POLICY BRIEF

Effects of Temperature and Rainfall Variability on the Net Income of Cereal Crops in Togo: Semi-Parametric Approach

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Abstract

This paper analyses the economic effects of temperature and rainfall variability on the net income of the main cereal crops in Togo based on a semi-parametric specification of the Ricardian model. The model provides a flexible functional form of the non-linear relationship between farmers' net income and climatic variables and evaluates the effect of climate variability on the net income of these crops. Using data from the National Agricultural Census in Togo, temperature and rainfall data from spatial interpolation over all prefectures and soil type data for each locality, the results of the semi-parametric estimates reveal a complex non-linear relationship of temperature and rainfall variability on the net income

of crops. In addition, a combination of crops and agro-forestry practices reduce the effects of climate variability on net income from cereal crops. Furthermore, variations in temperature and rainfall under socio-economic scenarios result in lower net income from cereal crops. The projections show that long-term variability in temperature and rainfall will have a negative impact on net income and that the impact will be greater in 2050 for all crops.

Background and justification

Globally, and particularly in most developing countries, the agricultural sector is the lung of the national economy, contributing a significant share to the formation of Gross Domestic Product (Bryan et al., 2011). It also provides the basis for feeding all humankind by ensuring its social well-being and prosperity. However, the growth of the world population in recent years and its projection reveal that food production should increase by 60% to 70% by 2050 to guarantee food security for its inhabitants (Tilman et al., 2011; FAO, 2009, Bruinsma, 2009). However, agricultural production, mainly dependent on rainfall, in most developing countries and particularly in Togo, remains sensitive and vulnerable to the climatic parameters variability witnessed over the past decades (Mendelsohn, 2000; IPCC, 2007; Kurukulasuriya and Mendelsohn, 2006).

In this context, observation of the climate system in Togo on the basis of direct measurements of climatic variables conducted by the national meteorological services during the period from 1961 to 2012 reveals a global warming trend of 1°C for the period from 1961 to 2012, coupled with a decrease in average rainfall throughout the country. This global warming became more pronounced during the years 1986 to 2012 compared to the normal level from 1961 to 1985, with annual deviations of between 0.7°C and 1.2°C, respectively. Considering the 1961-1985 baseline period, the years 1986 to 2012 show a deficit in terms of rainfall, with reductions in rainfall between 3mm and 81mm. The evolution of rainfall patterns reveals an alteration in rainfall distribution with, among the major climatic risks, situations of extreme droughts or paradoxically floods and a decrease in the number of rainy days.

As agriculture in Togo is essentially dependent on rainfall, this climate variability is likely to influence crop yields and reduce farmers' income. In this context, several studies have attempted to analyze the impact of climate variability on agricultural production in several countries around the world and at the regional level (Dall'erba and Domínguez, 2016; Kabubo-Mariara and Karanja, 2007; Kurukulasuriya and Mendelsohn, 2008; Mendelsohn and Dinar, 2003; Mendelsohn et al., 1994), but few studies on Togo, following the example of Gadédjisso-Tossou et al. (2016) and Pilo and Adeve (2016). Thus, the literature abounds with several approaches and tools used to analyze the potential effects of climate parameters variability on agriculture

(Mendelsohn and Dinar, 2009). However, among the pioneering works, Adams et al. (1990) and Kaufmann and Snell (1997) used biophysical crop models to simulate the impact of climate variability on plant growth and input requirements.

In addition, assessment of the impact of climate parameter variability has focused on crop productivity (Schlenker and Roberts, 2009; Welch et al., 2010) or agricultural profit (Deschênes and Greenstone, 2012) by making greater use of statistical or econometric models with time series, cross-sectional or panel data. However, these different methods do not integrate farmers' adaptation strategies in response to climate variability, which may lead to biases in the estimates. To consider the limitations of these previous approaches, Mendelshon et al. (1994) introduced the Ricardian approach in the economic literature. This approach is based on the notion of a competitive market in which the value of agricultural land reflects the present value of all the expected future benefits that can be derived from it (Ricardo, 1817). The Ricardian model specification is generally implemented by regressing agricultural land values on climatic variables, mainly temperature and rainfall, and a set of exogenous control variables. The main advantage of this approach is that it integrates farmers' adaptation strategies. There are, however, some criticisms associated with it, notably those relating to the implicit fixed price assumption and the functional form of its specification.

Indeed, Ricardian analysis generally assumes that the impact of climate variability will affect the value of agricultural land in a non-linear manner (Mendelsohn and Dinar, 2009). Thus, model specification integrates the quadratic terms of the climate variables to show this non-linear relationship between climate and agricultural land value. Moreover, previous research has shown that in hedonic models, the restrictive parametric specification to the quadratic form of the climate variables cannot be justified a priori (Cropper et al., 1987 and Ekeland et al., 2002; 2004). However, an alternative semi-parametric or non-parametric method can provide several advantages over this limitation of the specification of the functional form of the standard Ricardian model (Anglin and Gencay, 1996; Parmeter et al., 2007; Bontemps et al., 2008). In comparison to parametric regression, the semi-parametric method provides a superior fit and reveals a strong interaction between climate variables. Furthermore, predictions of the impact of climate variability are not significantly different from those obtained using the standard specification.

Methodology

The Ricardian approach (Mendelsohn et al., 1994) examines how agricultural land values vary according to a set of exogenous variables such as climate and soils. It is based on David Ricardo's (1772-1823) observation that in a competitive market, land income would reflect net agricultural land income (Ricardo, 1817) and analyzes the impact of climate and other variables on land values or farming incomes. This approach is attractive because it corrects for biases in the production function approach by directly measuring the effects of climate on the value of production of different crops, and the indirect substitution of different inputs and the introduction of potential adaptation strategies by farmers as responses to the negative effects of climate (Mendelsohn et al., 1994).

Conclusion and policy implications

The interest of this research was to assess the effects caused by climate variability through the variability of these components (temperature and rainfall) on the net income of cereal crops in Togo. Most of the recent studies in Togo on the effect of climate variability on agriculture have focused on the extent of damage caused to all agricultural products. However, a more important issue is to study how net cereal crop incomes are affected by temperature and rainfall variability. The Ricardian approach was adopted for this study because it implicitly takes into account farmers' adaptations to climate variability. Thus, to address some of the limitations of the standard Ricardian model, estimates were made by estimating a semi-parametric specification of the Ricardian model. The results revealed from the Akaike information criterion statistics that the semi-parametric specification is better than the standard Ricardian model specification.

The results also suggest that climate affects the net income of cereal crops. An increase in mean temperature variability decreases the net income of cereal crops, while an increase in rainfall variability increases net crop income. The results further suggest that there is a non-linear relationship between temperature variability and net crop income, and between rainfall and net crop income. These results are consistent with previous studies on the impact of global warming on agriculture, but this relationship is more complex with semi-parametric estimation. In addition, we also find that soil types and some socio-economic variables influence the net income of Togolese farmers. The estimated elasticity reveal that net crop income is sensitive to variations in climatic parameters, but less sensitive to temperature variation than to rainfall.

This paper also provides the impact of different scenarios of climate variability on net cereal income. We used two scenarios from RCP 8.5 (Representative Concentration Pathway 8.5) published by the IPCC in 2013. The predictions show that long-term variability in temperature and rainfall will have a negative impact on net income of all cereals. However, the impact will be greater over time (2050). In terms of adaptation strategies, the results of the estimates reveal that crop combination and agro-forestry practices reduce the effects of climate variability on the net income of cereal crops. The use of improved seeds does not contribute to increasing the net income of cereal crops.

The results of this study highlight the impact of climate variability on the net income of cereal crops and the importance of farmers' adaptation strategies in improving their net income and reducing the effects of climate on them. Thus, the implications of economic policies in terms of addressing constraints to the adoption of strategies should be promoted, coupled with better understanding of the effects of climate variability. Compared to the adaptation strategies already implemented by farmers, it would be interesting to encourage the use of these strategies that improve farmers' income and to promote others. Regarding improved use of selected seeds, it would be interesting to intensify awareness on their better use, given the negative effects of their application on net cereal income.

By considering the projected effects in relation to different cereal crops, we note that the effects will be greater on the net income of rice and maize crops. These crops are more cultivated and consumed and it would be interesting to intensify actions to reduce the effects of climate variability on their income.

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