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Experimental insights on the investment behavior of small-scale coffee farmers in central Uganda under risk and uncertainty

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ABSTRACT

In this study, we investigate the investment behavior of small-scale coffee farmers in central Uganda in an experimental setting. We consider a situation in which farmers are asked to make an investment under uncertainty and analyze whether and to what extent the Real Options Approach can predict the investment behavior of farmers and whether these predictions are better than those derived from the Net Present Value Approach. We also investigate whether the presence of a price floor has an effect on farmers' investment behavior. Our results suggest that the Real Options Approach more accurately predicts the decision-making behavior of farmers than the Net Present Value Approach. However, the results also show that neither of the approaches entirely explains the observed investment behavior. Specifically, the presence of a price floor does not significantly affect the investment behavior. The latter is, however, significantly determined by the order in which treatments with and without price floor are introduced, alongside various demographic and socio-economic characteristics.

1. Introduction

Being a farmer involves making economic decisions, for instance, about expanding certain production activities, replacing older technologies with newer ones, or adopting different production techniques. All these farm-level decisions can be considered as investments, which often have long-term implications for a household's income and consumption patterns, particularly, for poor farm households in developing countries (Feder et al., 1985; Rosenzweig and Wolpin, 1993; Zimmerman and Carter, 2003). Uncertain future returns stemming from the risks associated with price fluctuations, crop and livestock diseases, or adverse weather conditions influence most economic farm-level decisions. Previous research has shown that farmers are reluctant to invest in situations characterized by uncertainty (Winter-Nelson and Amegbeto, 1998; Hill, 2010a; Kabunga et al., 2012). It is, thus, not surprising that farmers are considered to be particularly conservative and averse to changes (Jose and Crumly, 1993). Risk-averse behavior is likely to be particularly pronounced in developing country settings, given that a majority of the poor people lives in rural areas, whose livelihoods depend on agricultural production under risk and uncertainty. In such conditions, the role of risk is particularly salient because strategies or markets designed to cushion farmers from risk, such as insurance and other safety-net mechanisms, are incomplete or non-existent (Hill and Viceisza, 2012). Hence, understanding farmers' investment behavior is crucial for gaining insights into the dynamics of how uncertainty affects their decision-making, and to predict this behavior in the future. It can also contribute to predicting the likely effects of policy changes that affect small-scale farmers and to design effective agricultural programs that support farmers in how to deal with risk and uncertainty. This is particularly true for Sub-Saharan Africa, where policy instruments and incentives supporting the transformation of the agricultural sector from subsistence-oriented towards more commercialized farming systems are built around farm-level technology adoption. The latest Africa Agricultural Status Report identifies limited adoption of more productive and diversified agricultural technologies as the root cause of poverty and food security (FAO, 2016).

The present study aims to experimentally investigate which investment theory best describes poor rural households' decision-making behavior under uncertainty. Specifically, we analyze whether and to what extent the real options approach (ROA) can predict the investment behavior of small-scale coffee farmers in central Uganda and whether these predictions are better than those derived from the net present value (NPV) approach. We also investigate whether the presence of a price floor, a minimum price guarantee or price insurance that hence decreases price risk, has an effect on farmers' investment behavior.

Investment decisions made by coffee farmers typically have long-

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term implications. The very planting of a coffee tree, for instance, is an investment decision associated with benefits obtained over many years. Coffee is a perennial crop that takes three-to-five years to reach productive maturity and thereafter can remain economically viable for 30-to-40 years. Investing in coffee, to some extent, is also irreversible. Coffee trees have no value when they are removed from the ground and it is not possible to recoup the opportunity cost of land being tied up with no output until the trees bear fruit (Hill, 2010a). Coffee farming is a major livelihood activity in eastern Africa. In Uganda, around 1.7 million small-scale farmers produce coffee (UCDA, 2016). Coffee is a relatively profitable production activity for Ugandan households but investing in coffee is risky owing to price volatility and the trees' susceptibility to diseases. Anecdotally, farmers in Uganda report coffee price risk to be a major concern to their welfare. Households might hence decide to invest more in coffee production, a high-return, but also a high-risk activity, if a minimum price guarantee was given, which would reduce farmers' uncertainty about future returns (Hill, 2010b).

The ROA – also known as the new investment theory – provides the conceptual framework and empirical methodology commonly used to examine irreversible and uncertain investments (Dixit and Pindyck, 1994). The ROA facilitates an analysis of investment under uncertainty, explicitly taking into account irreversibility of the investment decision and flexibility with respect to the investment timing. According to the ROA, there is an incentive to delay an investment owing to the option value of the investment (Abel and Eberly, 1994; Dixit and Pindyck, 1994). The classical NPV, on the other hand, ignores irreversibility and flexibility regarding the timing of investment, as well as uncertainty of investment returns (Trigeorgis, 1996). Critics, however, argue that all these factors are crucial for farmers' investment decisions because they may influence their decision-making behavior. Since these factors are ignored, the NPV approach might not be sufficient to capture and evaluate farmers' decision-making process. Over the past two decades, agricultural economists have increasingly prioritized the ROA to analyze investments in agriculture over classical investment models based on the NPV (e.g. Pietola and Myers, 2000; Richards and Green, 2003; Luong and Tauer, 2006; Hill, 2010a).

Numerous prior empirical applications of the ROA to agricultural investment decisions exist (e.g. Pietola and Myers, 2000; Richards and Green, 2003; Luong and Tauer, 2006; Hill, 2010a; Feil and Musshoff, 2013; Feil et al., 2013). Despite its popularity, an empirical validation of the ROA has proved somewhat difficult. First, predictions of the ROA usually refer to investment triggers that are not directly observable (Odening et al., 2005). Second, ROA models are criticized because they are based on a risk-neutral valuation framework that renders subjective risk preferences obsolete (Isik, 2005). Third, econometric estimation of ROA models are hampered by heterogeneity because multiple investment options may coexist, owing to financial constraints, alongside policies that may affect farmers' investment decisions (Sckokai and Moro, 2009; Serra et al., 2009; Huettel et al., 2010). In light of these limitations, assessing investment decision-making behavior through quantitative household surveys and normative approaches is likely to be insufficient. Economic experiments are, hence, a suitable option to help fill the gap surrounding an empirical ROA validation. In experiments, all relevant variables are observable and controllable, allowing direct testing of a given theory. Rauchs and Willinger (1996), Yavas and Sirmans (2005), Denison (2009) and Oprea et al. (2009) were among the first researchers who tested the ROA in an experimental setting with students. The study closest to ours is Maart-Noelck and Musshoff (2013), who analyze the investment behavior of German farmers in an ROA experiment, without considering the effects of price guaranteeing measures.

The experiment carried out in this study considers a situation in which farmers were asked to make an investment under uncertainty, on the one hand in a treatment 'with price floor' (WPF) and on the other hand in one with 'no price floor' (NPF). We repeatedly confronted farmers with a range of investment opportunities and they were asked to decide between investing immediately, postponing, and not investing at all. The observed investment decisions were contrasted with theoretical benchmarks of the NPV and the ROA. An additional experiment based on a Holt and Laury lottery (HLL) was carried out to elicit the subjective risk preferences of participants (Holt and Laury, 2002), since the individual risk attitude is highly relevant for decision-making under uncertainty (Fellner and Maciejovsky, 2007). Particularly, it is argued that risk-averse decision-makers are possibly not willing to accept an investment with uncertain returns despite an anticipated positive net present value because their risk premium has not been covered (Isik and Khanna, 2003).

To the authors' knowledge, there has not been any application of the ROA in an experimental setting in a developing country. The main contribution of our paper stems from the fact that this type of investment experiment was conducted with small-scale farmers in a developing country. The controlled conditions of the experiment provide a better basis for the analysis of the effects of uncertainty, irreversibility, and flexibility on individual farmers' investment behavior than data collected through quantitative household surveys. Experiments, hence, increase the internal validity of empirical research (Roe and Just, 2009; Roosen and Marette, 2011). A second contribution of our paper is that we analyze the effect of a price floor on the investment behavior of farmers in a developing country in the context of the real options theory. This understanding is crucial for assessing farmers' decision-making behavior and contributes to formulating adequate predictions of the effects of (potential) future agricultural policy changes on investment behavior. A third contribution is that we measure and include the individual risk propensity of farmers to identify normative benchmarks for the investment decision. Given the relatively low levels of formal education and literacy prevalent in the sample, the original lottery by Holt and Laury (2002) was modified and rendered more accessible to farmers in developing countries.

2. Literature review

2.1. Net present value and real options approach

One standard approach for evaluating investment opportunities is the NPV. According to the NPV, a decision-maker should invest in a project if its NPV is positive and discard a project if its NPV is negative. A project's NPV is the present value of the difference between the project's value and its cost. Although the NPV framework is one of the standard approaches to investment decision-making, it has important limitations. The approach, for example, assumes that it is not possible for decision-makers to react to new information once the investment decision is taken, although many investments confer future options and management flexibility. Such flexibility may involve decisions to expand, contract, or abandon projects over the course of an investment, which can contribute significantly to the value of the project. The NPV approach also ignores flexibility with regard to the timing of an investment decision, particularly, the option to defer a project or to 'wait and see' and, hence, delay an investment decision to a future date when key determinants of the project's value are known. The NPV approach assumes that the investment decision is a now-or-never decision at a particular moment in time. The static nature of the NPV approach leads to a systematic undervaluation of investment opportunities that provide future options. Under certain circumstances, for instance, when uncertainty and flexibility are significant, the NPV approach can lead to poor policy and investment decisions (Abel and Eberly, 1994; Dixit and Pindyck, 1994; Pindyck, 1991).

The ROA, on the other hand, analyzes investment decisions in a stochastic dynamic context and typically generates results that differ from those of the classical NPV approach, particularly, because the returns required to trigger an investment increase significantly (Purvis et al., 1995). According to the ROA, an investor may increase profits by deferring an irreversible investment decision instead of