European Economic Review 99 (2017) 5–30

Contents lists available at ScienceDirect

European Economic Review

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

The climate challenge for agriculture and the value of climate services: Application to coffee-farming in Peru[☆]

Filippo Lechthaler[a], Alexandra Vinogradova[b,*]

[a] Center of Economic Research, CER-ETH, Zurich and Swiss Tropical and Public Health Institute, University of Basel, Basel, Switzerland
[b] Center of Economic Research, CER-ETH, Zurich, Switzerland

ARTICLE INFO

Article history:
Received 3 June 2016
Accepted 8 February 2017
Available online 27 June 2017

JEL Classification:
C25
D81
H41
O13
Q12
Q16
Q51

Keywords:
Agriculture
Choice experiment
Coffee farming
Coffee rust
Climate change adaptation
Uncertainty

ABSTRACT

The use of climate information in economic activities, typically provided by climate services, may serve as a possible adaptation strategy to changing climate conditions. The present paper analyzes the value of climate services which are aimed at improving agricultural productivity through a reduction in weather-associated risks. The first part provides a theoretical foundation for estimating the value of climate services based on a stochastic life-cycle model of a rural household which faces uncertainty with respect to the timing and the size of an adverse weather shock. We subsequently calibrate the model to match the environment of coffee producers in the Cusco region of Peru and provide a range of estimates for the value of climate services for a single average household, the region, and the country as a whole. In the second part of the paper we use empirical data to corroborate the numerical estimates. We assess the value of climate services in the agricultural sector in Cusco based on a choice experiment approach. Data are analyzed using a standard as well as a random parameter logit model allowing for preference heterogeneity. Farmers show a significant willingness-to-pay for enhanced climate services which is particularly related to the service accuracy and geographic resolution. On average, the yearly value of a climate service in the coffee sector is found to be $21 per ha and $8.2 million for Peru as a whole.

1. Introduction

The direct impact of climate variability on economic performance is currently gaining increasing scientific and public-policy attention due to the ongoing efforts to deal with climate change. Alteration in climate conditions, such as an increase in the global temperature and an amplification of temperature variability, impose new challenges on adaptation strategies, which are particularly eminent in climate-sensitive sectors such as agriculture or health (IPCC, 2014). Climate services, as defined by Tall (2013), consist of dissemination of climate information to the public or a specific user. Climate services thus represent an essential instrument for adaptation as they provide end-users with information and predictions which decrease the risk of weather and climate-related disasters and therefore improve the overall efficiency of the decision-making process. In fact, in 2009, the third World Climate Conference (WCC) established a Global Framework for Climate Services in order to strengthen production, availability and delivery of climate information.

☆ A Publisher's error resulted in this article appearing in the wrong issue. This article is reprinted here for the reader's convenience and for the continuity of the Special Issue. For citation purposes, please use the original publication details; Eur. Econ. Rev., 94, 45–70. DOI of original item: http://dx.doi.org/10.1016/j.euroecorev.2017.02.002. Copyright line should match previous version–002, 2017.

* Corresponding author.
E-mail addresses: f.lechthaler@unibas.ch (F. Lechthaler), avinogradova@ethz.ch (A. Vinogradova).

http://dx.doi.org/10.1016/j.euroecorev.2017.06.006
0014-2921/

One of the major issues in addressing the challenges of climate change is related to the specific needs of less developed economies, which typically lack capital and knowledge for adaptation and are characterized by a higher climate vulnerability (Bretschger and Suphaphiphat, 2013). In particular, less developed or emerging economies exhibit a relatively high dependence on climate-sensitive sectors such as agriculture. In this regard, climate services provide a useful infrastructural contribution, as they assist individuals and organizations in making improved climate-related decisions on livelihood strategies, which may generate significant potential benefits for societies. At the same time, due to their (quasi) public good nature and relatively high fixed costs, the development and implementation of climate services is likely to be financed by the public sector. Therefore, as it is outlined by the *Madrid Action Plan* of the *World Meteorological Organization* (WMO, 2007), it is of high importance to quantify the benefits of such services in order to justify the required public investments (Freebairn and Zillman, 2002a).

In the present study we quantify the value of climate services for the agricultural sector, where weather conditions determine to a large extent the quality and the quantity of agricultural output. Natural disasters, such as droughts, heat waves, intensive rainfalls, floods, frosts, pests etc., may have a profound negative impact on the harvest. Typically these events cannot be easily predicted by individual farmers as they occur at random points in time and cause a random-size damage. If their occurrence and intensity could be foreseen, appropriate adaptation mechanisms and precautionary measures could be implemented—in terms of investments, crop and fertilizer choice, field size, dams, irrigation systems, etc. This is why comprehensive climate services may be needed in order to improve the performance of the agricultural sector as a whole and welfare of individual farmers. This issue is relevant for both the developed and the developing countries, especially those where agriculture represents an important share of GDP and particularly those vulnerable to climate change.

Coffee farming is one of the agricultural activities which has been particularly affected by changing climate conditions in the past several years. "Coffee is an important global crop and the second most valuable commodity exported by developing countries, worth around $19 billion in 2015. More than 120 million people in more than 70 countries rely on coffee value chain for their livelihoods" (The Climate Institute, 2016). Moreover, it is the only source of income and subsistence for rural population working on coffee farms. According to The Climate Institute (2016), climate change is projected to cut the global area suitable for coffee production by as much as 50% by 2050. By 2080, wild coffee, an important genetic resource for farmers, could become extinct. In the next few decades, coffee production will undergo dramatic shifts, away from the equator and further up in the mountains, coming into conflict with other land uses such as forests. "There is a strong evidence that rising temperatures and altered rainfall patterns are already affecting coffee yields, quality, pests, and diseases, representing a threat to economic security in many coffee-producing regions" (The Climate Institute, 2016, p. 1). All the coffee-producing countries of Central and South America have seen drops in production of 30% or more in 2012–2014 due to the spreading of the fungus *Hemileia vastatrix*, commonly known as "coffee rust". In these economies coffee represents an essential export commodity with export revenues contributing a considerable share to their GDP, e.g., more than 10% in smaller states such as Nicaragua, Guatemala and Honduras.[1] Heavy rainfall and warm temperatures constitute propitious conditions for the development of coffee rust, which threatens livelihood of a large share of rural families, leading to poverty, malnutrition and undermining the global food security. The adverse effects can be mitigated by a timely application of fungicides. The challenge, however, is that they must be applied preventively, i.e. a few weeks in advance of the onset of humid and warm days, which requires specific knowledge of the *future* weather conditions.[2] Consequently, quality weather services are crucial for harvest preservation and the well-being of agricultural workers.

The contribution of the present study is two-fold. First, we provide a theoretical foundation for elucidating the value of climate services (CS for short) in a dynamic stochastic framework. The CS consist of information provided to farmers about the timing and the intensity of an adverse random weather event. The climate service value (hereafter CSV) is assessed by comparing a representative farmer's welfare under two scenarios—one where CS are available and the other where they are not. The model is subsequently calibrated to match the conditions facing coffee farmers in the region of Cusco, one of the major coffee-producing regions of Peru. Peru appears to be especially exposed to changing climate conditions due to the presence of the El Niño phenomenon and its mountainous topography (see e.g. Vargas, 2009). In recent years, Peru, as almost every coffee-producing country in Latin America and Africa, has suffered from outbreaks of *Hemileia vastatrix* and crop losses of up to 80% in hard-hit regions (e.g. district of Santa Teresa), amounting to several tens of millions of USD annually. The numerical results stemming from the calibrated model suggest that climate services may be worth $17–$28 per cultivated hectare and as much as $1.64 million for the Cusco region.

In the second part of the paper we corroborate the numerical findings by assessing the economic value of climate services empirically using discrete choice methodology. The corresponding survey was carried out in the region of Cusco in 2014. In addition to the data on coffee producers, we also collected information on maize farmers in order to assess the economic plausibility of the empirical results with regard to different types of crops. The climate service presented to farmers was a product which provided them with climate and weather related information (early warning system), closely corresponding to the risk-reducing mechanism described in our theoretical model. As climate services are only rarely implemented in less developed countries and since they exhibit typical characteristics of (quasi) public goods, observability of corresponding market outcomes is restricted making the use of market data for empirical validation impossible. This

[1] Honduras, Nicaragua, Vietnam, and Guatemala rank in the top 10 for climate-related damages since 1990s (The Climate Institute, 2016, p. 1).

[2] See, e.g., Avelino et al. (2015) and Kushalappa and Eskes (1989).