Chapter 1

General Introduction

1.1 Background

Nearly one billion people are reported to be undernourished globally, with the highest prevalence in sub-Saharan Africa (FAO, 2009; FAO, 2010). Most of the affected people live in rural areas and are mainly engaged in agricultural production, which contributes to their household income, food and nutritional security. These farmers lack access to information on new technologies and management techniques that could improve their productivity. Improving the availability of and access to suitable agricultural technologies, as well as the advancement of farmers' related skills, are paramount and remain high priority on the agenda to fight global poverty and hunger (Byerlee et al., 2009; World Bank, 2007).

Technologically induced productivity gains in locally grown staple crops can potentially help reduce poverty and food imbalances in poor countries (Lipton, 2006; World Bank, 2007). Apparently, a wide range of technologies with high expected returns to agriculture have been developed and are readily available for potential uptake (FAO, 2011). These include, among others, genetic modification and micro-propagation technologies (mainly as in vitro tissue culture) that have been specifically devised to improve crops with complex genetic makeup, which would otherwise be difficult to breed conventionally. In spite of their potential, the rate of agricultural technology uptake has been less than expected in developing countries. Adoption rates are even much lower in sub-Saharan Africa (Suri, 2011); a region that is in much need of rapid agricultural development if it is to achieve the desired development goals. This situation is worrying for economic policies geared toward enhanced food production and household incomes but also illustrates the empirical puzzle that generally motivates this research.

This thesis aims to advance the research direction of new technology adoption and impacts thereof in developing countries. Using a case of tissue culture (TC) banana technology in Kenya, this study investigates adoption behavior outcomes of a relatively knowledge and input intensive technology before relaying the technology's actual impacts on enterprise productivity and welfare outcomes. This study comes at a time of renewed attention to agricultural intensification as a priority for addressing wider development challenges. A heightened focus on food security, particularly since the upward pressures on food prices globally since 2007, has led to a flurry of responses from governments, civil society organizations, individual and group organizations. This thesis extends existing methodological foundations to empirically show that new technologies suitable for small farm sector can play a crucial role in improving agricultural productivity, household income and food security in developing countries, but that innovations are not often widely adopted due to, partly, institutional and infrastructural constraints.

The remainder of this introductory chapter is organized as follows: In the next section, literature on agricultural technology adoption and impact is reviewed with the intent to identify research gaps. Section 1.3 gives an overview of the role of agriculture and banana in Kenya and makes a case for TC banana technology introduction. Section 1.4 presents the problem statement, while section 1.5 presents the research objectives and specific research questions to be analyzed. Section 1.6 briefly describes the sampling, the data and the analytical methods used to answer the research questions posed. Finally, section 1.7 gives an overview of how the subsequent chapters of this thesis are arranged.

1.2 Agricultural Technology Adoption in Developing Countries: The Research Gap

Since the advent of the Green Revolution in the 1960s, agricultural research has been central in availing yield-increasing and cost-saving, risk-mitigating and/or quality-improving technologies to farmers in developing countries. Farmers are expected to benefit from these new technologies directly through increased food production and household incomes and indirectly through lower consumer food prices, increased rural and non-rural employment and wage effects (Byerlee et al., 2009; Datt and Ravallion, 1998). Currently, there are many agricultural innovations on the market, but researchers, governments and international donors are searching for adaptable ways that can benefit the highest number of producers worldwide.

The quest to understand the underlying foundations that stimulate technology adoption and its actual or potential benefits to welfare outcomes of farmers in developing countries has been an important research topic for several decades (Feder et al., 1985; Feder and Umali, 1993; Sunding and Zilberman, 2001). A synthesis of available literature increasingly shows that investment in agricultural technologies has positive impacts on millions of smallholder farmers in Africa and beyond (de Janvry and Sadoulet, 2002; Gollin et al., 2002; Hazell, 2005; Jama and Pizarro, 2008; Lipton, 2006; Matuschke et al., 2007; Murphy, 2007; Peacock et al., 2004; Qaim and Zilberman, 2003; Subramanian and Qaim, 2010). Despite this, there is still a gap in understanding adoption as well as its potential or actual effects of new technologies due a general lack of robust economic studies. Particularly, most new technologies require farmers to substantially change their traditional production practices in order to make significant gains. These changes entail not only intensifying input regimes but also acquiring new information regarding the successful use of the new technology. These issues are well documented in literature but lack empirical support for wider policy making.

1.2.1 Adoption analysis

Several studies have indicated that constraints to technology adoption can be endogenous (e.g., human capital, attitudes towards risk and certainty or access to financial capital) but also exogenous (e.g., agro-ecological, institutional and market infrastructure). However, this has not fully provided solutions to persistent low technology adoption rates still observed in many developing countries. With specific reference to sub-Saharan Africa, farming systems are characterized with very limited (and in some cases no) technology uptake. By 2000, for instance, Africa had adopted only 17 percent (total harvested area) of the modern maize varieties compared to 90 percent in Asia and 57 percent in Latin America (Gollin et al., 2005). Similarly, recent studies in specific African countries show that 4 percent of farmers in Côte d'Ivoire adopted new rice varieties (Diagne and Demont, 2007); 30 percent of maize farmers in Kenya use hybrid seed (Suri, 2011); less than 24 percent of farmers use fertilizer in Kenya and Ethiopia (Dercon and Christiaensen, 2011); and only 15 percent of farmers in Madagascar practiced rice intensification systems, with 40 percent of these disadopting within 5 years (Moser and Barrett, 2006).

These low rates and/or partial adoption of technology packages still challenges the traditional approaches for conducting adoption studies (Doss, 2006). In particular, considering that different technology strategies can have profound and quite different effects on outcomes (Alston et al., 1995); and that the relative effects of a technology depend on the nature of the technology in question, the structure of poverty and the policy-institutional context in which the technology is released (de Janvry and Sadoulet, 2002), it is crucial that adoption studies can identify and give explicit consideration to some rather important adoption constraints.

Among these constraints is the general notion that information dissemination drives technology adoption following a sequence of thoughts and actions (Beal and Bohlen, 1955; Rogers, 2003). Although acknowledged across the board, not much has been done to explicitly integrate the empirical significance of information dissemination processes in determining adoption outcomes at the individual and population levels. This is particularly crucial for complex technologies that require substantial adjustments to conventional production practices, which principally exemplify many agricultural innovations. Functional agricultural extension systems are responsible for agricultural information diffusion on new technologies and how to execute them. Yet, extension systems are weak in most developing countries, lacking the necessary logistical and technical capacity to deliver advice to farmers. For instance, a recent study by Somado et al. (2008) shows that out of 39 African countries, 23 percent had no extension services at all, while 31 percent relied on extension provided by external agencies. Moreover, most African countries have inefficient seed supply and distribution systems (Shiferaw et al., 2008; Tripp and Rohrbach, 2001).

The failure of these systems implies that farmers will rely on other information sources including, their own field trials, neighbors and relatives as well as members of their social networks. This means that information access is inevitably costly[1] but also generates information asymmetries in form of ambiguities and flow imperfections. Given these constraints, it is possible that action outcomes of few agents can have far-reaching implications on others. This fact is recognized in empirical adoption studies that have scrutinized peer network effects (Bandiera and Rasul, 2006; Matuschke and Qaim, 2009). However, peer network effects address only one strand of the information dissemination package; and do not fully capture the effectiveness of the disseminated information on adoption outcomes. Besides, clear distinctions between the early and later stages of the information diffusion process[2] merit recognition. The mere awareness of a technology's existence is conceptually different from having ample knowledge of a technology's performance attributes, risks and potential benefits. Indeed, some studies have pointed out that learning forces have significant impacts on adoption (Foster and Rosenzweig, 1995; Foster and Rosenzweig, 2010). Yet, how these forces influence adoption at the individual and population levels is not yet well understood. This knowledge gap is addressed in this thesis.

[1] consider traditional access means such as, transport, radio, newspapers, among others
[2] The diffusion process follows a sequence of stages: awareness, interest, evaluation, trial and adoption (Beal and Bohlen, 1955).

1.2.2 Socioeconomic impact analysis

The fact that wide adoption often has not taken place, even when the potential or actual benefits of a new technology are obvious, calls for a shift in the impact analysis framework so as to establish better foundations for future policy making. In estimating the impact of a new technology, economists normally start with the technology's effect on productivity at the farm level. Traditional impact studies rely on the superiority assumption of the new technology vis-à-vis the conventional one without giving ample considerations to heterogeneous farm and farmer characteristics across adopter and non-adopters. Such analyses may lead to suboptimal conclusions especially when new technologies are input- and/or knowledge-intensive, requiring substantial changes in traditional practices. Under such cases, it is prudent to disentangle technology effects from changes in farmer behavior, environmental and institutional factors (Barrett et al., 2004; Morris and Heisey, 2003). In this study, net technology impacts are isolated to the extent possible, while observed and unobserved heterogeneity between adopters and non-adopters is explicitly taken into account.

Even when heterogeneous characteristics across farms and individuals are considered, net productivity effects will not sufficiently explain household welfare effects. This is because positive yield impacts on profits could be mitigated to some extent by increased expenditures on inputs and intra-household labor reallocations (Foster and Rosenzweig, 2010). It is thus necessary that impact assessments also focus on broader welfare outcomes, including household incomes and food security. Past research linking agricultural technologies and welfare effects has, to some extent, focused on estimating income and the broader technology effects on poverty outcomes (Christiaensen et al., 2010; Cunguara and Darnhofer, 2011; Haggblade et al., 2007; Thirtle et al., 2003). However, there is very little empirical evidence directly linking agricultural technologies to food security. One possible reason could be that food security assessment is severely hampered by lack of low-cost and operationally reliable indicators at the household level.

The complexity in quantifying food security emanates from its multidimensionality, involving several intertwined aspects with no universal and precise measureable parameters (Barrett, 2010; Webb et al., 2006). For most of the poor, the lack of access to food is a greater problem than food availability (Sen, 1982). Agriculture's potential to generate income is as important for food security as its ability to avail local food supplies; while gender biases and other cross-cutting issues are vital for agricultural growth but also instrumental in ensuring sufficient household access to quality food (Katz, 1995; Quisumbing et al., 1995). Methods that have been proposed and used to study household food security at the micro level include those that rely on dietary recalls, anthropometric indicators, or health data (Babatunde and Qaim, 2010; Ecker and Qaim, 2010; Haddad et al., 1998; Rusike et al., 2010; Smith et al., 2006; Smith and Wiesmann, 2007) while others feature household coping strategies (Maxwell et al., 1999; Maxwell et al., 2008). However, all these methods are data-intensive and expensive to implement (de Haen et al., 2011), necessitating the development of standard and innovative but simpler and cost-effective tools that can be used widely. We contribute to the available methodologies by employing and discussing a tool for food security assessment that has not been used in impact analysis before.

1.3 The Relevance of Tissue Culture (TC) Banana Technology in Kenya

Kenya's economy is predominantly dependent on agriculture. The sector directly contributes 26 percent of the Gross Domestic Product (GDP) and another 25 percent indirectly, and employs over 40 percent of the total population and over 70 percent of the rural people. Food security and poverty remain major challenges in Kenya: over 43 percent of Kenyans are food insecure and about 46 percent—many of whom are in rural areas—live in absolute poverty (KNBS, 2007). Although agriculture contributes more than 60 percent of the total export earnings, about one-half of total agricultural output is non-marketed subsistence production of major starchy food staples, including maize, roots, tubers and bananas, among others. The agricultural sector growth