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Income and Health in Tanzania. An Instrumental Variable Approach

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Summary. — There is a substantial debate over the direction of the causal relation between income and health. This is important for our understanding of the health production process and for the policy debate over improving healthcare. We instrument income with rainfall measurements by matching satellite information on timing and positioning of 21 rainfall stations to longitudinal data (1991–94) of over 4,000 individuals in 51 villages in Tanzania. A 10% increase in income reduces the number of illnesses by 0.02. We also find that a 10% increase in income implies an increase of about 0.1 vaccinations of children under six.

Key words — Tanzania, rainfall shocks, income, health, spatial interpolation

1. INTRODUCTION

There is a large literature that associates income and health. Despite the strength of this correlation, substantial debate continues over the direction of causation. Income affects health (Ettner, 1996; Smith, 1999) as individuals with more income live in healthier areas and can afford better healthcare. But health can also affect income, as healthier individuals are able to work more productively (Levy, 2000; McClellan, 1998; Wu, 2003). A final alternative is that both income and health are determined by other factors, such as time preferences (Barsky, Juster, Kimball, & Shapiro, 1997).

The nature of this relationship is important for our understanding of the health production and consumption process, but also for the public policy debate over improving healthcare (see for example, Attanasio & Hoynes, 2000).

Establishing a causal link between income and health requires an appropriate instrumental variables strategy. In the United Republic of Tanzania, the country we focus on in this paper, about 38% of the population lives below the national basic needs poverty line (National Bureau of Statistics, Tanzania National Budget Survey, 2007). Agriculture accounts for about half of gross production and employs about 80% of the labor force (Thurlow & Wobst, 2003). Agriculture in Tanzania is primarily rain-fed, with only 2% of arable land having irrigation infrastructure (FAO, 2009). Its main staple crops, like maize, are particularly susceptible to weather conditions. Because of this high dependence on weather events, we use meteorological data as an instrument for income.

Many studies in developing countries examine the effect on health of income shocks provoked by natural disasters (see for example, Bengtsson, 2010; Datar, Liu, Linnemayr, & Stecher, 2013; Edoka, 2013; Miller & Urdinola, 2010; Pörtner, 2010; Rose, 1999; Yamano, Alderman, & Christiaensen, 2005).

The principal contribution of this paper to the literature is a novel construction of rainfall data, using satellite measurements of historical rainfall data linked to individual-level longitudinal data. We use the timing and positioning of 21 weather stations across 51 villages from satellite data to generate a village-specific rainfall measurement through spatial interpolation of distances of the stations to the center of the village. We then match households' interview dates, which vary by as much as seven months, to historical rainfall data and allow for spatial correlation in the covariance matrix.

The lack of variation in the instrument is a drawback of the previous literature. For instance, Rose (1999) linked household-level data, the Indian Additional Rural Incomes Survey, to district-level rainfall data collected by the World Bank. Bengtsson (2010), with the same Kagera data as in this paper, uses a time series of rainfall to instrument for income shocks and to identify causal impacts on body weight. However, he only exploits differences between rainfall measurements of five districts with only one weather measurement per district.

Using satellite-linked data to interview dates not only allows us to exploit within-villages and between-households variations, but also provides an "objective" measure of income shock. For instance, Edoka (2013) uses self-reported measures of weather shocks, which might be biased by measurement error, if exposure to weather shocks is correlated with differential perception of the impact on household's welfare (Dercon, 2002).

An additional contribution of this paper is that we examine a wide range of health outcomes (i.e., Body Mass Index (BMI), number of self-reported illnesses; height-for-age, and weight-for-height for children under the age of six) and a preventive behavior, the number of vaccinations for children under the age of six. The World Health Organisation (WHO) considers these indicators as risk factors for other health problems and predictors of infant mortality. In our main specification, we find no statistically significant effect of transitory income changes on BMI, height-for-age, or weight-for-height. However, we do find a reduction in illnesses, such as acute fever, chills, coughs, severe headaches, and abdominal pain. In contrast, the main analysis of Bengtsson (2010) uses only one transitory health outcome measure, namely, relative weight defined as the deviation of individual weight from its mean. He finds a statistically significant increase in relative weight but only for females. We have

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been able to replicate his results with our novel construction of the instrument.

Only one study, by Miller and Urdinola (2010) does focus on the effect of income shocks on vaccinations and health outcomes for children. They examine the effect of world coffee price fluctuations on infant and child mortality in Colombia and find evidence of increased mortality and reduction of vaccinations for children under the age of one, which they attribute to an increase in the opportunity cost of time spent on childcare. By contrast, we find an increase in the number of vaccinations for children under the age of six. We are unable to measure the time spent on childcare directly, but we infer from the finding that rainfall variation in our data does not change the overall time spent on work, that it does not change. Compared with Miller and Urdinola (2010), the weather-related changes to income are smaller than coffee price variations and hence do not substantially change the opportunity cost of time. Like in Colombia, vaccination is almost entirely "free" in the Kagera region of Tanzania. But the distance to the nearest health center can often be quite large. We therefore infer that the prevailing income effect over the substitution effect in our data might be due to better access to healthcare centers (i.e., via transport mode).

The studies that found worse nutritional status in children have focused on small-scale natural disasters (see for example, Datar *et al.*, 2013; Edoka, 2013; Pörtner, 2010) as opposed to the transitory weather changes we examine in this paper.

Our final contribution is the extensive discussion over the validity of our instrument, which is generally neglected by the literature. Weather shocks could affect health in two ways. Firstly, they could have a direct effect through morbidity and mortality. Secondly, they could impact the demand for health inputs, through their effect on income. There is empirical evidence suggesting the direct effect of weather shocks on health occurs when such shocks are extreme and not transitory like in our case (Burgess, Deschêne, Donaldson, & Greenstone, 2011; Deschêne & Greenstone, 2011). Nevertheless, like Bengtsson (2010), we assess whether our rainfall measure has a direct effect on health with a specific focus on malaria and we find no such effect. Secondly, one novelty of our paper is the use of a number of additional instruments from the National Aeronautics and Space Administration (NASA)-linked climate data, such as temperature, humidity, and wind speed to indirectly test for the validity of rainfall. If rainfall could be argued to directly affect diseases such as malaria, this is less likely with wind speed. The test for the over-identifying restriction cannot reject the null hypothesis of uncorrelated residuals with the set of exogenous instruments. Our results are robust to checks around omitted variable bias, intra-household correlation, attrition rates and non-linear specification of our outcome models.

The paper is structured as follows. Section 2 contains a description of the data; summary statistics are reported in Section 3. The empirical strategy is explained in Section 4, while Section 5 reports the results and Section 6 concludes.

2. DATA DESCRIPTION

We link together three data sources, namely, the Kagera Health and Development Survey (KHDS), the Tanzania meteorological rainfall data, and the National Aeronautics and Space Administration (NASA) climate data.

(a) *Kagera health and development survey (KHDS)*

We use baseline data from a longitudinal Living Standards Measurement Survey (LSMS) conducted in the Kagera region of North Western Tanzania, [1] the Kagera Health and Development Survey (KHDS). It is one of the few long-running surveys containing questions on individual socioeconomic characteristics, wealth and income, health behaviors, and outcomes. KHDS also contains a rich set of community characteristics on health care, children's education, and local market prices.

The Kagera region is predominantly rural and lies just south of the equator, bordering to the north with Uganda and to the west with Rwanda and Burundi. The population of 1.9 million people is predominantly engaged in agricultural production of banana and coffee in the north, and livestock and rain-fed annual crops, primarily cotton, maize, and sorghum, in the south. The agricultural sector accounts for 45% of GDP. About 29% of all households in Kagera are below the basic needs poverty line (Kessy, 2005). In 1991, household average annual expenditure was US$217 per capita, with a range of US$118 and US$357 across the six districts of the Kagera region.

The longitudinal survey consisted of four initial waves from 1991 to 1994. [2] The first survey consisted of 915 households interviewed up to four times, from September 1991 to January 1994 (at 6–7-month intervals). Households were drawn

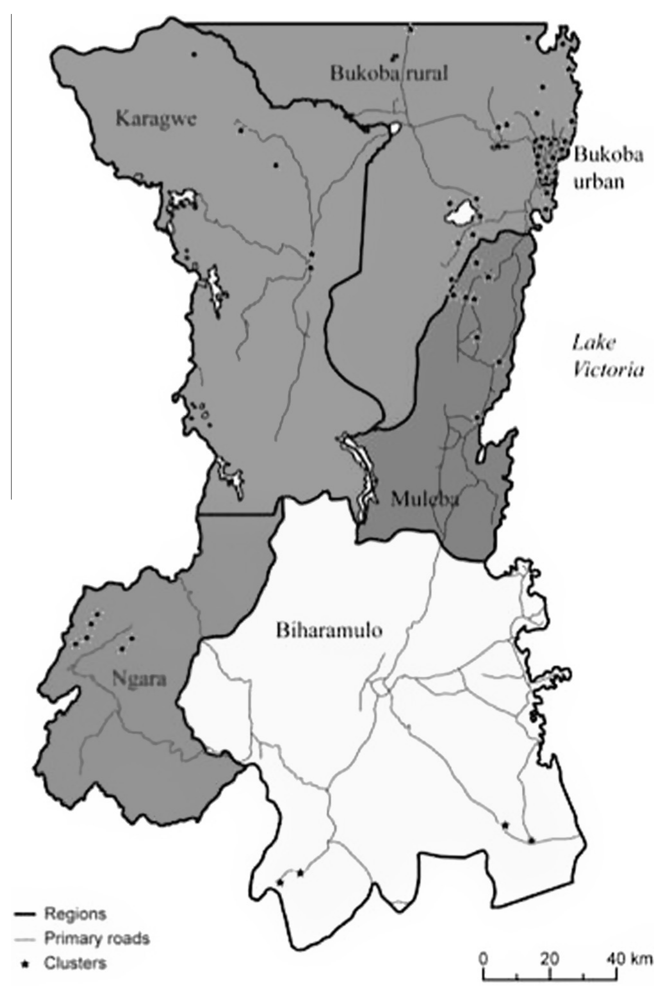

Figure 1. *Map of the Kagera region with districts and sampled clusters. Source: Luzi (2010)*