households, and enhances inequalities. The main transmission channels are agricultural yields and agricultural total factor productivity (TFP). No impact on asset growth is found, suggesting that asset smoothing is taking place. That is, poor households choose to destabilize their consumption in order not to have to sell their assets, or do not have enough assets to sell to cope with the fall in income caused by temperature shocks. We find a *poverty-induced climate trap* rather than a *climate-induced poverty trap*, since the negative impacts of temperature shocks are significant only for households whose initial consumption level lies below a critical threshold. It follows that a clear-cut policy implication for policymakers in Tanzania is to prioritize modernizing agriculture. The reward is twofold: closing the yield gap and making farmers less *vulnerable* to climate change (Tol, 2016).

Given the short-run nature of this dataset, our capacity to assess convergence is limited, and we can only cautiously infer long-run trends. Also, we do not directly test for the presence of multiple equilibria and hence for the existence of a poverty trap. Under a classic 'poverty trap' threshold, households are trapped in an equilibrium with permanently low income, whereas here we only check whether there is a consumption threshold above which temperature impacts turn insignificant, i.e. whether impacts disappear as households grow richer. Deceleration is not bifurcation, as noted by Dercon (2004) and Jalan and Ravallion (2002): temperature shocks slow the convergence process but they do not reverse it, at least not in the time frame of our data. Finally, interpreting our weather results with respect to climate change is hard, given the intrinsic difference between short-run weather shocks and long-run changes in climate.

The contributions of this paper are the following. First, it complements aggregate growth – climate empirics with available micro panel data, providing evidence on the (short-run) micro causal relationship between weather anomalies, poverty and growth. Second, it links the weather-economic growth literature with the development literature on poverty traps, by applying the tools and models of the latter to the research questions of the former. Third, it contributes to the development literature, by testing for consumption *vs* asset smoothing, which has been rarely been done according to Carter and Lybbert (2012), and by showing that, when controlling for temperature shocks (often ignored in development literature), precipitation impacts are insignificant and close to zero.

The rest of this paper is arranged as follows. Section 2 reviews the relevant literature. Section 3 illustrates the empirical framework and the identification strategy. Section 4 describes data and provides introductory descriptive statistics. Section 5 presents the results of the empirical analysis. Section 6 conducts a host of robustness checks. Section 7 investigates the channels of the heterogeneity of impacts. Section 8 wraps up, illustrates the policy implications of the analysis with regard to climate change, adds *caveats* and concludes.

2. Literature review

A growing body of empirical work focusing on the weather/climate-economy relationship has recently emerged with the aim to understand and quantify the future impacts of climate change on human welfare. In a thorough review of this literature Dell et al. (2014) notice how earlier cross-sectional works (Dell, Jones, & Olken, 2009; Gallup, Sachs, & Mellinger, 1999; Nordhaus, 2006), whose validity is challenged by endogeneity and omitted variable bias, have recently been replaced by more appropriate and robust panel methods, both macro (Bansal & Ochoa, 2011; Burke, Hsiang, & Miguel, 2015; Dell, Jones, & Olken, 2012; Hsiang & Jina, 2014; Hsiang, 2010) and micro (Cachon, Gallino, & Olivares, 2012; Dercon and Christiaensen, 2011; Graff Zivin & Neidell, 2014; Heal & Park, 2015; Niemelä, Hannula, Rautio, Reijula, & Railio, 2002; Schlenker & Lobell, 2010; Sudarshan & Tewari, 2013). This literature typically uses weather shocks, which are hard to extrapolate to climate change, although some studies uses changes over longer periods to look at climate variation or interactions between climate and weather variables.

The main finding of this emerging literature is that weather affects economic activity and growth through a wide range of channels, particularly in poor countries.[2] Agriculture, health and labour productivity have been frequently cited as the most important transmission channels of such impacts. Several studies have investigated the relationship between crop yields and weather variability, starting from the plausible assumption that extreme temperatures and too much and too little rainfall may damage crops (Challinor, Wheeler, Craufurd, & Slingo, 2005; Li et al., 2010; Porter & Semenov, 2005; Rowhani et al., 2011; Schlenker & Lobell, 2010; Welch et al., 2010). Low crop yields could be one of the reasons why smallholder farmers are trapped in poverty (Barrett & Swallow, 2006; Sachs, 2008; Tittonell & Giller, 2013). Barreca (2012), Burgess, Deschenes, Donaldson, and Greenstone (2011), Deschênes and Greenstone (2011) and Goldberg, Gasparrini, Armstrong, and Valois (2011) have documented the effects of temperature and heat waves on health, particularly mortality, using panel methods. (Cachon, Gallino, et al., 2012; Cachon et al., 2012; Graff Zivin & Neidell, 2014; Heal & Park, 2015; Niemelä et al., 2002; Park, 2017; Sudarshan & Tewari, 2013) have found effects of temperature on the productivity of workers, especially on those who work outdoors.

In parallel, the development literature looks at the impacts of weather shocks on household welfare, vulnerability and poverty. This literature uses weather variation as an instrument to study non-climatic relationships. Paxson (1992) found that unexpected rainfall shocks do not have serious welfare consequences for Thai

[1] http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=TZ.

[2] These panel estimates have then been employed and calibrated *ad hoc* in simulation studies on the impacts of future climate change (Lemoine & Kapnick, 2015; Moore & Diaz, 2015) to provide empirically-grounded impact estimates for Integrated Assessment Models (IAMs), so to overcome the critiques about the arbitrary choice of crucial parameters like the damage function and climate sensitivity (Pindyck, 2012, 2013; Stern, 2013; Weitzman, 2009, 2010).