COMPLIANCE WITH INTERNATIONAL FOOD SAFETY STANDARDS: THE CASE OF GREEN BEAN PRODUCTION IN KENYAN FAMILY FARMS

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ABSTRACT

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The food safety scandals of the 1990s have led developed country governments and retailers to enact strict international food safety standards (IFSS) covering four broad areas: pesticide residue limits, worker safety, packer hygiene, and traceability. This study investigates the impact of these standards on green bean farmers in Kenya.

The first essay uses econometric analysis to examine whether transitioning to safer pesticides affects farmers' health costs of pesticide exposure, incidence of acute pesticide-induced illnesses, and use of protective gear. It finds that enforcing and monitoring developed country pesticide standards reduces the health costs of pesticide-related illnesses and also increases the use of protective gear. The essay concludes that there are health benefits to Kenyan farmers beyond the acknowledged income generation from selling to the premium developed country market.

The second essay uses survey data and econometric analysis to investigate the effect of wealth on green bean farmers' ability to obtain a contract with an exporter firm and the degree of subsequent compliance with IFSS. It finds that endowments

with physical capital, human capital, and social capital affect both the likelihood of a green bean farmer obtaining a marketing contract from an exporter firm and the subsequent degree of compliance with IFSS. While this finding implies that IFSS marginalize smallholders, related evidence indicates that developing country smallholders can avoid being marginalized by banding together and collectively investing in costly fixed assets.

The third essay uses case study techniques to analyze how small and large Kenyan green bean family farms are complying with IFSS. It finds that IFSS increase the transaction costs of producing beans and make quality verification problematic. As a result, both types of farmers use contracts to safeguard their specific investments. Buyers, on the other hand, tackle the information asymmetry of enforcing compliance with hard-to-observe IFSS requirements using closely monitored contracts, the threat of contract termination, and variable product pricing. Buyers have also required smallholders to band together into marketing groups in order to reduce monitoring costs. The essay concludes that the future of smallholders lies in banding together into cooperative groups that collectively invest in fixed and specific assets thereby attaining the scale economies needed to remain viable.

This study demonstrates that IFSS can reduce farmers' pesticide-induced morbidity. It also demonstrates that while the fixed investments needed to comply with IFSS present a major barrier to poor smallholders, such farmers can overcome this hurdle by banding together and meeting the costs of fixed investments as a group.

DEDICATION

To God whose invisible footprints dot every page.
To my mom, Catherine, who taught me the virtues of hard work and perseverance and my late dad, Henry, for teaching me the value of education.
To my wife, Ruth and our children Shaddi, Imane and Shalord for encouragement, motivation, patience and understanding.

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Above all, to the King eternal, immortal and invisible – the only God – be all the glory.

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LIST OF ACRONYMS

AFC	Agricultural Finance Cooperation
COLEACP	Liaison Committee for Europe Africa Caribbean and Pacific
COI	Cost of Illness
DC-PS	Developed Country Pesticide Standards
ES	Economies of Scale
EU	European Union
EUREP-GAP	Euro Produce Retailers Working Group Good Agricultural Practices
FPEAK	Fresh Produce Exporters Association of Kenya
HCDA	Horticultural Crops Development Authority
ICIPE	International Center for Insect Physiology and Ecology
IDRC	International Development Research Center
IFSS	International Food Safety Standards
IPM	Integrated Pest Management
KHE	Kenya Horticultural Exporters
KHFG	Karie Horticultural Farmers Group
MRL	Maximum Residue Limit
NGO	Non Governmental Organization
NRI	Natural Resources Institute
PA	Principal Agent
PAT	Principal Agent Theory
PHI	Pre-Harvest Interval
TA	Technical Assistant
TC	Transaction Cost
TCE	Transaction Cost Economics
SACCO	Savings and Credit Cooperative
UK	United Kingdom
WHO	World Health Organization
WRI	World Resources Institute

CHAPTER 1

INTRODUCTION

1.1 The era of food safety and worker protection

Developed country consumers form the main market for developing country non-traditional exports, in particular fresh export vegetables. Over the years these consumers have tended to emphasize aesthetic attributes such as color, shape and spotlessness. Spotlessness (i.e., freedom from pest injury) has been the first quality attribute against which fresh export vegetables are graded by developing country exporters. Produce with the slightest signs of pest injury do not make it past the initial farm-level grading. This emphasis on aesthetic attributes has encouraged developing country farmers to rely increasingly on heavy amounts of pesticides. Pesticide reliance has been exacerbated in humid tropical climates which encourage outbreak and rapid multiplication of pests and diseases. Heavy use of pesticides has been reported in parts of Latin America, Asia, and Africa (Mwanthi and Kimani, 1990; Ohayo-Mitoko, 1997; Thrupp et al., 1995) and heavier yet in Europe. This heavy reliance on pesticides has been accompanied by increased incidence of pesticide related acute and chronic illnesses. Revelations of widespread use of pesticides, pesticide-induced morbidity among developing country farm families and farm workers producing fresh export vegetables and the possibility of food contamination with pesticides has raised concern among developed country consumers and authorities.

The European food safety scandals of the 1990s brought to the fore another issue – that of microbial contamination of food. Major outbreaks of food borne illness in Europe in the 1990s eroded consumer confidence on the safety of their food and their governments' food safety regulatory system (Friedberg, 2004; Jaffee, 2004). The ensuing consumer anger and backlash, especially in Europe, led developed country governments to revise their food safety regulations. In Europe, for instance, the scandals led to the review of pesticide legislation and withdrawal of some of the active ingredients commonly used for pest control in developing countries. It also resulted in the enactment of Food Safety Act of 1990 in the United Kingdom (UK) hence shifting responsibility for food safety to food retailers. The shift to the retailers of responsibility for assuring food safety led major retailers (supermarkets) to develop their own protocols relating to i) pesticide residue limits in food, ii) packer hygiene and iii) traceability.

Several previous studies have covered a wide range of topics on pesticide use and farmer health in developing countries including i) health costs and acute toxicity symptom incidence related to pesticide exposure among cotton farmers (Maumbe and Swinton, 2003), ii) effect of pesticide exposure on farmers' health and productivity (Rola and Pingali, 1993), iii) epidemiology of pesticide exposure among horticultural growers (Thrupp et al.,1995; Ohayo-Mitoko, 1999) and iv) farmers' willingness to pay for reduction of exposure to toxic pesticides (Cuyno, 1999). However, these studies focus on domestic pesticide policy and do not address the effect of developed country food safety standards on developing country farmers' health and morbidity due to pesticide exposure.

Similarly, a number of authors have addressed the subject of costliness of complying with foreign standards in export vegetables (Dirven, 2001; Dolan and Humphrey, 2000; Farina and Reardon, 2000; Jensen, n.d). Some other studies have specifically analyzed how withdrawal of certain pesticides affect farmers' profits and hence production viability (Carlson, 1998); Deepak et al., 1999; Swinton and Scorsone, 1997). However, this set of studies mainly focuses on developed countries and impacts of domestic pesticide policy. The only studies that have focused on developing countries have based their estimates of costs of meeting developed country standards on expert opinions and guesstimates (Jaffee, 2004; Nyangito, 2002). Unfortunately, these case studies are not based on systematic empirical analysis of the effects of IFSS on green bean growers.

Indeed, the introduction of international food safety standards (IFSS) has given rise to the need for farmers to change their production and marketing practices. To be IFSS compliant, farmers find it necessary to: i) adopt alternative ways of managing pests, ii) adopt safer ways of handling, storing and disposing pesticides, iii) establish hygienic packing conditions, and iv) establish traceability system. The investments needed to make these changes are, in most cases, lumpy in nature and require various forms of capital. Small and large farms generally differ in their capital endowments and in the way they raise capital needed to finance new investments. Do these differences affect farmer compliance with IFSS?

In theory, IFSS if enforced, have the potential of reducing the amount of pesticides used by farmers, their exposure to these toxic chemicals and hence cost of pesticide-related illnesses. Unfortunately, there is little attention given to this topic in the literature. Specifically, there are no studies that focus on how developed consumer nation pesticide residue standards may affect developing country farmers' health and morbidity due to exposure to pesticides. Similarly, enforcement of IFSS requires capital investments, most of which are specific to green beans, yet no study has looked at the effect of capital endowments on IFSS compliance and how small and large family farms are actually meeting these developed country foods safety standards.

1.2 Study objectives and organization

The objectives of this dissertation research are to:

- Determine the effects of developed country pesticide standards on the health and morbidity of Kenyan green bean farmers,
- Investigate the effect of capital endowments on farmer compliance with IFSS, and
- Conduct an in-depth analysis of small and large green bean family farms to assess how they are complying with IFSS.

The dissertation research focuses on compliance with international food safety standards by Kenyan green bean family farms producing beans for the European market. Green bean is one of the most important fresh export vegetables from developing countries and Kenya is currently the leading supplier of French beans to Europe. European market is the leading destination market for Kenyan vegetables. For more than a decade, major retailers in this market have developed stringent food safety standards making it a suitable case to study.

The study uses survey data collected in Kenya during 2003/04 from 180 green bean family farmers stratified by compliance with IFSS. The primary data was supplemented with information generated via structured interviews with various stakeholders in Kenyan horticulture industry (e.g., pesticide traders, farmers, and officials of green bean exporters, exporters' association, farmer groups, Horticultural Crop Development Authority and Ministry of Agriculture) and information from existing sources (e.g., industry journals and reports and newspapers).

This dissertation research is organized into 3 essays. The first essay (in Chapter 2) investigates the impact of developed country pesticide standards (DC-PS) on health and morbidity of Kenyan green bean growers. DC-PS require farmers to meet specific pesticide residue limits and also ensure that pesticides are handled, stored and disposed in ways that do not threaten the health of farm workers, farm family members and other non-target plants and animals. Due to European pesticide residue limits, use of some the pesticides regarded as toxic has been withdrawn and replaced with safer ones. The safety practices promoted under DC-PS require that farmers use protective gear, store pesticides in a secured pesticide store, and dispose of pesticides in secured disposal pits, among others. Essay 1 (Chapter 2) therefore investigates the effects of these changes in pesticide use, handling, storage and disposal on health and morbidity of Kenyan green bean growers and on the use of protective gear. It uses survey regression (which controls for clustering effect on variance within a village) to estimate pesticide-induced health cost model and survey Poisson regression to estimate acute symptoms and protective gear use models.

Essay 2 (in Chapter 3) investigates whether a farmer's capital endowment including physical, human and social capital affects his/her participation in contract production of green beans and the degree of IFSS compliance. In particular this essay addresses the double hurdle problem facing contracted green bean farmers: deciding the degree of IFSSS compliance following the choice to participate in contract production of green beans. Hence in the first stage, this essay uses survey probit regression to investigate how capital endowments affect a farmer's ability to obtain a marketing contract with an exporter firm. It then uses survey Poisson regression in the second stage to examine the effect of capital endowment on the degree to which a farmer who obtains a contract will comply with IFSS.

Essay 3 (in Chapter 4) presents a systematic case study of the strategies used by small and large green bean family farms to comply with IFSS. It particularly examines how these farms are meeting the cost of IFSS fixed investments, acquiring the skills needed to meet the traceability requirements and transitioning to safer but more costly pesticides. This essay uses case study methods to test five propositions generated based on theoretical expectations. It uses transaction cost, principal-agency, and economies of size theories to formulate hypotheses that are tested against behavior of case farmers. The case study approach is chosen because it most suited for answering the how questions.

Finally, Chapter 5 presents conclusions for the three essays, with policy implications and recommendations for future research. The survey instrument used to generate quantitative data is presented in the final Appendix.

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CHAPTER 2

THE EFFECT OF DEVELOPED-COUNTRY PESTICIDE STANDARDS ON HEALTH AND PESTICIDE-INDUCED MORBIDITY OF KENYA'S GREEN BEAN FAMILY FARMERS

2.1 Introduction

Consumers in developed countries form the bulk of the market for high value fruits and vegetables from developing countries (Diop and Jaffee, 2005). Over the years their demand for produce with specific physical attributes, such as color, shape, size and spotlessness, has encouraged farmers in developing countries to rely increasingly on the use of pesticides to control pests (Thrupp et al., 1995). Increased use of pesticides in response to these developed-country consumers' demands and the resulting widespread detrimental health and ecological effects on non-target plants and animals have been reported in Latin America by Thrupp et al (1995), and Africa by Mwanthi and Makau (1991), and Ohayo-Mitoko (1997). These reports have led to growing consumer, medical health and environmental concerns. In addition, the European food safety scandals of the last two decades have eroded consumers' confidence in existing food safety regulation (Freidberg, 2004; World Bank, 2005).

In order to protect consumers and farm workers from hazards of pesticide contamination and exposure and restore consumer confidence, developed-country governments have responded by revising their regulations pertaining to the registration of pesticides and the acceptable tolerances for pesticide residues in food. Regulatory changes, together with perceived commercial risks, have in turn led private companies, especially the major supermarket chains, to develop their own standards pertaining to pesticide usage. Among other things, these standards require that: i) food products meet prescribed pesticide residue levels; and ii) care be taken by farmers to reduce exposure of farm workers and other non-target plant and animals to pesticides. In the former, emphasis is placed on consumer safety by using only approved (less toxic) pesticides and strict observance of the pre-harvest interval which prescribes the latest date for pesticide use for insuring safe residue levels. The latter requirement emphasizes farm worker safety especially safe handling, storage of pesticides and disposal, and the use of protective devices and alternative pest management practices.

Many previous studies have investigated a wide range of topics on pesticide use and farmer health in developing countries. For example Maumbe and Swinton (2003) estimated the health costs and acute toxicity symptom incidence related to pesticide exposure among cotton farmers in Zimbabwe. Rola and Pingali (1993) and Antle and Pingali (1994) studied the effect of pesticide exposure on farmers' health and productivity in the Philippines. Thrupp, et al. (1995) and Ohayo-Mitoko (1999) analyzed the epidemiology of pesticide exposure in Latin America and Kenya, respectively. Cuyno (1999) estimated rice farmers' willingness to pay for reduction of exposure to toxic pesticides in the Philippines. These studies postulated recommendations for domestic pesticide policy. None addressed the effect of developed-countries' pesticide residue standards on developing-country farmers' health and the incidence of acute symptoms of pesticide exposure.

In theory, developed-country pesticide standards (DC-PS), if enforced, could reduce exposure of developing country farmers to toxic pesticides and hence their cost of pesticide-related illnesses. Unfortunately, there are no studies that focus on the effect of developed consumer nations' pesticide standards on developing country farmers' health and morbidity due to pesticides exposure. This paper addresses the following research questions:

- What is the effect of DC-PS on cost of illnesses associated with pesticide exposure?
- Do the DC-PS affect the incidence of pesticide-related acute disease symptoms?
- What is the effect of these standards on how developing country farmers use pesticides?

This study focuses on green beans produced by Kenyan family farmers for export to the United Kingdom (UK) as fresh produce. Kenya is one of the leading exporters of green beans to the UK. Major retailers in the UK have developed private pesticide standards that directly affect the types of active substances used by its suppliers (and pesticide residue content of food products), making it a suitable case to study.

2.1.1 Green bean production and marketing in Kenya: historical overview

Green bean production in Kenya started in the 1960s and increased rapidly in the 1980s and 1990s (Kimenye, 1993; McCulloh and Ota, 2002). Production is dominated by small and medium family operated farms, mainly because of the labor intensity of its production activities. It is estimated that smallholder farmers alone accounted for 62 percent of green bean production in the early 1990s but their share has since declined to about 40 percent due among other things to DC-PS (Dolan and

Humphrey, 2000; Jensen, n.d.). Estate production of green beans is limited, being hampered by the high cost of labor monitoring and pest control, although there has been an increase in the share of medium and large family farms in the last few years (Jaffee and Masakure, 2005.

Major farm-level DC-PS driven changes in pesticide handling, use and storage in Kenya's green bean industry started in late 1990s with UK retailers requiring their Kenyan suppliers to show evidence of compliance with UK pesticide legislations. Since then, significant changes have occurred in the production and procurement of green beans from small and medium-sized family operated farms. In particular, DC-PS have caused a shift by major exporters from sourcing beans through loose contracts and spot market operations to more closely monitored contracts (Kimenye, 1994; Harris, 2001; McCulloh and Ota, 2002; Jaffee, 2004). In such contracts, farmers are organized into groups of 25-30 and closely monitored to ensure that i) they only use approved pesticides (usually less toxic to humans than ones used before), ii) they produce beans that meet UK pesticide residue limits, iii) pesticides are applied only when pest scouting reveals need to do so, and iv) pesticides are handled, used, stored and disposed off in ways that do not pose health threats to non-target plants and animals. The groups are issued a list of approved pesticides with correct dosage and preharvest interval. The provision of such information is followed by varying intensity of supervision. Based on whether or not farmers' use, handling, storage, and disposal of pesticides are closely supervised, green bean production in Kenyan family farms can therefore be categorized into "monitored" and "unmonitored" regimes. Family farmers who supply exporters that routinely monitor and enforce compliance with DC-PS comprise the monitored regime while those whose buyers do not monitor and enforce DC-PS compliance constitute the unmonitored regime.

2.1.2 Overview of pesticide use, exposure and epidemiology in export vegetables

Pesticide use can lead to health hazards for farmers, their family members and neighbors through contact or ingestion. Different classes of pesticides are used for pest and disease control in export vegetables. Over the years, relatively large quantities of toxic pesticides such as organophosphates, carbamates, organochlorines and pyrethroids have been used in fresh export vegetables, mainly in order to satisfy export markets' demand for aesthetic appeal (e.g., spotlessness) (Mwanthi and Kimani, 1990; Ohayo-Mitoko, 1997; Thrupp, et al, 1995). At the same time, most farmers, farm family members and farm workers have been careless or ignorant of the dangers of exposure to these toxic substances and therefore use and store pesticides in ways that expose them and others to their hazards (resulting in major health impairments (World health Organization, 2004).

Individuals get exposed to pesticides primarily via four routes, namely inhalation, dermal absorption, ingestion and absorption through the eyes. In practice, however, total exposure involves a combination of these primary routes. Meanwhile, pesticide exposure mechanisms differ for different individuals in a farming community. Pesticide mixers and applicators are mostly exposed through pesticide contact with exposed skin (e.g., legs, hands, arms, face and neck), especially if no protective clothing is used, inhalation of pesticide aerosol droplets or fumes, and accidental ingestion (and in some case purposeful ingestion e.g. in suicides and homicides). Most cases of accidental pesticide ingestion by mixers and applicators take place when, for example, they eat, drink and/or smoke during the mixing or spraying process (Rola and Pingali, 1993; Cole, et al, 1999). Exposure could also occur during in-store handling or use of the discarded pesticide container for domestic cooking or storage purposes.

Bystanders and farm family members are exposed to pesticides when they i) enter a sprayed field before expiration of re-entry interval (usually at least 12 hrs), ii) work in the field while it is being sprayed, iii) inhale pesticide vapors and aerosol droplets drifted by wind, iv) contact aerosol droplets on exposed skin, iv) use cooking pots, water bucket or bathing basins earlier used for mixing pesticides, v) convert pesticide containers for domestic uses, vi) store unwashed protective clothing in the house, and vii) inhale fumes from open or improperly closed containers with pesticides that are stored in the living or bedroom, especially at night (Ohayo-Mitoko, et al, 1997; Wachira-Wakwa, 1999; Rola and Pingali, 1994; Crissman, et al, 1998).

Exposure to pesticides can result in a number of acute and chronic illness symptoms. These symptoms include: i) skin irritation (e.g. rash, itching, burning or prickling), ii) eye irritation (lacrimation, conjunctivitis, impaired vision, redness), iii) stomach irritation (nausea, vomiting, diarrhea, excessive salivation, abdominal pain), and iv) respiratory irritation (chest pain, cough, running nose, wheezing, difficulties in breathing, throat irritation), v) cancer, vi) neurological problems (seizures, confusion), vii) stillbirths and abortion (Rola and Pingali, 1993; Ohayo-Mitoko, 1997;

Thrupp et al., 1995; Cuyno, 1999). How seriously these symptoms are manifested depends on the toxicity of pesticide and duration of exposure.

Farm worker pesticide exposure can be significantly averted by the use of safety measures such as a properly secured pesticide storage area, a pesticide container disposal pit and the use of protective gear during pesticide mixing and application. The use of protective gear has received particular attention in the literature dealing with pesticide exposure mitigation (Antle and Capalbo, 1994; Maumbe and Swinton, 2003). However, most developing-country farmers do not wear protective gear due to discomfort, cost, and custom (Antle and Pingali, 1994). When they do, the gear is often inappropriate, inadequate or poorly maintained (Ohayo-Mitoko, et al., 1999; Wilson and Tisdell, 2001).

2.3 Theoretical model

Consider a farm that grows vegetables for export and uses pesticides. A farm can produce under one of the two regimes, monitored or unmonitored. Under the monitored regime, the farm is supervised to ensure compliance with DC-PS, while, under the unmonitored regime, these standards are not enforced. As earlier discussed, pesticide use can affect the farmer's health status through pesticide-induced ailments. Following prior authors (Cole, 1998; Hurley et al., 2000; Strauss and Thomas, 1998), the farmer's health status can be represented as:

(1) $$h = h[f, b, e(x, d), z)]$$

where h is the health status of the farmer; f is a vector of farmer-specific characteristics that impact health status (e.g., age, gender, education, income); b are behavioral factors (e.g., smoking and alcohol consumption); e is exposure to pesticides, $e = e(x,d)$, which depends upon x, a vector of pesticide inputs used by the farm and d a vector of defensive strategies, such as exposure averting behavior (e.g., use of protective devices) and exposure mitigating strategies (e.g. use of alternative pest management practices, hand-washing and water bathing following pesticide handling and application). Lastly, z represents institutional factors such as access to extension services, pest management information and medical services.

The farm uses both pesticide and non-pesticide inputs to produce output represented as:

(2) $q = q[x, v, T, k, z]$

where q is the output of vegetables, x is a vector of pesticide inputs, v are non-pesticide inputs such as land, fertilizer; T is the total effective field labor requirement comprising effective family labor, ($l(h)$), which depends on health impairment due to pesticide exposure and hired labor (r). Following Antle and Pingali (1994), we assume that the hired labor bears the cost of health impairments due to exposure to pesticide via inability to work when sick. Finally, k and z are fixed capital inputs and institutional factors, respectively.

Output, output price and the vector of non-pesticide inputs are assumed predetermined, since vegetables produced following DC-PS are grown under contract (Jaffee and Masakure, 2005). The farmer's optimization problem therefore is to choose x, and d to minimize the combined health and production costs subject to labor availability and contracted output level and quantity q^o. That is,

$$(3) \quad \underset{x,d}{Min} \quad c(x,d) = w_x x + w_d d$$

subject to

1) $q \geq q^0$

2) $T \geq l(h) + r$

The Lagrangean expression associated with this cost minimization problem is:

$$(4) \quad L = w_x x + w_d d + \delta\{q^0 - q(.)\} + \lambda\{T - l(h) - r\}$$

The first order conditions are:

$$x\text{:} \quad w_x - \delta(\frac{\partial q}{\partial x} + \frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x}) - \lambda(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x}) = 0 \qquad (4.1)$$

$$d\text{:} \quad w_d - \delta(\frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}) - \lambda(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}) = 0 \qquad (4.2)$$

$$\delta\text{:} \quad q^0 - q\{x, v, T, k, z) = 0 \qquad (4.3)$$

$$\lambda\text{:} \quad T - l(h) - r = 0 \qquad (4.4)$$

The Lagrange multiplier δ represents the marginal value of added output while λ is the marginal cost of labor.

We assume that the cost and production functions are concave and that $h_e < 0$, $e_x > 0$, $e_d < 0$, and $l_h > 0$. Re-arranging equation 4.1 above yields:

$$(5) \quad w_x = \delta\frac{\partial q}{\partial x} + \delta\frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x} + \lambda(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial x})$$

The terms on right hand side of this expression can be interpreted as follows: the first term is the value of marginal product of pesticides. It is positive as signed. The second term is the value of marginal product of labor as affected by exposure to pesticides. This term is negative as signed. Lastly, the third term is the value of marginal product of labor as affected by reduction in effective field labor time due to health impairments caused by exposure to pesticides. This last term is negative as signed. When health effects of pesticide exposure are ignored, the second and third terms on the RHS of equation 5 become zeros which overestimates the marginal productivity of pesticides. Clearly, therefore, the overall effect of including the health effects of pesticide exposure is that it reduces the value of marginal product of pesticides. Consequently, fewer pesticides are used at the optimal level.

Similarly, the optimal level of defensive health measures is given:

(6) $$w_d = \delta\left(\frac{\partial q}{\partial l}\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}\right) + \lambda\left(\frac{\partial l}{\partial h}\frac{\partial h}{\partial e}\frac{\partial e}{\partial d}\right)$$

In this expression, the first term is the quality of labor effect (i.e., the marginal productivity of labor as affected by the use of defensive strategies) while the second term is quantity of labor effect of using defensive strategies. This effect arises from increase in productivity due to improved health of the farmer (and hence increased effective field labor time), both of which are positive as signed. The optimal level of defensive strategies therefore depends on labor availability, pesticide exposure and farmer health status. In sum, optimal pesticide use entails lower health risks, which can be achieved by i) using less toxic pesticides or ii) employing more protection from exposure.

Since the mid 1990s, a number of Kenya's leading green bean exporters have switched from supplying wholesale markets to retail markets, where meeting UK pesticide standards is mandatory (Hatanaka et al., 2005; Jaffee, 2004). As earlier indicated, these exporters govern their farmers' use, handling, storage and disposal of pesticides, and some even test farmers' beans for residue content. The exporters particularly train farmers in safe use, storage, and disposal of pesticides. In addition, these suppliers of UK retail markets have withdrawn the use by their farmers of pesticides that have been banned in the UK (and Europe) due to health hazards they pose to farmers, farm workers and consumers. As shown above, it is expected that monitored farmers are exposed to less toxic pesticides and more likely to protect themselves from exposure, and hence:

Hypothesis 1: *Monitored farmers will incur lower pesticide-induced health costs than the unmonitored farmers.*

Among practices promoted in meeting DC-PS, the most emphasized are the use of pesticide exposure averting and mitigating practices (including the use of protective gear, pest scouting, bathing after pesticide application and keeping the sprayer in good condition). These practices can reduce exposure to toxic pesticides and hence incidence of acute pesticide exposure symptoms (such as skin, stomach and eye irritations). Indeed, inadequate training on safe use, handling, use and storage of pesticide; poorly maintained sprayers; and nonuse of protective gear when mixing and applying pesticides have all been linked to the incidence and severity of acute pesticide exposure symptoms (Wilson and Tisdell, 2001). Furthermore studies indicate that due to lack of training on safe application of pesticide, farmers in developing countries often use greater quantities of pesticides (especially toxic insecticides) and also use them more frequently and haphazardly than those used in developed countries (World Resources Institute, 1999). Given that under the monitored regime farmers are trained in safe use of pesticides and required to apply them only when pest scouting reveals the need, we hypothesize that:

Hypothesis 2*: Monitored farmers will experience fewer incidences of pesticide induced acute illness symptoms than their unmonitored counterparts.*

Demand by consumers for produce free from pest and disease injury is the leading cause of heavy reliance on pesticides by developing-country farmers (Thrupp et al., 1995). Wearing protective clothing is one of the means by which farmers can protect themselves against pesticide exposure. Typical protective clothing includes a long-sleeved coat, rubber gloves, gum boots, and face-mask. Exposure to pesticides is often attributed to a failure to use protective clothing (Rola and Pingali, 1993; Cole et al, 1998; Mwanthi and Kimani, 1991). At the same time, regulations governing proper storage and disposal of pesticides and mandatory use of adequate, appropriate and well maintained protective gear are either absent or undeveloped in many developing countries (Ajayi, et al., 2002; Carlsson, 2004; Wilson and Tisdell, 2001). Consequently, toxic pesticides are often used carelessly and stored in family residences, thereby exposing farmers, farm workers and children to their hazards (Kaoneka and Akhabuhaya, 2004; World Health Organization, 2004. In addition, studies show that awareness about the dangers of pesticide exposure and the measures for reducing exposure (such as use of protective clothing) do not necessarily translate into use of protective gear (Brown, 2003; Yassin, et al., 2002). Under the monitored regime, farmers are not only trained on the importance of protective devices but are also required to use them. We therefore expect:

Hypothesis 3*: Monitoring farmers for compliance with DC-PS will induce greater use of pesticide exposure protective devices.*

2.4 Data and Empirical methods

2.4.1 Data

Data on the last crop of green beans in 2003 was collected from 180 family farmers during a primary field survey conducted between October 2003 and June 2004 in major green bean growing areas of Kenya. A list of major green bean growing villages (primary sampling units) was drawn and 30 villages that have both monitored and non-monitored farmers selected. Six farmers were then randomly sampled from each of the 30 villages stratified by compliance with DC-PS, giving a total of 180 farmers. A pre-tested questionnaire was administered on each sampled farmer separately through personal interviews. Survey interviews were conducted by the author assisted by a trained enumerator. At the beginning of each interview, the farmer was informed that he/she would be rewarded with a certificate of participation for answering all the questions truthfully. Health information was generated by first asking the respondent (farmer) to recall if he/she experienced eye, skin and or stomach irritations soon after mixing and/or applying pesticides on green beans. If the answer was in the affirmative, the farmer was asked to report, for each symptom, the number of times the symptom was experienced, days of sickness, number of visits to a local dispensary, cost of treatment per visit, travel expenses as well as costs of self treatment (e.g., buying over-the-counter medication, milk, or soup to reduce dizziness). Rural daily (market going) farm wage rate was used to convert days lost due to pesticide illness into indirect/opportunity cost of pesticide-related illness. Based on the reported pesticide used, pesticide toxicity was looked up from the World Health Organization (WHO) toxicity classification as class 1 (very toxic), class 2 (toxic), class 3 (slightly toxic) and class 4 (unharmful) (World Health Organization, 2005; Worthing and Hance, 1991). The WHO class 4 pesticides were omitted from further analysis because they are not considered to be a health hazards to users. Table 2.1 summarizes statistics for key variables. Of the 180 interviews conducted, five questionnaires were not fully completed and are dropped from further analyses, leaving 175 usable responses. Table 2.1 also presents the results of paired t tests of equality of means of key variables among the unmonitored and monitored farmers. For each test, the null hypothesis was that the mean among the unmonitored and monitored farmers are equal against the alternative that the mean of unmonitored farmers is greater than that of monitored.

2.4.2 Empirical methods

The above hypotheses are tested empirically using survey regression, with *village* as the primary sampling unit, in order to account for the clustering effect on variance within a village. To test the hypothesis that monitoring and enforcement of DC-PS reduces the cost of pesticide-related morbidity, we estimate two empirical models of cost of illness (COI) using survey regression. First, we estimate a model containing all the pesticide exposure averting and mitigating practices recommended under the monitored regime alongside farmer specific, behavioral and institutional variables. However, green bean exporters that monitor and enforce DC-PS compliance typically require their farmers to adopt certain practices that reduce exposure to pesticides and ensure compliance with residue limits as part of meeting the DC-PS requirements. So including these practices in the model along with the *regime* binary variable can lead to "double-counting". Indeed a Wald test shows that regime can substitute for some of these practices variables. We therefore estimate second a "restricted" model in which practices that are highly correlated with the *regime* variable (correlation coefficient greater than or equal to +0.1 (Appendix 1)) are dropped from the model.

The practices that are most correlated with the *regime* variable are the use of protective gear, regular maintenance and calibration of the sprayer, and scouting for pests to determine if there is need to use chemical control before spraying. These practices are more aggressively emphasized by exporters that monitor and enforce DC-PS compliance and hence can substitute for the *regime* variable. However, in a Wald test for joint exclusion of gear items worn, pest scouting, and sprayer maintenance[1], the null hypothesis of no joint effect on pesticide-induced health costs was rejected. Hence the *regime*-only model entails some loss of explanatory power. This was expected, because many unmonitored farmers are using some of the exposure-reducing practices their monitored colleagues are required to use (See Table 2.2). In particular, Table 2.2 shows that there is no major difference between

[1] We tested the null hypothesis that number of gear items worn, pest scouting, and sprayer maintenance jointly have zero coefficients in pesticide-induced cost of illness model against the alternative that at least one of the coefficients is different from zero. The p-value of this test was 0.032.

monitored and unmonitored farmers with regard to exposure practices such as eating, drinking and smoking when handling or spraying pesticides. In addition, both monitored and unmonitored farmers alike used pesticide exposure averting and mitigating practices such as bathing immediately after spraying, disposing pesticides safely, washing hands, and washing protective gear before next use.

The general form of the empirical model of health cost is specified as:

(7) $hc = hc\{G(f,b,z), e(x,d)\} + \varepsilon$

where, the dependent variable, *hc,* is the natural log of direct costs (cash/treatment) plus indirect costs (e.g. opportunity cost of time spent recuperating including travel costs to local health facility) of pesticide-induced illnesses measured in Kenya Shillings (Kshs) (We added 0.5 to cases where health cost entry was zero to permit taking the logs.); *G* is a vector of farmer generalized health status from Equation (1) including farmer-specific variables (*f*), behavioral variables (*b*) and institutional variables (*z*); and *e(.)* represents a vector of pesticide exposure variables which are in turn categorized into exposure enhancing and the exposure averting and mitigating variables. The empirical variables used in estimating equation (7) are:

1) Generalized health status:

i) farmer-specific variables (*f*) (*age, male* and *education)*;

ii) behavioral characteristics (*b*) (*alcohol intake* and *cigarette smoking*), and

iii) institutional variables (*z*) (*distance to clinic* and *regime*).

2) Exposure variables (*e*):

i) Exposure enhancing variables (x): *class2 pesticides, class3 pesticides, primary applicator and primary mixer* and,

ii) Exposure averting and mitigating variables (d): *wash gear, gear items used, pest scouting, bathe, sprayer maintenance.*

The second hypothesis about the effect of monitoring and enforcement of DC-PS on pesticide-related acute symptoms incidence is tested by estimating three survey Poisson regression models with *village* as the primary sampling unit. First, we separately estimate survey Poisson regression models for the number of self reported skin and eye irritations. Second, we estimate a total acute symptoms model that combines skin, eye and stomach irritations reported by the farmers. The general form of the empirical model of incidence of acute symptoms estimated is:

(8) $$asi = asi\{G(f, b, z), e(x, d)\} + \varepsilon$$

where *asi* is acute symptom incidence (a count of self-reported number of acute symptoms such as acute skin, eye and stomach irritations) experienced by the farmer. The empirical acute symptoms incidence model has the following explanatory variables:

1. Generalized health status (G):

i) farmer-specific variables (*male, age, education);*

ii) behavioral variable (*cigarette smoking, alcohol intake);* and

iii) institutional variables (*distance to clinic and regime*).

2. Exposure variables are (e):

i) Exposure enhancing (x): *drinks spraying, unwashed gear in house*, *class1 pesticides, class2 pesticides, class3 pesticides, primary applicator, skincontact, eatspraying* and,

ii) Exposure averting and mitigating variable (d): *sprayer maintenance, container disposal, label literacy, pest scouting, wind direction, wash hands, bathe.*

Last, we test the hypothesis that monitoring and enforcement of DC-PS increases the use of pesticide exposure protective devices by estimating a survey Poisson regression model of the number of protective devices used by the farmer. We use the number of items of protective gear worn by the farmer as a proxy for the extent of use of protective devices. The general form of the empirical model estimated is specified as:

(9) $$prodev = prodev\{G(f,b,z), e(x,d)\} + \varepsilon$$

where *prodev* is a count variable for the number of protective devices used by the farmer and the other variables are as defined above. Independent variables used in this model are similar to those used in the estimation of acute symptom incidence models (equation 8).

2.5 Results

Common pesticides used by both monitored and unmonitored farmers are organophosphates, carbamates, pyrethroids, and inorganic copper and sulfur compounds. The first three of these pesticides have been associated with many of the acute symptoms of pesticide exposure in Kenya and elsewhere (Maumbe and Swinton, 2003; Ohayo-Mitoko et al., 1999). Contrary to expectations, the types and quantities of pesticides used by monitored and unmonitored green bean growers showed little difference (Table 2.3). For example, the monitored farmers used WHO class 2 fungicides in their last crop of green beans, while their unmonitored counterparts used none. In addition, monitored farmers used more WHO class 1 insecticides per acre although the total quantity of this class of insecticides was less and total acres covered was fewer than unmonitored farmers.

The finding that there is little difference in types and quantities of pesticides used by both regimes may be due to two factors. First, exporters who monitor and enforce compliance with DC-PS place a lot of emphasis on physical appearance of green beans, which implicitly encourages chemical control of pests and diseases. Spotlessness is the first attribute by which green beans are graded against. Control of major insect pests and diseases (bean flies, bean flower thrips, and rust) continues to be a major challenge to many smallholder green bean farmers; the challenge is exacerbated by the tropical climate, which favors outbreak and rapid multiplication of pests making use of alterative pest management practices less effective. It also appears that green bean exporters who monitor and enforce DC-PS compliance indirectly promote the use of chemical control by handing farmers a weekly spray program.

The second reason for the scant difference in pesticide use between the two groups is that most unmonitored farmers follow some of the practices being enforced under DC-PS. There are three possible ways by which the unmonitored farmers have been able to "catch up" with monitored counterparts. First, a number of them may have benefited from CropLife International's Kenya Safe Use Project that ran between 1991 and 1997 and was aimed at training farmers to adopt safer ways of using and storing pesticides. The project trained approximately 50,000 coffee growers in Kenya, some of whom are now green bean growers. Second, the International Center for Insect Physiology and Ecology (ICIPE) conducted some smallholder-targeted integrated pest management campaigns in selected horticultural areas. The campaign addressed alternative pest management strategies and the dangers of pesticides. Third, some unmonitored farmers may be learning the "good agricultural practices" from family members, friends and neighbors (since the two groups live in the same villages and in some case same extended family) through a demonstration effect. There were indeed some cases where one family member was monitored for pesticide use while others were not, but they all used the same sprayer that is calibrated semiannually by the monitored farmer's buyer and the same pesticide store that the monitored family member constructed to meet DC-PS.

2.5.1 Effect of DC-PS enforcement on pesticide-related cost of illness

The results from the cost of illness models are presented in Table 2.4. The restricted model shows that enforcing compliance with developed-country pesticide residue standards significantly reduces pesticide related health costs. The direction of effect of most variables in the two models is the same, indicating that the results are robust. However, *regime* variable is insignificant in the unrestricted model presumably due to the "double counting" effect discussed above. The proceeding discussion is therefore based on the restricted model. As anticipated, the regime variable in the unrestricted model is insignificant, presumably because its effect is overshadowed by inclusion of the same practices it should capture. Other important factors that reduce health costs of pesticide exposure among farmer specific and institutional variables are education, distance to health facility and income. An additional year of education reduces health costs of pesticide exposure by close to 18 percent.

Results show also that the elasticity of health cost with respect to distance to health clinic is -0.552, indicating that proximity to clinic reduces health costs of pesticide induced illnesses. On the other hand, the elasticity of health cost with respect total family income is 0.405, indicating that a 10 percent increase in family income would boost pesticide related health expenditures by 41 percent. Increase in total family income therefore increases the amount allocated to medical care. This finding is in line with existing literature suggesting that health is a luxury good in developing countries (Mcguire and Serra, 2005). In addition, the restricted model shows that primary pesticide mixers incur higher health costs. Although not surprising, it corroborates previous findings by Harper and Zilberman (1992) for the US agriculture.

Among the exposure mitigating and averting strategies, the restricted model shows that applicators who change clothing contaminated by pesticide leak and wash of the pesticides from their bodies (*change clothing*) experience lower cost of pesticide illness than those who do not, presumably because they reduce skin contact with pesticides. However, washing the gear before next use (*wash gear*) increases the cost of pesticide related sickness. While this finding is contrary to expectations, it may be indicative of exposure to pesticides during the washing of contaminated clothes.

2.5.2 Effect of monitoring and enforcement of DC-PS compliance on acute pesticide-exposure symptoms

The significant effect of pesticide related health costs of exposure averting and mitigating expenditures is likely linked to specific illness symptoms. Table 2.5 indicates that unmonitored farmers reported a higher incidence of pesticide-related illness symptoms than monitored farmers in seven out of eight illness categories. Clearly, there are differences in the number of skin and eye irritations[2] reported by the two groups of farmers. Monitored farmers experience fewer incidences of these acute illnesses than their unmonitored counterparts. The same is true for common pesticide related illnesses e.g., dizziness and nausea.

Table 2.6 gives the results of survey Poisson regression models fitted to determine if monitoring and enforcement of DC-PS has significant effects on the incidence of pesticide-related acute symptoms. Following the earlier format, we estimate both the unrestricted and restricted models. The unrestricted model contains all the variables based on theoretical expectations.

The restricted model, on the other hand, explicitly omits the practices variables that are most closely correlated with DC-PS monitoring (namely, pest scouting, sprayer maintenance and use of protective gear). In addition, other practices

[2] Data on gastrointestinal irritations are not presented separately because only a few farmers reported experiencing them. However, they are included in the total symptoms data.

variables (e.g., eating while applying pesticides, observing wind direction, hand washing, public extension, pesticide container disposal) were dropped after a Wald test revealed that they explain very little of the variability in total acute symptoms incidence (p-value = 0.658). As shown in Table 2.6, the signs on coefficients of both restricted and unrestricted models as the same, indicating that results are robust. We, however, focus on the restricted model which addresses the possible problem of "double counting".

As hypothesized, the restricted model shows that enforcing compliance with DC-PS reduces reported total acute symptoms (i.e., skin, gastrointestinal and eye) of pesticide poisoning. Other things equal, monitored farmers experience over 50 percent fewer incidences of total irritations than unmonitored.

The other farmer specific and institutional variables affecting the incidence of acute symptoms of pesticide exposure are gender and education. Male farmers reported experiencing greater incidence of pesticide poisoning than females. This finding is probably because pesticide handling (mixing and application) is done mostly by males. Farmer's education, on the other hand, reduces the total number of acute symptoms reported by the farmers. An additional year of education lowers the self-reported total irritations by 21 percent.

Of the exposure enhancing practices, keeping unwashed protective gear in the family residence (*unwashed gear in house*), skin contact with pesticides during handling (*skin contact*) and taking a drink while spraying significantly increase the risk of exposure to pesticides and hence acute symptom incidences. In addition, the results show that both primary mixers and applicators of pesticides experience greater incidence of pesticide poisoning.

Among the exposure averting and mitigating practices, label literacy and changing clothing contaminated by pesticide leakage followed by washing of pesticides from exposed skin (*change clothing*) affect acute symptoms incidence. In particular, farmers who change contaminated clothing and wash off pesticide from exposed skin experience 7 percent fewer incidences of pesticide poisoning than those who do not. At the same time, farmers' ability to read and follow pesticide label instructions (*label literacy*) reduces incidence of pesticide poisoning. Taken together with education, the fact that more literate farmers experience fewer acute symptoms incidence implies that illiteracy increases the risk of exposure to pesticides.

2.5.3 Effect of monitoring and enforcement DC-PS compliance on the use of protective devices

The use of protective devices (especially the protective gear) stands out as one of the main pesticide exposure averting practices that is significant in reducing the cost of pesticide-related morbidity through reduction in the incidence of skin irritations among green bean growers in Kenya. Does enforcement of developed-country pesticide residue standards affect the use of these devices?

In order to address the above question, we fit two survey Poisson regression models. First, we estimate the unrestricted model in which the explanatory variables are included based on *a priori* theoretical expectations. For instance, theoretically we expect that a pesticide applicator who observes wind direction could decide not to use the full gear because observing wind direction reduces his exposure to pesticides. Similarly an applicator could neglect to use the full gear arguing that even if the skin gets exposed, taking a bath following pesticide application would eliminate the danger. Hence based purely on theoretical expectations, we include nine explanatory variables in the unrestricted model. The variables included based on theoretical expectations are farmer-specific variables (cigarette smoking and alcohol intake), exposure enhancing practices (skin contact with pesticides, using mixing container for domestic purposes and sprayer leaks), and exposure averting and mitigating practices (observing wind direction, bathing after pesticide application, bathing immediately if sprayer leaks on the back, and washing the gear before next use). However, all these variables turn out to be individually insignificant even at the 10 percent level. We therefore performed a Wald test of joint insignificance on these nine variables. The p-value of the Wald test is 0.9495, indicating that these variables add very little information in the unrestricted model. Based on these results, we estimate a restricted model in which all the nine variables are dropped. As explained earlier, we also drop the variables for practices emphasized under DC-PS, i.e., pest scouting and sprayer maintenance. The Wald test for joint exclusion of these two variables gave a p-value of 0.045. Table 2.7 presents the results of both models. The remainder of the discussion on this section is based on the restricted model.

As hypothesized, monitoring and enforcement of the DC-PS do have significant effect on the number of protective gear items used by green bean growers. Other factors being equal, monitored farmers use more gear items than the unmonitored farmers as shown by the restricted model. Results also show that the elasticity of number of gear items used with respect to age is -0.300 which implies that older people use less protective devices. This finding may, however, be because spraying is normally done by younger people, especially men.

Among the pesticide exposure enhancing practices, only label literacy affects the use of protective gear. It increases the number of gear items used by a farmer. An additional color-band of the pesticide label correctly interpreted by the farmer increases the number of gear items used by the farmer by about 8 percent. In addition, the restricted model shows that the costliness of the protective gear, the discomfort of using it in a hot tropical climate, and the feeling among farmers that using full gear slows the speed of spraying individually reduce the number of protective gear items used by green bean growers. These findings corroborate those of similar previous studies in the Philippines and Central America (Antle and Pingali, 1994; Mauceri, et al., 2005).

2.6 Conclusions

This study contributes to the growing literature on effects of pesticide use on farmer health by looking at the effect of developed-country pesticide standards on farmers' cost of pesticide-related illnesses and use of defensive strategies. It demonstrates that private regulation of pesticide use through buyer enforcement of DC-PS coupled with education and pesticide safe use training available to monitored farmers work together to reduce the cost of pesticide-related illness. This finding supports evidence from other developing countries indicating that effective solution of farmer health problems associated with pesticide use requires a combination of policies (Antle and Capalbo, 1995).

These findings imply that DC-PS standards have health benefits to Kenyan farmers beyond the acknowledged income gains from selling to the premium European produce market. The findings of this study therefore refute the common argument by exporting country governments that DC-PS have no tangible benefits to farmers (Murimi, 2004). The possibility of endogeneity among monitored farmers could, however, limit the potential impacts of policy with non-monitored farmers. Never the less, one area of future research would be to investigate to what extent the “good practices” promoted under DC-PS spill over into production of domestically marketed produce such as tomatoes, which normally requires heavy use of pesticides, and whether monitored farmers obtain the same benefits when growing tomatoes and other export crops.

This study also demonstrates the importance of education and literacy in promoting the use of protective gear (hence safe use and handling of pesticides), which in turn reduces exposure to toxic pesticides, the accompanying incidence of pesticide-related acute illnesses, and hence pesticide exposure health costs. The implication of this finding is that more effort should be directed at training farmers in the safe use and handling of pesticides. Related to this are the findings of studies done elsewhere, indicating that farmers who are informed about the health effects of pesticide exposure might hire pesticide applicators as a defensive strategy. This strategy was not investigated in this study due to lack of information. Future research should therefore specifically investigate if some farmers intentionally hire pesticide applicators as way of protecting themselves from the pesticide induced illnesses.

Finally, the finding that DC-PS has health benefits to farmers presents an opportunity for the Kenyan government to work with exporters to reduce the health hazards of pesticide exposure among growers of export vegetables. In particular, the government should target unmonitored farmers who still use large quantities of toxic pesticides. Providing institutional support farmers need to mobilize themselves farmers into farmer groups and linking such groups with exporters while also encouraging exporters to enforce DC-PS would be one way to get unmonitored farmers to use and handle pesticides judiciously while connecting them to attractive marketing opportunities. The success of such exercise will, however, depend on continued availability of market to absorb expanded bean volume from such groups.

Table 2.1: Definition and summary statistics of the variables used in empirical estimations, Kenyan green bean growers, 2004.

Variable	Monitored		Unmonitored		Test of Means	
	Mean	Std. Dev	Mean	Std Dev	t-stat	p-val
Dependent variables						
Health cost (Kshs)	186	253	261	247	1.536	0.063
Skin irritations (count)	2	3	3	5	1.892	0.030
Eye irritations (count)	1	3	1	3	0.888	0.188
Total irritations (count)	3	5	4	8	1.632	0.052
Protective gear (count)	3	1	1	1	-8.127	0.000
Farmer specific and institutional variables						
Farmer's age (years)	39.9	11.2	37.3	12.1	-1.482	0.070
Male farmer (0,1)	0.8	0.4	0.8	0.4	0.226	0.411
Education (years)	8.4	3.5	10.0	2.9	1.071	0.857
Alcohol intake (years)	6.6	10.4	5.1	8.4	-1.061	0.145
Cigarette smoking (years)	10.5	18.0	9.7	16.4	-0.337	0.353
Exposure enhancing variables						
Class 1 pesticides (grams)	40	388	85	512	1.144	0.127
Class 2 pesticides (grams)	711	978	749	865	1.400	0.082
Class 3 pesticides (grams)	263	620	551	1436	-0.222	0.059
Eat spraying (0,1)	0.2	0.3	0.1	0.3	0.759	0.225
Drink spraying (0,1)	0.2	0.4	0.1	0.3	-0.890	0.187
Unwashed gear in hse (0,1)	0.3	0.4	0.3	0.5	0.589	0.292
Primary applicator (0,1)	0.5	0.5	0.6	0.5	1.254	0.100
Skin contact (0,1)	0.8	0.4	0.9	0.4	0.268	0.083
Exposure averting and mitigating variables						
Wind direction (0,1)	0.6	0.5	0.7	0.5	0.171	0.395
Wash hands (0,1)	0.8	0.4	0.8	0.4	0.986	0.837
Wash gear (0,1)	0.7	0.5	0.7	0.5	-0.303	0.432
First-aid knowledge (0,1)	0.6	0.5	0.6	0.5	0.014	0.506
Bathe (0,1)	0.2	0.4	0.2	0.4	0.526	0.700
Container disposal (0,1)	0.9	0.3	0.9	0.3	-0.482	0.512
# of times sprayer maintained	1.0	1.5	0.6	1.3	-2.288	0.012
Label literacy*	0.6	1.4	0.2	0.3	-4.812	0.000

Source: Author's survey, 2004; * is a count of number of pesticide container color bands correctly interpreted by the farmer.

Table 2.2: Comparison of pesticide exposure practices among Kenya's monitored and unmonitored green bean family farmers, Machakos and Kerugoya Districts, 2004

	Monitored (n = 92)		Unmonitored (n = 85)	
Pesticide exposure practices	Count	%	Count	%
Exposure enhancing practices				
Mixing container used at home	4	04	11	13
Smokes inside pesticide store	14	15	11	13
Sprays when others in the plot	6	07	8	10
Eats applying pesticides	6	07	8	10
Drinks applying pesticides	16	17	10	13
Keeps gear in hse before washing	23	26	24	30
Exposure averting and mitigating practices				
Bathes immediately after spraying	76	83	71	86
Stores pesticides safely	41	45	32	39
Scouts for pests before spraying	72	78	51	62
Disposes pesticide containers safely	82	89	72	87
Inspects sprayer before use	87	95	76	93
Washes hands with soap	89	97	77	93
Has secured pesticides store	50	54	32	38
Washes gear before next use	55	69	63	66
Average # of gear items used	3	1		
Average # of sprayer maintenance	2	0		

Source: Author's survey, 2004

Table 2.3: Aggregate pesticide use by green bean growers in Kenya by regime, 2004

Pesticide Type	WHO toxicity class	Regime	Total a.i.* (grams)	Total acres	Average a.i. (gram/acre)
Fungicides	Very toxic (1)	Monitored	0.0	0.0	0.0
		Unmonitored	0.0	0.0	0.0
	Toxic (2)	Monitored	2531.0	5.0	506.2
		Unmonitored	0.0	0.0	0.0
	Slightly toxic (3)	Monitored	27869.0	14.5	1922.0
		Unmonitored	62525.0	10.1	6172.3
Insecticides	Very toxic (1)	Monitored	3600.0	1.8	2057.1
		Unmonitored	6970.0	4.3	1640.0
	Toxic (2)	Monitored	65905.0	94.4	698.4
		Unmonitored	63799.5	73.4	868.8
	Slightly toxic (3)	Monitored	752.3	3.8	200.6
		Unmonitored	968.0	2.0	484.0

Source: Author's survey, 2004 ; * a.i. = active ingredients

Table 2.4: Determinants of pesticide-related health costs among Kenyan green bean growers, 2004 - Survey regression

Dependent variable: Natural log of farmer's direct and indirect health costs of pesticide exposure in Kenya Shillings[3]

Independent variables	Unrestricted model		Restricted model	
	Coefficient	p-value	Coefficient	p-value
Farmer specific and institutional variables				
male	-0.488	0.446	-0.537	0.419
log age	-1.603	0.029	-1.486	0.031
education	-0.150	0.083	-0.176	0.024
log income	0.468	0.405	0.045	0.069
log clinic	-0.463	0.031	-0.552	0.018
cigarette	-1.020	0.074	-0.834	0.091
alcohol	0.837	0.057	0.858	0.069
regime	-0.525	0.144	-0.870	0.014
Exposure enhancing variables				
log class 1 pesticides	0.045	0.689	0.045	0.664
log class 2 pesticides	-0.025	0.891	-0.033	0.870
log class 3 pesticides	-0.037	0.491	-0.025	0.658
primary mixer	1.587	0.003	1.728	0.001
primary applicator	0.478	0.294	0.302	0.541
Exposure averting and mitigating variables				
wash gear	-0.858	0.009	0.710	0.044
change clothing	-0.859	0.076	-1.085	0.032
gear items worn	-0.219	0.015	--	--
pest scouting	-1.022	0.028	--	--
sprayer maintenance	-0.121	0.524	--	--
constant	7.281	0.085	7.167	0.008
F statistic	13.780		5.970	
p-value	0.000		0.001	
R-squared	0.291		0.235	
N	175		175	

Source: Author's survey, 2004.

[3] US$ 1.00 = Kshs. 78. In cases where health cost was zero, we added 0.5 to be able to take the logs.

Table 2.5: Self-reported acute and chronic symptoms of pesticide exposure among green bean growers in Kenya by regime, 2004

Symptom	Monitored (n = 92)		Unmonitored (n = 83)		Total (n = 175)	
	Sum	%	Sum	%	Sum	%
Acute symptoms						
Skin irritation	145	39.5	222	60.5	367	100
Eye irritation	77	42.8	103	57.2	180	100
Diarrhea	35	44.4	28	55.6	63	100
Other common symptoms						
Dizziness	82	43.3	107	56.7	189	100
Nausea	23	26.4	67	73.6	90	100
Colds	303	48.9	317	51.1	620	100
Headaches	54	41.5	76	58.5	130	100
Blurred vision	36	62.1	22	37.9	58	100

Source: Author's survey, 2004

Table 2.6: Determinants of pesticide-related acute symptoms incidence among green bean growers in Kenya, 2004, survey Poisson regression

Dependent variable: Count/number of total acute symptoms[4] incidences experienced

Independent variables	Unrestricted model		Restricted Model	
	Coeff.	p-value	Coeff.	p-value
Farmer-specific and institutional variables				
male	1.002	0.050	0.925	0.092
log age	0.412	0.445	0.337	0.520
education	-0.191	0.071	-0.214	0.053
cigarette smoking	-0.361	0.003	-0.281	0.004
alcohol intake	0.156	0.061	0.137	0.064
clinic	0.227	0.358	0.218	0.258
regime	-0.617	0.009	-0.601	0.013
Exposure enhancing variables				
drinks spraying	0.989	0.009	0.937	0.000
unwashed gear in hse	0.849	0.001`	0.842	0.012
log class1 pesticides	-0.027	0.717	-0.014	0.972
log class2 pesticides	0.172	0.245	0.155	0.332
log class3 pesticides	-0.085	0.042	-0.092	0.125
primary applicator	0.855	0.025	0.696	0.033
primary mixer	0.818	0.126	0.801	0.089
skin contact	1.151	0.062	1.364	0.040
eats spraying	0.115	0.674	--	--
smoke spraying	0.261	0.352	--	--
Exposure averting and mitigating variables				
container disposal	0.442	0.212	--	--
label literacy	-0.595	0.017	-0.576	0.022
wind direction	0. 340	0.202	0.303	0.186
wash hands	-0.009	0.336	--	--
change clothing	-0.812	0.076	0.741	0.076
Special mixing container	-0.711	0.068	--	--
distance to market	-0.191	0.318	-052	0.485
extension	-0.003	0.703	--	0.616
pest scouting	-0.340	0.004	--	--
gear	-0.219	0.310	--	--
sprayer maintenance	-0.039	0.782	--	--
intercept	-9.057	0.181	-3.692	0.075
N	165		165	
F	2.71		7.17	
p-value	0.305		0.001	

Source: Author's survey, 2004.

[4] Sum of self-reported skin, eye, and gastro-intestinal irritations experienced by the farmer following pesticide application on green beans.

Table 2.7: Determinants of the number protective gear items among Kenyan green bean growers, 2004, survey Poisson regression

Dependent variable: Number of items of the protective gear used by the farmer

Independent variables	Unrestricted model		Restricted model	
	Coefficient	p-value	Coefficient	p-value
Farmer specific and institutional variables				
male	-0.101	0.556	-0.069	0.657
log age	-0.341	0.049	-0.300	0.069
education	0.025	0.499	-0.012	0.892
log income	-0.015	0.753	-0.009	0.819
alcohol intake	-0.085	0.785	--	--
cigarette smoking	-0.020	0.120	--	--
plot size	-0.020	0.053	-0.010	0.314
regime	0.722	0.000	0.749	0.000
Exposure enhancing variables				
primary pesticide mixer	0.203	0.244	0.159	0.312
primary applicator	-0.069	0.635	-0.112	0.364
log class 1 pesticides	-0.054	0.190	-0.044	0.270
log class 2 pesticides	0.021	0.411	0.022	0.431
log class 3 pesticides	0.003	0.866	0.005	0.747
label literacy	0.068	0.033	0.083	0.003
eat spraying	0.201	0.105	--	--
sprayer leaks	-0.164	0.470	--	--
skin contact	-0.083	0.540	--	--
Exposure averting and mitigating variables				
gear too costly	-0.252	0.029	-0.305	0.024
gear discomfort	-0.277	0.022	-0.245	0.005
gear slows work	-0.459	0.035	-0.5434	0.005
pest scouting	0.106	0.393	--	--
sprayer maintenance	-0.066	0.085	--	--
change clothing	-0.145	0.542	--	--
washes gear before next use	-0.004	0.975	--	--
bathes after spraying	-0.059	0.719	--	--
observes wind direction	-0.004	0.958	--	--
constant	1.819	0.121	1.715	0.060
N	175		175	
F statistic	4.42		11.43	
p-value	0.201		0.000	

Source: Author's survey, 2004

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Appendix 2.1: Correlation matrix of key DC-PS practices variables among Kenyan green bean farmers, 2004

	regime	sprayer	gear	scout	applic	mixer	class1	class2	class3	washge	bathe	eatdr	ctnrdisp
regime	1.000												
sprayer	0.176	1.000											
gear	0.523	0.251	1.000										
scout	0.170	0.162	0.193	1.000									
applic	-0.090	-0.163	-0.007	0.061	1.000								
mixer	-0.010	-0.169	0.076	-0.068	0.640	1.000							
class1	-0.086	0.111	-0.131	0.038	-0.032	0.042	1.000						
class2	-0.105	0.047	-0.028	-0.131	0.041	0.020	-0.067	1.000					
class3	0.009	-0.049	0.011	-0.042	0.002	0.013	0.189	0.018	1.000				
washge	0.032	-0.045	0.032	0.137	0.129	0.082	0.049	0.002	0.013	1.000			
bathe	-0.028	0.099	-0.021	0.210	0.082	0.070	0.024	0.017	-0.004	0.053	1.000		
eatdr	-0.056	-0.081	0.006	0.100	-0.046	-0.016	0.033	-0.089	0.004	-0.028	-0.164	1.000	
ctnrdisp	0.035	0.02	-0.008	0.147	0.003	0.061	0.026	-0.097	-0.131	0.092	0.230	-0.019	1.000

Key:
sprayer = sprayer maintenance; scout = pest scouting; applic = primary applicant; mixer = primary mixer; class1-3 = toxicity class 1-3; washge = washing gear; eat = eat or drink while spraying; ctnrd = safe disposal pesticide containers

CHAPTER 3

DO INTERNATIONAL FOOD SAFETY STANDARDS MARGINALIZE THE POOR? EVIDENCE FROM KENYAN GREEN BEAN FAMILY FARMERS

3.1 Introduction

Food safety scandals and ensuing consumer concerns over food contamination by microorganisms and pesticides have led European governments to enact stringent food safety regulations (Freidberg, 2004). Fresh produce retailers in the European Union (EU), especially supermarkets, have responded by developing their own protocols and passing them downstream to developing-country exporters (Jaffee, 2004). For some developing country exporters, these upstream changes have meant that produce must be sourced through tightly coordinated contracts. Under such contracts developing country exporters impose strict pesticide use and handling conditions in addition to requiring that growers establish traceability systems and sanitary standards (Jaffee and Masakure, 2005).

What impact do these demanding international food safety standards (IFSS) and intensified oversight have on developing country smallholders who often have poor access to capital? For contracted farmers, meeting IFSS is a prerequisite for staying in business. Yet, to meet IFSS implies i) incurring higher variable costs (e.g., switch to new and safer but more costly pesticides), ii) investing in costly medium and long-term assets such as a grading shed, hessian/charcoal cooler, pesticide disposal pit and pesticide storage area and iii) keeping technical records of pesticide use and application.

The high capital needs of making these adjustments have led to growing concern that IFSS will exclude smallholder[5] farmers from the lucrative fresh export business (Dolan and Humphrey, 2000; Farina and Reardon, 2000). Farina and Reardon (2000) document the threat to smallholder dairy farmers in Brazil and Argentina following the introduction of safety standards by multinational companies that demanded adoption of farm level milk cooling facilities by farmers. In Kenya there is growing anxiety that thousands of smallholders may be driven out of fresh export business by strict implementation of European pesticide residue limits, hygiene and traceability requirements (Mungai, 2004). Friedberg (2004) cautions that many Zambian smallholder fresh export vegetable growers are likely to be excluded from the export business due to inability to invest in the costly cooling facilities and traceability systems demanded by major European retailers. Despite these concerns, there are as yet no studies that empirically investigate whether access to export contracts is biased against smallholder farmers in developing countries. In particular:

- What factors affect a farmer's ability to obtain a contract with an exporter firm?
- Are there wealth differences between contracted and non contracted farmers?
- What factors apart from access to a contract determine the degree to which farmers will comply with IFSS?

This essay focuses on Kenyan green bean family farms producing beans for export to the United Kingdom (UK). Kenya is the leading supplier of green beans to UK and has undertaken considerable changes in its production and farm level

[5] Following Kimenye (1993), we define small-scale green bean holding to be less than or equal 1 acre and large scale to be greater than 7 acres.

postharvest practices in response to the challenges posed by international food safety standards (Jaffee and Masakure, 2005). At the production level, farmers that supply UK supermarkets have had to make costly investments in medium and long term facilities to remain in business. These investments require considerable capital investments yet most green bean producers tend to be smallholders. On the other hand, major UK retailers have, over the past decade, developed stringent food safety codes of practice. These codes of practice require strict adherence to IFSS and are enforced through third party certification and unannounced inspection of farmers. Kenya and the UK therefore provide interesting cases to study.

3.2 Theoretical framework

This study uses principal-agent theory to derive the optimal contract between the buyer for an export farm (the principal) and a farmer who chooses to participate in contract production (the agent). It then uses theory of the firm to derive the farmer's choice of the degree of compliance with IFSS.

3.2.1 Farmer participation in contract production

Consider a farmer producing an export crop under contract for a buyer who demands compliance with a set of quality standards. Compliance with the buyer's quality standards requires choosing a set management practices for IFSS compliance[6] $m \in M$ which are costly to the farmer but at the same time cannot be directly

[6] From now on we refer to management practices for IFSS compliance simply as management practices.

observed or verified by the buyer. The set *M* includes the type and level of pesticide used, the pre-harvest interval, maintaining proper hygiene in the grading facility, keeping accurate records of pesticide use. Suppose also that besides the unobservable management practices, all other information relevant for completing exchange between the buyer and the farmer is common knowledge (i.e., known to both parties). In particular, the buyer knows the utility function of the farmer (Macho-Stadler and Perez-Castrillo, 2001). This crop contracting relationship can be analyzed by applying principal-agent theory in which the buyer (principal) contracts with a farmer (agent) to grow an export crop. The relationship between the buyer and farmer is characterized by a moral hazard problem because the actions of the farmer are hidden to the buyer.

In what follows, let θ be the state of nature that, together with the farmer's choice of management practices, jointly determine the outcome $q = q(m, \theta)$ and the principal's monetary payoff $\pi = \pi(m, \theta)$. θ can be interpreted as the stochastic shocks from weather and pest attack outbreak on the outcome q. The outcome q can be interpreted as the yield of the export crop. Due to the effect of θ, the principal has no way of telling whether low yield was due to lack of effort in complying with the quality standards or bad luck. Assume that the buyer and farmer's preferences can be expressed as von Neuman-Morgenstern utility functions given by $B(.)$ and $U(.)$, respectively, and that the following properties hold for their partial derivatives: $B'(.) > 0; B''(.) \leq 0; U'(.) > 0; U''(.) < 0$. That is, the buyer's and farmer's utility functions are concave, the buyer is either risk averse or risk neutral, and the farmer is strictly risk averse. Let $r(q) = pq(.)$ be the farmer's monetary remuneration and $c(m)$ be the cost to the farmer of choosing management practices required to meet the buyer's quality standards, that is, compliance cost. The buyer's and farmer's total utility are therefore given by $B(.) = B\{\pi(m, \theta) - r(q)\}$ and $U(.) = U\{r(q)) - c(m)\}$, respectively. Finally, following previous literature, we assume that q and θ have a joint distribution function $F(q, \theta)$ whose density function is $f(q,\theta)$ and that $F'(.) \leq 0$ (Holmstrom, 1979; Mascollel, et al., 1995).

The buyer's goal is to maximize expected utility. However in doing so it has to motivate the farmer to accept to participate in the contract and, having accepted the contract, to choose management practices that are consistent with the buyer's desires (i.e., choose management practices that are consistent with the desired quality standards). The buyer therefore has to write a contract that anticipates the farmer's behavior (Macho-Stadler and Perez-Castrillo, 2001). The buyer's problem therefore is to

(1) $\max_{r(q)} \int B(\pi - r(q)) f(q;m)dq$

subject to,

(2) $\int U\{r(q) - c(m)\} f(q;m)dq \geq U^0$

(3) m solves $\max_{m^*} \int U\{r(q) - c(m^*)\} f(q;m^*)dq$

where U^o is the farmer's reservation utility and m^* is the desired (optimal) set of management practices.

When binding, the first constraint (the participation constraint) insures that the farmer wishes to participate in contract production of the export crop because his expected utility from doing so is at least equal to what he would get by engaging in some alternative activity (including production of the same crop without contracting with the same exporter). The second constraint (incentive compatibility constraint) insures that the farmer's goals are aligned to the buyer's in that he will choose actions that result in compliance with quality standards.

The solution to the above optimization problem yields the optimal contract given by (p^*, q^*). The optimal contract does not include *a* (farmer's actions) as part of its arguments since the actions of the farmer are not observable and hence can not be verified by a court of law. Given that the optimal contract offers the farmer a payoff at least equal to his reservation utility and has a built-in incentive mechanism to align his goals with the buyer's, the farmer will accept the contract and choose the set of management practices desired by the buyer.

Assume now that the farmer's output is defined according to Hayami and Otsuka (1993) and Sadoulet and de Janvry (1995) as:

(4) $q = \theta q(m, m_{-1}, z, k),$

where, $m \in M$ is a vector of management practices needed to comply with buyer's quality standards, m_{-1} is a vector of other inputs, z is a vector of institutional variables, and k is vector of fixed and quasi-fixed capital. The factors affecting whether a farmer participates in contract production of the export crop can therefore be expressed as:

(5) $contract = contract(p, w, w_{-1}, z, k)$

where w and w_{-1} are vectors of prices of management practices and other inputs, respectively.

Buyers who contract with smallholders incur higher transaction costs than those who do not. The high transaction costs arise from costs of screening farmers, negotiating individual contracts, monitoring and enforcing contractual arrangements, and costs of renegotiating contracts. The demands by major European retailers for food safety assurance by suppliers and the need to establish traceability put further pressure on buyers to prefer working with farmers who can make the investments needed to meet these requirements. Previous studies indicate that the need to comply with IFSS requirements has led Zambian, Kenyan and Zimbabwean fresh vegetable exporters to require their outgrowers to hire technical assistants (especially entomologists or agronomists and recordkeepers) and invest in on-farm cooling and grading facilities and pesticide stores (Dolan and Humphrey, 2000; Friedberg, 2004). These requirements are likely to favor larger farms, which tend to have access to cheaper debt and equity capital, and therefore are more likely able to afford to hire trained technicians (Collins, 1995; Key and Runsten, 1999). We therefore hypothesize that:

Hypothesis 1: An increase in farmer wealth will increase the likelihood of getting a contract from an exporter firm.

3.2.2 Degree of compliance with IFSS

Once a farmer has settled on participating in contract production, the next question the farmer must address is how to combine the various production factors to produce the vegetables of quality specified under the contract. That is, the farmer must now choose the optimal actions m and other inputs m_{-1} to maximize expected restricted profit subject to producing output level q^0 specified under contract. This optimization problem can be expressed as:

$$(6) \quad \max_{m,m_{-1}} \; E\{p\theta q(m, m_{-1}, z, k) - c(m, z, k) - c(m_{-1}, z, k)\}$$

s.t. $q(.) = q^0$

The solution to this optimization problem yields input demand functions. In particular, demand for the management practices needed to meet the buyer's quality standards is given by

$$(7) \quad m = m(p, w, z, k)$$

Equation 7 is essentially an adoption function. It implies that a farmer's adoption of management practices specified under IFSS is a function of incentives (*p* and *w*) and capacity (*z* and *k*). In particular, a farmer's decision to adopt a set of management practices that require investment in costly facilities will depend on whether he or she has access to capital (Orr, 2003). Hence we hypothesize that:

Hypothesis 2: The degree to which a farmer with an export contract complies with IFSS will be greater the higher the capital endowment.

3.3 Empirical methods and data

3.3.1 Empirical model of participation in contract production

To identify the factors that condition participation in contract production, we cast the problem as an adoption problem. A farmer will adopt contract production that requires compliance with specific quality standards if the expected utility from contract production exceeds that from production outside a contract. Farmers' expectations are affected by, among other things, farmer characteristics, access to information, and endowments with fixed and quasi-fixed capital Mauceri, et al., 2005; Orr, 2003). Following from section 2.1, the general model of participation in contract production of green beans is expressed as:

(8) $contract = contract(w^o, f, z, k)+e$,

where *contract* is a dummy variable for participation in contract production of the export crop, w^o (i.e., w and w_{-1} combined) is vector of input prices (proxied by market distance), f is a vector of farmer specific variables, z are the institutional variables, k is a vector of fixed and quasi-fixed capital, and e is a stochastic term. The empirical model estimated contains the following variables (letters in parenthesis indicate related category variables from the conceptual model):

1) Input prices (w) = *marketdistance*

2) Farmer specific characteristics (f) = *age, male*

3) Institutional variables (z) = *extension, irrigation*

4) Fixed and quasi-fixed capital variables (k):

i) Physical capital (*physicalasset, farmsize, credit),*

ii) Human capital (*education, experience, pest mngt knowledge),* and

iii) Social capital (*groupmember).*

where *marketdistance* (a proxy for input prices) is the distance to the nearest market center in walking minutes, *age* is farmer's age in years, *male* is a dummy for gender, *extension* is the number of contacts with public extension sources during last crop of beans grown in 2003, *irrigation* is a dummy for access to irrigation water, *physicalasset* is value of physical assets other than land owned by the farmer (in

100,000's Kshs), *farmsize* is the total farm size in acres, *credit* is a dummy variable that takes the value of 1 if a farmer obtained credit during the last crop of beans in 2003, *education* is the years of schooling, *experience* is the number of times a farmer has grown green beans in the last 5 years, *pest mngt knowledge* is a count of number of pest management practices the farmer knew prior to growing beans, and *groupmember* is a dummy for membership to a farmers' group.

While the other explanatory variables included in the above empirical model are standard, farm size and physical assets require some discussion. Both variables are used as measures of farmer's capital endowments. Earlier studies, however, warn that these variables could be endogenous in adoption models (Doss, 2003; Fernandez-Cornejo and Mcbride, 2003). To forestall the endogeneity problem, assets acquired with green bean income and land rented or bought using green bean income was not included in the analysis. In addition, we performed the Hausman endogeneity tests on farm size, physical assets as well other variables that literature suggests could be endogenous (e.g., membership to a farmer's group, experience, initial knowledge of pest management, extension). The instruments used in conducting the Hausman endogeneity tests were household size, off farm income and administrative unit (sublocation). We found no evidence of endogeneity in the Hausman tests we performed. (See Appendix 3.1 & 3.2 for Hausman endogeneity tests on physical assets and farm size). Even with these measures, the results of this chapter should be treated with some caution since it is possible that physical asset ownership could be endogenous.

3.3.2 Empirical model of degree of compliance with international food safety standards

Table 3.1 presents a list of 15 critical requirements that contracted farmers are supposed to meet under IFSS and compares degree of compliance between contracted and non contracted farmers. The mean, median, minimum and maximum for the number of requirements met per farm in the whole sample were 9.65, 10, 0 and 15, respectively. As expected, incidence of compliance with IFSS is greater among contracted farmers than non contracted farmers. Notably, apart from a few critical requirements (in particular, observing the pre-harvest interval, having a toilet and bathing room near green bean plot, keeping records of pesticide use, and sprayer maintenance) compliance with IFSS requirements is not complete even under contract.

A closer look at Table 3.1, however, reveals that majority of contracted farmers have difficulty complying with fixed capital items (notably grading and cooling facilities, pesticide store, and full protective gear) on their own. For instance only16 percent and 7 percent of contracted farmers have grading sheds or charcoal coolers, respectively. However, as will be shown in essay 3 (Chapter 4), some contracted farmers have turned to farmers' groups that provide these facilities. In our sample, 31 (34%) of the contracted farmers are in groups that provide grading sheds with washable tables, 9 (10%) in groups that have a charcoal cooler and a clerk who controls hygiene and 70 (76%) in groups that have technical assistants that help members comply with pesticide residue limits and traceability requirements. Interestingly, contracted farmers seem to comply much more easily on their own with requirements that do not entail large capital outlay e.g., record keeping, pest scouting, and safe disposal of pesticides as shown in Table 3.1. In addition, all contracted farmers are complying with the pesticide residue limits that only entail strict adherence to the PHI. Table 3.1 further demonstrates that there is no case of full compliance with IFSS even among contracted farmers. However, the level of care taken in meeting the meeting the pesticide residue limits (enforced through adherence to PHI) and hygiene requirements (having a toilet and access to grading shed) and traceability are sufficient to ensure that only safe green beans get exported to the UK.

To examine if capital endowments affect degree of compliance with these critical IFSS requirements we estimate an empirical model whose general form is specified as:

(9) $compliance = compliance(w^o, f,z,k)$,

where *compliance* is a count of IFSS requirements the farmer complied with and the other variables are as earlier defined. The explanatory variables included in the estimated empirical model are the same as those in section 3.1. Hence the survey Poisson regression model estimated is specified as:

(10) *compliance = compliance(marketdistance, age, male, extension, irrigation, physicalasset, farmsize, credit, education, experience, pest mngt knowledge, groupmember) +e*

3.3.3 Data and Estimation

This essay uses data collected in Machakos and Kerugoya districts in Kenya during 2003/2004 from 180 smallholder green bean family farmers stratified by compliance with international food safety standards. The data was collected through personal interviews using pre-designed questionnaires. Table 3.2 gives summary statistics and paired t tests[7] of equality of means of the variables used in estimating contract participation and degree of compliance models. Clearly, contracted farmers have higher mean physical assets, farm size, credit, experience in growing beans, prior pest management knowledge, and group membership than non-contracted farmers. To investigate if capital endowments affect a farmer's ability to participate in a marketing contract, we estimate survey probit regression of contract participation model. Probit regression is used because the dependent variable is dichotomous. The entire sample of 180 farmers (encompassing both contracted and non contracted farmers) is used in the estimation.

To examine if capital endowments constrain the degree to which contracted farmers comply with IFSS, we specify a survey Poisson regression model as the second stage regression to the double hurdle problem facing a green bean farmer, namely choosing the degree of compliance with IFSS once a decision is made to participate in a contract production that requires meeting these standards. Survey Poisson regression is chosen because it is more suitable for estimating regression models in which the dependent variable is a count variable (in this case, the number of IFSS practices a contracted farmer is complying with) (Wooldridge, 2000). Only contracted farmers (n = 92 in our sample) are used in this estimation. Both estimations are done using survey regression techniques with *village* as the primary sampling unit, to control for the clustering effect on variance within a village.

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[7] As in Chapter 2, we tested the null hypotheses that the means of non contracted and contracted farmers are equal against the alternative that the mean of non contracted farmers is greater.

3.4 Results

3.4.1 Wealth Characteristics of Kenyan green bean family farmers

The smallholder green bean family farmers sampled in this study have various sources of income, both farm and non-farm. For the majority, agriculture (especially green bean production) is the primary income source. Table 3.3 presents income and wealth distribution for the contracted and non contracted farmers. Wealth measure is the sum of total value of physical assets, other than land. Clearly, contracted farmers have consistently greater wealth and farm income than their non contracted counterparts across almost all income and wealth quartiles. The predominant source of income for both contracted and non contracted farmers is the farm. The distribution of land holdings (in acres) between the contracted and non contracted green bean family farmers follows the same trend as wealth and farm income.

While contracted farmers have consistently higher income and wealth, the level of income and wealth disparity is higher among this group than the non contracted farmers as shown by the interquartile range in the last column of Table 3.3. One of the factors contributing to income differences between contracted and non contracted farmers is the more reliable market access the former have. This greater market access has enabled contracted farmers to increase their volume of sales and hence income.

3.4.2 Determinants of participation in contract production

To further investigate if the above observed wealth disparity between contracted and non contracted farmers affects a farmer's ability to obtain a marketing contract with an exporter, we estimate a survey probit regression model (Table 3.4). While noting the possible presence of endogeneity, we find as hypothesized, that endowments with all the three forms capital increase the likelihood of obtaining a marketing contract with the exporter firm. The physical asset variable has a positive coefficient indicating that wealthier farmers (i.e., those with more physical assets) are more likely to obtain a marketing contract. As shown in Table 3.4, the expected marginal effect of an increase in the value of physical assets by Ksh 100,0000 on the probability that a farmer obtains a contract is 0.046, all else equal. The other physical capital variables that affect likelihood of obtaining a marketing contract are farm size and credit. Both variables increase the likelihood of a farmer obtaining a marketing contract. The marginal effects of farm size and access to credit are 0.030 and 0.471 which implies that an increase in farm size by 1 acre and obtaining credit increases the likelihood of obtaining contract by 3 percent and 47 percent, respectively.

Of the human capital variables, both initial knowledge of pest management practices and experience in growing beans increase the probability of participation in a marketing contract. The respective marginal effects of prior knowledge of pest management practices and years of experience in growing beans are 0.122 and 0.012. Clearly, capital endowment increases the probability of a farmer participating in a green bean marketing contract.

Contrary to our expectations, however, we find no evidence that education (i.e., years of schooling) increases the likelihood of participation in contract production of beans. Education is believed to affect the probability of farmer participation in contract production of high value fresh exports (Key and Rusnten, 1999). The finding that education does not affect the likelihood of participation in contract production of beans may be attributed to three factors. First, farmers are probably substituting other forms of human capital (e.g., experience and prior knowledge of pest management strategies) for education. Indeed, previous literature indicates that experience strongly influences agricultural productivity (Fafchamps and Quisumbing, 1999; Young and An, 2002) while schooling has negligible to moderate effect (Adesina and Djato, 1996). Second, the mean years of schooling for both contracted and non contracted farmers was almost identical in the sample (see Table 3.2), underscoring the fact that most smallscale green bean growers in the sample have low levels of education. Third, most contracted farmers affiliated to farmers' groups depended on a group-hired technical assistant to meet technical aspects of IFSS compliance (e.g., pest scouting, keeping technical records, and adherence to pre-harvest intervals), so knowledge by the individual farmer was less important.

Results show that social capital (i.e., membership in a farmer group) strongly increases the probability of participation in contract production. This finding lends support to the argument above that farmers affiliated with groups use them to meet some of the requirements of IFSS. The importance of group membership also supports the case study findings (Chapter 4) that buyers prefer to contract with groups of smallholders as a way of reducing the high transaction costs of enforcing compliance with IFSS among individual smallholder farmers. The results further show that among farmer specific characteristics, age increases the likelihood of farmer participation in contract production of green beans. This finding contradicts the general belief that older farmers tend not to adopt new ideas because they are more risk averse (Adesina and Zinnah, 1993; Mauceri, et al., 2005). A possible explanation for this finding is that contract production actually reduces risk by helping farmers overcome some of their idiosyncratic market failures.

Lastly, Table 3.4 shows that access to irrigation increases the likelihood of participation in contract production. This finding is not unexpected. Green beans are susceptible to water stress especially during pod filling and since buyers that enforce IFSS supply markets where wrinkles and spots on the pods are unacceptable, it is expected that access to irrigation will enhance the likelihood of participating in contract production.

3.4.3 Determinants of degree of compliance with international food safety standards

Once a farmer chooses to participate in contract production of beans, the next decision to make is the degree with which to comply with IFSS. Is this decision affected by capital endowments? Table 3.5 gives the results of the survey Poisson regression model estimated to examine this question. While acknowledging the possible endogeneity of physical asset ownership, we find as hypothesized, that endowments of physical, human and social capital increase the degree of compliance with IFSS even among farmers holding production contracts. Size of land holdings and wealth (possession of physical assets) both increase the degree of compliance with IFSS. All else equal, an increase in farm size by one acre increases the degree of IFSS compliance by 7 percent while an increase in the value of physical assets by Kshs 100,0000 increases the degree of IFSS compliance by 12 percent. (See

Wooldridge (2000, pg. 547) for interpretation of coefficients of the Poisson regression model.)

Among human capital variables, experience in growing beans increases the degree of IFSS compliance. Other things equal, an additional year of experience in growing beans increases the degree of IFSS compliance by 9.5 percent. The coefficient on membership in a farmers' group (the sole measure of social capital in this study) implies that, other things being equal, the expected degree of IFSS compliance for a contracted farmer with membership in farmers' groups is 11 percent higher than for those with no membership in farmers' groups. The positive effect of group membership on degree of IFSS compliance was expected because, as discussed earlier, such groups usually supply some of the services farmers require to meet IFSS. However, this finding may also be due to the fact that group members are screened by group leaders for willingness to comply with IFSS prior to joining the group, and once in the group, they monitor each others' behavior.

Among institutional variables, the number of contacts with public extension sources increases the degree of compliance with IFSS. The importance of public extension in increasing the degree of compliance with IFSS was unexpected. There has been little focus by government extension personnel on green bean production, partly due to lack of timely market information. Green bean buyers have largely been responsible for giving their growers the technical advice they need. However, green bean farmers reported relying also on neighbors and pesticide traders for extension advice. Hence, it is unlikely that the positive effect of public extension on degree of IFSS compliance is a reflection of the importance of government funded extension service in meeting IFSS. Nevertheless, it does indicate that green bean growers rely on public extension sources in meeting IFSS standards.

3.5 Conclusion

This study corroborates the findings of the paired case study (Chapter 4) that farm size affects compliance with IFSS. Using a large sample in this study, the statistical results suggest that indeed, not just farm size, but the whole spectrum of farm capital resources significantly contribute to both the probability of obtaining an export contract and the degree of compliance with IFSS once a contract is obtained. Human capital is found to affect the probability of participation in contract production via experience in growing beans and prior pest management knowledge. Physical capital exerts influence through farm size, possession of physical assets apart from land, and credit. Membership in a farmer's group, the sole indicator of social capital, had a very strong effect favoring access to export contracts and IFSS compliance. Descriptive statistics indicate that contracted farmers have consistently higher wealth and income than non-contracted farmers. However, the degree of wealth inequality among contracted farmers is higher than for the non contracted counterparts. We however caution against over generalization of these results due to possible endogeneity of physical assets ownership, a measure of wealth in our analysis.

The importance of wealth in securing green bean production contracts and in the degree of compliance with IFSS suggests that resource poor farmers are likely to be marginalized by IFSS. However, as demonstrated by the paired case study in Chapter 4, smallholders can overcome the capital barrier by banding together into cooperative groups and then jointly investing in costly facilities. Furthermore, some contracted farmers have been able to substitute some forms of capital for others. For instance, farmers who lack the human capital needed to meet the IFSS have substituted this with social capital by joining farmers' groups that supply the technical expertise through group hired technical assistants.

One key implication of this essay is the need for the government to provide institutional support to green bean farmers. The government needs to encourage and facilitate smallholder farmers to organize themselves into producer marketing associations (i.e., farmer groups) that will then take advantage of collective size to invest in the costly long-term facilities required to comply with IFSS. In particular, the Kenya government can support the formation and sustainability of green bean farmer groups/associations by reducing the bureaucratic hurdles involved in registering a farmers association (especially the time spent and requirements for registration fees and fulfillment of set leadership structure). Formation of farmer groups can also be facilitated by strengthening the existing weak contract laws, ensuring (through Kenya government's regulatory arm, Horticultural Crop Development Authority) that contracts signed between exporters and farmer groups are enforceable, and ensuring that conflicts between farmer groups and exporters are resolved expeditiously and impartially.

Contrary to expectations, this dissertation research has demonstrated that green bean growers rely on public extension sources to meet IFSS. Kenya's government has in the past largely relegated green bean extension responsibility to exporters due to financial constraints and inability to access and transmit market information rapidly (Kimenye, 1993). This has led in some cases to careless use of pesticides (Okado, 2001). We therefore recommend that the government partner with exporters to provide extension services. In particular, the government can handle the group formation and agronomic aspects, while exporters provide such market information as pesticide use requirements and changes in consumer demand which the government has traditionally been poor at.

Farmers benefit from complying with IFSS through increased access to the export market which enables them increase their sales volume and hence income. However, for most smallholders, the capital needed for compliance with IFSS is beyond reach. Given the finding in this study that membership in a farmer group increases both the likelihood of obtaining a contract and degree of IFSS compliance by providing facilities and technical expertise needed to comply with IFSS, we recommend that resource poor smallholders be encouraged to band together into farmer groups to overcome wealth effects IFSS on compliance. Exporters who are abandoning smallholders due to higher transaction costs of monitoring IFSS compliance can benefit by encouraging farmers to group together and then monitor the group rather than individual farmers. The benefits to such exporters include diversification of supply base (hence reduced risk) and the reputation for being an ethical trading partner (i.e., being seen as helping the poor stay in business). The latter is especially of interest to leading UK retailers because they are using the ethical trading initiative to compete with each other (Freidberg, 2004).

Table 3.1: Compliance with key IFSS requirements among Kenyan green bean growers, 2004

IFSS requirement	Contracted farmers (n = 92)		Non contracted farmers (n = 83)	
	Count	%	Count	%
Hygiene standards				
Owns a grading shed	15	16	0	0
Owns a charcoal cooler	6	7	0	0
Has a toilet near plot	92	100	78	94
Grading shed has water	31	34	0	0
Pesticide standards				
Pesticide storage area	50	54	32	38
Owns full protective gear	37	40	6	7
Disposes pesticides safely	82	89	72	87
Sprayer well maintained	69	75	58	69
Observes PHI*	92	100	78	94
Scouts for pests	72	78	51	61
Has own agronomist	12	13	0	0
Sprayer maintenance	92	100	60	72
Bathing room near plot	90	98	69	83
Traceability				
Marks each bean plot	32	34	2	2
Keeps pesticide use record	22	24	16	31

Author's survey, 2004; * PHI = pre-harvest interval (the interval between last date of pesticide application and resumption of harvesting).

Table 3.2: Summary of Kenya's green bean farmers' data used in empirical estimations, 2004

	Contracted (n = 92)		Non contracted (n = 83)		Test of Means (n=175)	
Variable	Mean	Std Dev	Mean	Std Dev	t-stat	p-val
Contract (N=175) (0,1)	1.00	--	0.00	--		
IFSS met (N= 92) (count)	9.65	3.20	--	--	-3.797	0.000
marketdistance (minutes)	33.68	23.31	35.51	23.36	0.603	0.726
male (0,1)	0.79	0.81	0.80	0.64	0.226	0.589
age (years)	39.99	11.22	37.33	11.99	-1.481	0.070
extension (count)	4.00	3.00	3.50	3.25	-2.338	0.010
irrigation (0,1)	0.92	0.26	0.72	0.31	-4.720	0.000
physicalasset*	12.86	0.25	7.58	0.81	-2.080	0.020
farmsize (acres)	3.27	3.12	2.70	3.81	-1.534	0.063
credit (0,1)	0.91	0.52	0.21	0.49	-11.327	0.000
education (years)	8.00	3.00	9.00	3.00	1.071	0.857
experience (years)	23.06	17.00	16.15	14.81	-4.271	0.000
pest mngt knowledge (count)	3.74	2.00	2.80	2.11	-3.234	0.001
groupmember (0,1)	0.87	0.42	0.23	0.42	-9.475	0.000

Source: Author's survey, 2004; * Measured in 100,000's Kenya Shillings (Kshs)

Table 3.3: Income and wealth distribution among Kenyan green bean family farmers, 2004

Farmer type	Household income/wealth quartiles ('000 Kshs)				
	25th	50th	75th	95th	IQR*
Contracted (N=92)					
Farm income	30	54	100	355	70
Off-farm income	0	13	48	156	48
Physical assets	235	354	663	1519	428
Farm size (acres)	1.5	2.0	4.2	12.0	2.7
Non contracted (N=83)					
Farm income	21	35	62	208	41
Off-farm income	0	16	36	131	36
Physical assets	158	282	425	1132	336
Farm size (acres)	1.0	2.0	3 .0	7.7	2.0

Source: Author's survey, 2004; *Interquartile range

Table 3.4: Factors affecting farmer participation in contract production of green beans in Kenya, 2004 – survey probit regression

Dependent variable: contract (1 = farmer participates in a marketing contract)

Explanatory variable	Coefficient	p-value	Marginal effects
marketdistance	-0.010	0.108	-0.004
male	0.019	0.943	0.007
age	0.030	0.011	0.012
extension	-0.010	0.307	-0.003
irrigation	0.240	0.010	0.128
physicalasset	0.114	0.049	0.046
farmsize	0.076	0.041	0.030
creditaccess	1.264	0.034	0.471
education	-0.027	0.632	-0.010
experience	0.013	0.094	0.012
pest mgnt knowledge	0.307	0.000	0.122
groupmember	1.156	0.017	0.436
Constant	-7.377	0.000	

N =174 F = 6.04 p-value (F) = 0.000

Source: Author's survey, 2004

Table 3.5: Determinants of degree of IFSS compliance among green bean growers in Kenya, 2004 – survey Poisson regression

Dependent variable: Count of IFSS requirements with which a farmer complied

Explanatory variable	Coefficient	p-value
marketdistance	-0.001	0.391
male	0.111	0.021
age	0.003	0.244
extension	0.002	0.011
irrigation	0.032	0.143
physicalassets	0.119	0.013
farmsize	0.072	0.010
credit	-0.007	0.905
education	0.011	0.256
experience	0.095	0.079
pest mngt knowledge	0.002	0.862
groupmember	0.111	0.034
Constant	3.143	0.000
N =90	F = 5.49	p-value (F) = 0.000

Source: Author’s survey, 2004

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APPENDICES

Appendix 3.1: Hausman endogeneity test of farm size

Explanatory variable	Coefficient	P-val
farmsize	0.258	0.675
residuals	**-0.196**	**0.518**
male	-0.092	0.634
age	0.052	0.172
education	-0.020	0.909
marketdistance	-0.120	0.189
physicalasset	0.100	0.488
experience	0.038	0.092
creditaccess	1.119	0.049
pest mngt strategies	0.399	0.000
groupmember	1.360	0.026
constant	-4.099	0.293
N = 174	F=5.22	Pval (F) =0.001

Appendix 3.2: Hausman test for endogeneity of physical assets

Explanatory variable	Coefficient	P-val
physicalasset	0.122	0.468
residuals	**0.008**	**0.964**
male	-0.018	0.943
lnage	0.030	0.014
education	-0.027	0.629
marketdistance	-0.009	0.108
experience	0.031	0.090
creditaccess	1.265	0.032
pest mngt strategies	0.037	0.000
groupmember	1.153	0.016
constant	-3.546	0.293
N = 174	F=5.41	Pval (F) =0.001

CHAPTER 4

COMPLIANCE WITH INTERNATIONAL FOOD SAFETY STANDARDS IN KENYA'S GREEN BEAN INDUSTRY: A PAIRED CASE STUDY OF SMALL AND LARGE FAMILY FARMS[8]

4.1 Introduction

Food safety scandals and the ensuing consumer concerns with food contamination by microorganisms and pesticides in the European Union (EU) over the past decade have led European governments to enact more stringent food safety regulations (Jaffee, 2003; Mungai, 2004). EU fresh produce retailers, especially supermarkets, have responded to consumer concerns and these regulatory changes by developing their own protocols and passing them upstream to developing-country exporters (Fox, 2000; Marsden, 2000). These private protocols are often more stringent than official regulatory requirements.

To secure their markets in the EU, developing country exporters have, in turn, responded to the international food safety standards (IFSS) by imposing strict requirements on fresh produce suppliers (Dolan and Humphrey, 2000). These requirements include: i) pesticide use and handling standards, ii) establishment of traceability systems, and iii) hygiene standards.

Fresh vegetable exporters have, over the years, sourced their supplies from their own farms, contracted outgrower farms, spot market, or a combination thereof. Until the early 1990s, the dominant source was the spot market supplemented by loose contracts with smallholder farmers. Following the introduction of IFSS, leading exporters that supply developed-country supermarkets and/or EU countries that

[8] A paper based on this essay is in revision for the *Review of Agricultural Economics*.

demand IFSS compliance have moved away from these sources into more closely governed contracts that require farmers to comply with IFSS. Compliance entails costly investments in i) variable inputs (in particular, the switch to approved pesticides), and ii) long-term structures (e.g., grading shed, charcoal cooler, disposal pit and pesticide store) (Murimi, 2004). These IFSS investments are "lumpy" in nature and mostly specific to the fresh export vegetable business. There is, therefore, growing concern that the high cost of making these investments will exclude developing-country smallholders from the lucrative fresh export business, given their limited access to capital and information (Cowell, 2003; Farina and Reardon, 2000; Mungai, 2004). Despite these concerns, there are as yet no studies that systematically investigate *how* developing-country farmers are complying with these developed-country standards. In particular:

- How are developing country farmers meeting the cost of fixed investments?
- How are they acquiring the skills needed to meet the traceability requirements?
- How are they transitioning to safer but more costly pesticides?

This case study focuses on compliance with IFSS by Kenyan family farms that produce green beans for supermarkets in the United Kingdom (UK). Green beans are the most important fresh vegetables exported from developing countries, and Kenya is currently the leading supplier of green beans to UK supermarkets. The UK has developed stringent food safety standards, making it a suitable case to study.

4.1.1 Brief historical perspective

Kenya's green bean industry dates back to the 1950s, although production and trade expanded most rapidly in the 1980s and 1990s (Kimenye, 1993; McCulloh and Ota, 2002). Kenyan exports of green beans increased from 6,000 tons in the early 1980s to more 27,000 tons in 2003. In 2002, green beans alone accounted for 22 percent of the value of all Kenyan horticultural exports and was hence the second largest foreign exchange earner in the industry (HCDA, 2003). However, as shown in Figure 1, the rate of expansion of trade in green beans slowed down in the 1990s as the industry adjusted to challenges created by IFSS and competition from other African producers (Dolan and Humphrey, 2000). The strong recovery is attributed to increased supermarket trade by leading exporters in the wake of IFSS due to pre-pack (prepared produce) business. Production response to IFSS has followed the same trend, but with a significant impact on production structure.

Green bean production has been the domain of small and medium scale growers, although the share of smallholders has declined in the recent past. In the 1980s, smallholders produced 40-50 percent of all green beans grown in Kenya (Kimenye, 1993). While no official figure exists, unofficial estimates indicate that smallholders' share has now fallen below 40 percent largely due to the cost and difficulty of complying with IFSS (Dolan and Humphrey, 2000; Jensen, n.d.). Following Kimenye (1993), we define small, medium and large scale green bean farms to be 0-1 acres, 1-7 acres and more than 7 acres, respectively. Figure 2 shows a rapid decline in the number of smallholder green bean growers supplying one leading exporter from the districts of Meru and Machakos. Over the same period, production of green bean on exporters' own (estate) farms and by medium and large scale growers has increased.

IFSS were introduced in the early 1990s in response to food safety regulatory changes in the UK and the EU as a whole. In the UK, these standards emanated from the UK Food Safety (Due Diligence) Act of 1991 and the resultant supermarket-developed codes of practice. These regulatory changes were initially aimed at addressing the problem of microbial contaminants in food. They later evolved to cover three broad areas: i) pesticide residue standards, including pesticide usage, handling, and storage as well as disposal of pesticide containers and leftover pesticides, ii) hygiene standards, including sanitation of grading and storage facilities and general personal hygiene, and iii) traceability requirements, including documentation of production activities, especially pesticide usage, planting and spraying dates, and labeling of graded beans.

Heavy pest pressure in humid tropics and the insistence of European consumers on freedom from pest and disease blemishes has made green bean production rely heavily on pesticides. Prior to the IFSS era, farmers applied many different types of pesticides (including those unregistered) on green beans, often with sprayers that were old and poorly maintained and dosages that were higher than recommended (Okado, 2001). Smallholders applied pesticides weekly regardless of need, using scant protective gear, and pesticide containers were either left in the field or disposed in domestic waste pits. In addition, most smallholders stored pesticides in the food store, family residence or kitchen. Farm-level postharvest handling of green beans also received little attention. Beans were transported to a collection point, usually under a tree by the roadside, where they were graded on the ground and packed into cartons previously distributed by exporters' agents. In the rare instances where farmers had a collection center, the facility was a simple low cost shed (Jaffee and Morton, 1995). Since export markets only emphasized physical attributes (spotlessness, size, shape and length) green bean grading in the pre-IFSS era was done by visual inspection and was hence fast and inexpensive.

Introduction of IFSS has changed all these practices. Besides meeting the cosmetic requirements of UK consumers, IFSS-compliant beans have to meet specific production and farm-level postharvest handling requirements, namely: i) spray operators wear full protective gear, ii) pesticides are handled in ways that ensure safety to mixers and applicators, iii) pesticide applicators bathe immediately after spraying or when pesticides accidentally come into contact with the skin, iv) pesticides are stored away from foodstuffs in a fully secured pesticide store with adequate ventilation, v) disposal of pesticide containers and leftover pesticides is done in ways that do not threaten the health of humans or animals, and vi) farmers discontinue the use of unapproved pesticides and ensure that residues of approved pesticides on the harvested beans remain below the maximum residue level (MRL). In addition, green beans are required to meet a number of postharvest handling requirements. In particular, grading must minimize contamination by microbes or foreign objects (e.g., dirt and human hair) and shield the beans from the tropical heat. Lastly, each farmer is required to document pesticide use practices for each plot of beans. The record of pesticide usage accompanies each consignment of green beans sold.

In order to become IFSS-compliant, a farmer needs to change a number of production practices and make significant investments including the following: i) purchase protective gear, including long-sleeved overalls, gumboots, rubber gloves, nose mask, goggles, and hat; ii) construct a shower room for use by the spray operators, a well ventilated and secured pesticides store area, a pesticide disposal pit and an incinerator; iii) apply only approved pesticides (typically more costly, but safer than those used previously); iv) implement an integrated approach to managing pest and disease problems, and only use pesticides when absolutely necessary (i.e., upon approval by the exporter's agronomist or technical assistant); v) construct a grading shed (with cement floor, washable tables, and facility for washing hands) and a pit latrine adjacent to the shed; vi) build a charcoal cooler for holding graded beans prior to pickup by exporter; vii) observe personal hygiene at all times during grading of green beans. The hygiene measures taken include the use of headscarves by women and hats by men, barring children from the grading area, and barring the wearing of perfumes from sorting and grading areas.

4.2 Theoretical framework

This paper uses transaction cost economics (TCE), principal-agent theory (PAT) and the concept of economies of size (EOS) to develop hypotheses that are tested in this case study. Transaction cost economists assume that parties to a transaction will choose a governance structure that, while allowing exchange, will economize the cost of carrying it out. The governance structure used in coordinating the acquisition of goods and/or services can range from open market transactions to vertical integration. Which governance form economizes costs of exchange will depend on the degree of asset specificity, behavioral and environmental uncertainties, and frequency of exchange (Williamson, 1985) .

The production of an export crop involves many decisions in which the farmer has an informational advantage over the buyer; a situation that makes exchange both risky and uncertain from the buyer's perspective. PAT provides a sound theoretical background for analyzing how costs of information asymmetry and risk and uncertainty can be reduced through the design of a proper incentive system and risk sharing.

Production of export crops often requires that farmers invest in long-term, lumpy assets. Such investments increase the fixed costs of producing an export crop. The concept of economies of size suggests that larger farms face lower unit costs because they are able to spread their fixed cost over larger output quantity. Consequently, larger farms compete more favorable than smaller ones. In the following sections, we discuss these theories in light of the fresh export vegetable business and generate case study propositions.

4.2.1 Transaction cost economics

4.2.1 a) Asset specificity and uncertainty

Transaction cost economics emphasizes asset specificity which is the degree to which the assets used in the exchange relationship are specific to that relationship. Martinetz (2002) identifies four types of asset specificity in agriculture: i) physical specificity – such as a non-deployable investment in physical facilities needed to complete the exchange process, ii) site specificity – where there is need to locate processing/manufacturing plant close to raw material source usually aimed at reducing transport cost, iii) temporal specificity – where timing of the delivery of exchange goods/services affects their value, iv) knowledge/skill specificity – in which a party to exchange has to acquire certain skills/knowledge to expedite transaction. The assets used in fresh produce trade are certainly temporally specific. To a lesser extent, they are also physically and skill specific. High asset specificity can subject the farmer to price "hold-up", i.e., a situation in which the buyer lowers the agreed price in an attempt to extract rents (Williamson, 1989).

High asset specificity *per se* does not pose a problem unless exchange is characterized by significant uncertainty. There are four main types of exchange-conditioning uncertainties (Martinetz, 2002): i) behavioral uncertainty - caused by a strategic behavior in form of nondisclosure, disguise or distortion of information by one of the parties, ii) environmental uncertainty - caused by demand volatility, lack of timely communication and inability to determine timely plans/decisions made by others, iii) technological uncertainty – caused by changes in technology needed to complete the transaction, and iv) quality uncertainty- caused by inability to verify at low cost quality of the produce at the time of product delivery. All four types of uncertainty characterize the Kenyan green bean business.

A combination of high asset specificity and uncertainty has important ramifications for how exchange partners do business. Opportunities may exist for one party to take advantage of another by using exclusive information (North, 1990). In anticipation, the uninformed party will seek to safeguard its specific assets through vertical coordination.

Contracting is the most widely used form of vertical coordination to safeguard specific assets in agriculture. In this study, we define a contract as written binding agreement between two exchange partners specifying the roles and responsibilities of each party. Contracts can facilitate close working relationship between exchange partners hence allowing them to resolve future contingencies by "working things out" (Martinetz, 2002; Williamson, 1985). The three most common types of agricultural contracts are production, resource-providing, and market specification (Minot, 1986). In production contracts, the buyer supplies some of the inputs and retains the decision-making and ownership rights to the contracted product throughout the supply chain. In resource-providing contracts, the buyer provides technical advice and some production inputs but ownership of the product changes at the time of delivery. In market specification contracts, the farmer provides the production inputs, is responsible for production decision-making and retains ownership until the products are delivered. The farmer may, however, receive technical advice on quality and timing of delivery for the product. In all three cases, price and quality of the produce are specified in the contract terms.

Proposition TC1:

Farmers will choose to produce under contracts to safeguard their specific investments.

4.2.1 b) Measurement costs

Transaction costs can also result from information asymmetry among trading partners regarding unobservable product characteristics and producer effort. Martinetz (2002) argues that if a partner to an exchange cannot directly observe some product attributes, that partner may be willing to incur search, sorting and screening expenses to obtain better information. The problem is exacerbated if the traded product has some attributes that the buyer desires, but cannot be assessed until consumption (as in the case of *experience goods*) or may not be assessed at all (as in the case of *credence goods*).

Verifying product quality has become an important issue in the fresh produce trade (Rehber, 1998). Chambers and King (2002) argue that where quality verification is costly or difficult, exchange partners will govern their exchange using tighter vertical coordination systems, such as closely coordinated contracts. Such contracts enable the less informed exchange partner to monitor production processes to discourage the more informed partner from engaging in opportunistic behaviors such shirking and cheating (Milgrom and Roberts, 1992).

Monitoring an exchange partner provides the less informed partner with a tool for evaluating the more informed partner's performance. It also enables the less informed party to device ways of aligning the goals of the more informed party to hers. When product attributes are not directly observable, a high level of monitoring may be required to detect cheating (Bagetoft and Olesen, 2004). Further, the expenses associated with evaluating partners' performance through monitoring will rise with the number of partners involved in exchange. In smallholder agriculture, where the more informed partners (the farmers) are widely dispersed, the material and personnel costs of monitoring can be prohibitive relative to small volumes of product delivered (Olson, 1985). In addition to monitoring costs, an exchange partner may incur other *ex ante* transaction costs, such as search and screening costs of recruiting farmers and costs of negotiating contract terms with each farmer. Even after the contract is signed, the buyer still faces the *ex post* direct and opportunity costs of renegotiating (bargaining) and adapting the contract to changes in the production or market environment. The high cost of monitoring individual contracts involving small volumes makes vertical coordination through relational contracts with farmers' groups, associations and cooperatives preferable.

Proposition TC2: *High transaction costs associated with monitoring individual smallholder farmers will motivate buyers to contract with farmer-groups or associations rather than individual smallholder farmers*.

4.2.2 Principal-agent theory

The crop procurement relationship between a buyer and farmer(s) can be modeled as a principal-agent problem where the principal (a buyer) engages the agent (a farmer) to grow a crop that has pre-specified quality attributes. As part of the contract, the farmer carries out effort-demanding activities that impact quality attributes of the contracted crop. The buyer faces information asymmetry caused by uncertainty about the farmer's effort and performance under the contract because the buyer cannot completely observe the farmer's effort. While the buyer wants the farmer to work hard, the farmer may not wish to do so.

Minimizing risks through risk-sharing and providing the agent with rewards adequate to motivate a high level of effort are core issues of the principal-agent theory (PAT). If effort cannot be completely observed, then it makes sense to base reward on outcomes (Eisenhardt, 1989; Grossman and Hart, 1983; Shavell, 1979). To elicit a high level of effort from the farmer, the buyer should pay a price that varies with the outcome; however, this exposes the farmer to production risks unrelated to effort (e.g., weather and pests) (Shavell, 1979). The buyer should therefore monitor the farmer so as to isolate the farmer's effort from outside influences and reward it accordingly. While perfect monitoring of input use and farmer effort is impossible, partial monitoring combined with a performance-based price keeps agent behavior aligned with the principal's objectives (Hueth, 1999).

Proposition PA1

The contract between buyers and farmers will be such that the buyer shares the risks with farmers by paying a price that is variable.

To the extent that the buyer only insures the farmer against some of the risks, farmers must devise ways of dealing with uninsured risks. Small and large farmers will differ in the way they deal with risk left uninsured by the buyer. Like large buyers, farmers who own large farms are assumed to be less risk averse than smallholders (Bagetoft and Olesen, 2004; Eisenhardt, 1989). Such large scale farmers are usually wealthier than smaller ones, which makes them less vulnerable to bad outcomes and less risk averse. More importantly, farmers who own large farms often have preferential access to low interest bank loans, venture capital, exclusive inputs and technical information. In addition, some large scale farmers spread their risks by maintaining off-farm businesses. Consequently, large scale farmers are often better able than smallholders to cope with exposure to risks left uninsured by the buyer. The smallholder farmer may therefore insure against uninsured risks (for instance, untimely or poor access to credit, crucial inputs and technical information) by sharing them through a program or group.

Proposition PA2:

Smallholders will deal with some of their risks by joining a contracted farmer's group/association while larger farmers produce under individual contracts.

4.2.3 Economies of size

Economies of size (EOS) exist when a firm's average cost declines as its output increases (Debertin, 1992). In particular, average fixed costs must diminish with increasing output. Economies of size can also arise from decreasing variable costs, such as reduced prices for variable inputs through bulk purchases (Debertin, 1992). Economies of size allow a large farm to take advantage of advanced, but lumpy cost-reducing technologies that are unaffordable to a smaller producer. Examples in Kenyan horticulture include fax machines and telephone hookups to rapidly access market information (Dolan and Humphrey, 2000), constructing grading and cooling facilities, or hiring a full-time, trained manager. Input market imperfections, an endemic problem in developing countries, can also confer special pecuniary economies of size on large farmers who can afford bulk purchase (Key and Runsten, 1999).

Proposition ES1: *The high fixed costs required to become compliant with IFSS will motivate smallholder farmers to join in groups in order to attain economies of size.*

4.3 Case study design and methods

To investigate the four propositions above, we examine two Kenyan family farms that grow IFSS-compliant green beans for sale in supermarkets in the UK. A case study approach was selected because it is better at answering the *how* questions than quantitative methods (Yin, 1989). The study is based on one small and one large case farm that had, respectively, 0.5 and 10.0 acres under green beans. The two farms are representative because these were the respective mean farm sizes for small and large family farms for the last crop of green beans at the time of the survey in 2003. Both case farms sell to buyers who insist on IFSS compliance in order to supply the UK supermarkets.

The information needed to address the case study propositions was obtained through personal interviews with case farmers and industry participants between October 2003 and May 2004. Buyers/exporters, government officials, officials of Fresh Produce Exporters Association of Kenya, third party certifiers of EUREP-GAP as well as officials of both existing and defunct farmers' marketing groups involved in fresh export produce were interviewed. Additional data was obtained from official government and industry statistical reports, industry newsletters and newspaper articles on the subject.

4.4 Compliance with IFSS: a paired case study

The small and large farms are owned by Chomba and Mango, respectively (these are pseudonyms). Table 1 offers summary information about the two case farmers. Chomba earns his living from entirely from farming. Besides growing green beans, he produces tomatoes and maize for the domestic market, from which he earned Ksh 25000 (US$ 321) in 2003. He also has five bunches of bananas that earned him approximately Kshs 5000 (US$ 64) in 2003. Green bean production is therefore Chomba's most profitable enterprise. Mango, on the other hand, has diversified agricultural production into dairy and other cash crops. She has 12 dairy animals and earns an average of Kshs 27, 000 (US $ 346) per month from milk sales. She also grows coffee and tomatoes, but was quick to point out that "these are not my main focus…. the coffee farm is far from irrigation water source hence can't be used for horticulture while tomatoes pay my workers during bad times". In addition, Mango grows field maize mainly for fodder. However, Mango's major source of income are her two hardware businesses in Machakos town that earned a net income of Kshs 1.4 million (US$ 17949) in 2003.

Chomba and Mango produce *Amy* variety of green beans which is primarily for export. Some green beans get sold in the domestic market either for canning or fresh consumption. Chomba and Mango are however locked out of the domestic canning industry because canners use *Paulista* variety of green beans. In addition, domestic market for fresh green beans is very thin, being limited to a small urban population and accounting for only 0.2 percent of the total household expenditure on fruits and vegetables by that population. Both Mango and Chomba do not sell their green beans in domestic market. Consequently, green beans that they are unable to sell to their buyers end up as waste.

4.4.1 Asset specificity in green bean production under IFSS

The speed with which green beans are moved from the farm to the buyer's packhouse has always been critical since green beans are perishable. How long beans are held on the farm after picking, the conditions under which they are stored, how they are transported from the field to the collection point, and how long they are held at the collection point all affect the overall quality. Consequently, harvesting, farm-level grading by the farmer and collection by the exporter occur under a highly synchronized system. To ensure that pods do not overgrow, Mango and Chomba pick beans every Monday, Wednesday, and Friday. Picking takes place in the morning before the pods get warmed by the high tropical heat. Once harvested, beans are immediately taken to the grading shed, where they are sorted and packed into crates and then kept shielded from heat awaiting collection by refrigerated trucks the same day. Production of fresh export green beans is therefore characterized by temporal specificity.

Mango has made a number of specialized investments in both production and farm-level post-harvest handling practices to become IFSS-compliant. She has constructed a pesticide disposal pit, shower room, incinerator, and fully secured pesticide storage area. She has also employed a trained agronomist/entomologist as a manager. The manager supervises pesticide usage, handling, storage and disposal, keeps technical information on pesticide use, and scouts for pests and diseases (alongside buyer's field technical assistant). Chomba, on the other hand, is exempted from making some of these production investments. Since his farm is small and located close to his home, the buyer has allowed him to use the family's pit latrine to dispose of leftover pesticides and pesticide containers, and he may use the family wash room to bathe after spraying. In addition, Chomba has not been pressured to build a pesticide storage area because his buyer believes that he buys just the amount of pesticide needed each time he sprays his green beans.

For postharvest handling, Chomba and Mango have invested in specialized physical and human assets. They each have a grading shed with cement floor and washable tables, a pit latrine, facility for washing hands, a charcoal/hessian cooler and a crate storage area. These facilities are part of the requirements for meeting IFSS hygiene requirements and, especially, preventing contamination of beans by microbes and foreign objects. Both farmers also observe strict personal hygiene within the grading shed during the handling of green beans. The personal hygiene requirements include washing hands, wearing a headscarf (for women) or a hat (for men), wearing no perfume, earrings or loose finger rings. Chomba and Mango have also hired trained personnel to help them comply with IFSS production and post harvest practices. Both have a clerk who oversees all aspects of hygiene in and around the grading shed. They also have a trained agronomist or entomologist to oversee pesticide use, handling, storage and disposal requirements. The two farmers, however, differ in the way they have invested in the above IFSS requirements. Mango has invested individually. She has her own facilities and has hired a clerk and a trained manager. Chomba, on the other hand, uses the facilities and services of trained personnel provided by the Karie[9] Horticultural Farmers Group (KHFG), to which he belongs.

KHFG was formed in 1999 by a group of smallholder green bean growers. Membership was 31 farmers in 2004. New members are screened for good conduct and character and have to pay a membership fee upon joining the group. Members have personal savings accounts with the group into which they contribute Kshs 3/kilogram of beans sold through the group as personal savings and Kshs 2/kilogram for running the group. The group is governed by an elected committee comprised of the chair, secretary, treasurer and two members. The committee enforces the group by-laws and represents the group in contract negotiation and dispute resolution with the buyer. However, policy decisions are made by all members through voting. KHFG employs a trained clerk and a trained technical assistant. The former is in charge of enforcing physical and personal hygiene in and around the grading shed, while the latter enforces member compliance with pesticide use, handling, storage and disposal requirements.

The investments Chomba and Mango made to be IFSS-compliant are specific to green beans and motivated by buyer demands. For instance, a clause in a contract between one of the exporters and its farmers says; "the group shall provide … one grader (clerk) and field supervisor employed by the group..." By requiring Chomba

[9] This is a pseudonym used for confidentiality.

and Mango to invest in medium and long-term assets, these IFSS lock them into the green bean business and also into producing for specific exporters. Apart from green beans, both farmers grow maize and tomatoes. These crops do not need specialized assets, because they are sold in the domestic market where consumers are not concerned with the way they are produced and handled. Investments made for IFSS compliance are therefore unused if a farmer or group ceases producing green beans. For instance, when one IFSS-compliant group broke up in 2002 over a payment dispute with its buyer, it simply abandoned the grading shed, pit latrine and charcoal cooler which had cost Ksh 96,000 to construct. The grading shed is occasionally used for social meetings, but the charcoal cooler has no current use.

Only farmers producing beans under some form of marketing arrangement with exporters have invested in these IFSS-driven production and postharvest practices. The extent to which the IFSS requirements are met depends on the nature of the marketing arrangement. Farmers with verbal agreements tend not to have most of the IFSS-driven investments. Their most common investment is a simple grading shed with earth floor and no washable tables. Farmers that grow beans under such informal arrangements are unwilling to commit money to upgrading their grading shed and constructing a latrine and charcoal cooler because they interpret the absence of written contracts as evidence of a weak buying commitment. Two medium-scale farmers that left a buyer after being asked to upgrade their grading sheds indicated during the interviews that the buyers they left did not want to commit themselves by signing written contracts. This reluctance to sign a contract made the farmers fear that they might lose their investment if the buyer abandoned them or lowered the price to a point where they are forced to quit growing beans. One farmer reported,

> "My exporter has given me 3 months to construct a grading shed and charcoal cooler, but I won't. Look at my neighbor, Peter. He put up a grading shed in his farm 2 years ago after his exporter asked him to. Last season his exporter offered him a lower price, which he disputed. Now the exporter is gone and the structure lies there unused. I don't want to 'burn' my money like that unless he [the exporter] is ready to commit himself through a contract co-signed by HCDA[10]."

The exporter this grower was talking about is one of the many medium-sized exporters that send trucks and loaders each day from Nairobi to buy green beans directly from the spot market or through loose verbal arrangements with growers via brokers. Such medium-sized exporters buy green beans seasonally, exporting them when market conditions are good and moving to other fresh export fruits and vegetable crops during other times (Harris, et al., 2001). These exporters eschew written contracts, making it easy for them to abandon a farmer or change price at will.

Price reduction by the exporters is a major concern among green bean growers who produce under loose contracts. Mrs Mbugua, one of the area agricultural officers, summarized the problem as follows:

[10] Horticultural Crops Development Authority (HCDA) is a government parastatal responsible for licensing exporters and arbitrating conflict between horticultural growers and exporters.

> “Prior to planting, an exporter and farmers agree on a specific price and volume of beans. When the crop is in flower stage, it (exporter) sends a verbal message through its truck loader to farmers that the price will be lower because the ‘market is bad’. At harvest, the exporter sends another message with even lower price. At this time the green beans must be picked and sold hence farmers have no choice but to take the price. If they dispute the price offered, the exporter leaves the area and goes to buy in another region. I see this often during peak production season when there are plenty of beans”.
> Price holdup by buyers more often takes a subtler form of the rejection rate.

Most buyers maintain that beans are rejected purely based on their failure to meet ‘exportable quality’. However, some exporters’ representatives interviewed during this survey conceded that rejection rates are sometimes used to shield the exporters from market losses especially during periods of oversupply. Consistent with proposition TC1, Chomba and Mango produce under contracts and work closely with their buyers in order to protect their specialized investments from price holdup practices. Both have faced lower rejection rates (2-6%) than those who sell in the spot market or under informal marketing arrangements (10-40%) even under periods of oversupply.

Another reason that Chomba and Mango find contracting appealing is to meet the frequent need to adjust production practices while remaining IFSS compliant -- especially for the type and dosage of approved pesticides. Under their formal contracts, they have access to certified seed and technical information needed to meet the IFSS from their buyers, which eases the technological uncertainty. Information on the IFSS-approved pesticides and their preharvest interval (PHI) requirements is especially important because Chomba and Mango are sometimes forced to switch to alternative pesticides when pests and diseases develop resistance to conventional pesticides. Both farmers receive the technical information from their buyers in the form of handouts containing information on approved pesticides, the bean growth stage at which they should be used, and the dosage. Mango gets additional technical information and advice via regular farm visits by the buyer's trained technical assistant, who must be consulted before pesticides are switched.

Chomba's and Mango's contracts specify the volume and quality of beans they should produce and the price they are to receive during the contract period. They also get a calendar scheduling the delivery plan. For both farmers, a written contract signifies a binding commitment by their respective buyers to continue collecting beans at the established prices and reduces the fear of possible loss of specialized assets through holdup or unfair contract termination. Both growers indicated that they completed IFSS investments only after receiving written contracts from respective buyers. Mango tested her buyer's commitment by asking for a two month extension of deadline for constructing a charcoal cooler and wash room.

Although rarely used by green bean farmers, Kenya government through its regulatory arm, HCDA, provides for punishment of buyers that engage in opportunistic behavior. Such punishment includes revocation of export licenses and legal suit. Both Chomba and Mango have never used these channels to resolves disputes although they are aware of their existence.

4.4.2 Quality verification and enforcement costs and the choice of monitoring strategy

The introduction of IFSS has also changed the way Chomba's and Mango's beans are graded. Under IFSS, quality assessment has shifted from easily observable characteristics to credence attributes related to production processes. This shift has created quality verification and enforcement problems in the production of IFSS-compliant beans. Chomba and Mango's buyers now face greater risk due to information asymmetry associated with inability to observe production and post-harvest practices used by the farmers. To overcome the quality risk posed by this information asymmetry, both buyers have developed elaborate systems of farmer monitoring.

Mango and Chomba are subjected to very close monitoring throughout the year, although there is a difference in the way they are monitored. Mango is monitored directly by her buyer through a trained technical assistant. The technical assistant visits her twice a week to address any pest and disease control problems, to scout for pests and to inspect compliance with traceability requirements, use of protective gear, and physical and personal hygiene within the grading shed. In addition, the technical assistant conducts unannounced inspections of the pesticide storage area to ensure that unapproved pesticides are not kept there at any time. This strict separation of green bean pesticides from those used in other crops is aimed at reducing accidental use of unapproved pesticides on green beans.

Chomba's buyer, on the other hand, monitors the entire KHFG group and punishes the entire group for lapses in IFSS compliance. To facilitate monitoring Chomba's group, the buyer has two field coordinators and a field supervisor. A coordinator visits Chomba's group once every week to inspect hygiene conditions around the grading shed as well as the group's production and pesticide use records. In addition, the field coordinator accompanies the group-hired technical assistant to the fields of one or two farmers every week to address a pest or disease problem that the group is unable to deal with or to assess the performance of the crop. Although the group is normally unaware, the field coordinator uses such field visits to gather information about production practices used by the farmers and especially about pesticide use, handling and storage. In 2003, Chomba personally was visited only three times by the buyer's field coordinator.

The field supervisor of KHFG's buyer, on the other hand, works on more difficult issues, such as pest outbreaks, and also ensures that accurate records about individual group members' use of pesticides are kept and that those records accompany the group's beans to the buyer's packhouse in Nairobi. She, in addition, relays information to the buyer the morning of every bean collection day about the production outlook situation (hence the volume of beans to be expected from each of the groups). The field supervisor also monitors the activities of brokers (i.e., middlemen between farmers and buyers who use spot market) and reports to the buyer if there is threat of losing their contracted beans to brokers who sometimes woo group members with higher and instant pay especially when there is high demand for beans in the UK.

Chomba's direct and most rigorous monitoring comes from KHFG's trained technical assistant (TA). The TA visits each member of the group at least 3 times between field preparation and green bean harvest. During each visit, the TA scouts for pests and recommends pesticide remedies. The TA also monitors the area planted, from which he is able to estimate expected sales volume. This is crucial for preventing sale to the group of green beans from non-members, most of whom use unapproved pesticides and/or do not observe the PHI. After the visit, the TA records Chomba's production practices on his spray record. Chomba is required to submit information to the TA on actual dosage used and the date and time the pesticide was applied.

The second approach used by Chomba's group to monitor and control pesticide use by its members is through a small pesticide store, which sells to members only. Chomba's group purchases key pesticides in bulk and makes them readily available to members at a discount. This arrangement has allowed the group to control the type and quantity of pesticides used by most of its members, as well as helping to enforce the minimal interval between last spray and harvest, by dispensing only pesticides that are appropriate for the growth stage of the beans. The scheme has also made it easier for the TA to keep more accurate technical records of pesticide use by individual members. Perhaps most important, the scheme has eliminated the need for group members to build pesticide storage units in their homes. The scheme has allowed Chomba and most other members of his group to buy pesticides as needed, rather than build separate pesticide storage units in their farms.

Why did Chomba's buyer choose to monitor him through a group whereas Mango's buyer monitors her individually? The answer lies in the high costs of searching, recruiting and monitoring individual farmers *vis a vis* a group. Consistent with proposition TC2, Chomba's buyer minimized these costs by contracting with an existing group and choosing to monitor the group instead of individual farmers. The group shouldered the *ex ante* and *ex post* transaction costs by mobilizing and screening its members. It also reduced contract negotiation costs. The production manager of Chomba's buyer underscores the point when he says,

> "We are not in the business of making groups and supervising farmers. That is the work of the groups through its leaders. We can't afford to monitor each farmer. If we did, we would never break even… We supervise the group and penalize the whole group if they don't deliver on their promises. It is up to them (leaders) to supervise members."

Chomba's buyer has two other advantages in dealing with KHFG. By punishing the whole group for quality lapses, his payment system encourages farmers to police each other and be loyal to the group and therefore to him. Their loyalty is useful during low seasons when brokers entice group members to sell beans outside the group by offering higher pay. Secondly, the buyer is able to diversify sources and hence mitigate the risk of crop failure since individual farmer's crop loss due to idiosyncratic risk is compensated by other group members.

Why, then, has Mango's buyer been buying green beans from her through individual contract? In the last few years, her buyer has focused procurement strategy on medium-and large-scale farmers. Mango, like the rest of her colleagues, had to show proof that she could put more than five acres of land into beans at any given time before she secured contracts with her buyer. The large volume enables her buyer to reduce the transaction costs of dealing with individual farmers, which also fits with proposition TC2.

4.4.3 Risk and risk insurance and the use of variable prices

Chomba and Mango encounter various risks in the production of green beans that meet their buyers' quality specifications. Generalized (systemic) risk such as diseases and pests are a problem, exacerbated by the IFSS-driven reduction in number of approved pesticides. Chomba's beans, like those of other smallholder farmers, are prone to pest and disease infection from neighboring beans. The area agricultural officer attributes the widespread pest and disease incidence in smallholders' farms to another factor. Smallholders grow beans all year round or rotate them with tomatoes (which hosts green bean fungal diseases), resulting in pest and disease buildup. Chomba and Mango encounter significant market risks too. Cancellation of buyers' orders by UK importers is usually transferred to them, at least in part, as are any changes in price due to changes in currency exchange rates or contract renegotiations between their buyers and UK importers.

Chomba's and Mango's buyers on the other hand, face quantity and quality risks. They use monitoring to enforce compliance with quantity and physical quality attributes like spotlessness. However, monitoring is less effective in enforcing compliance with unobservable attributes such as residue content. Mango's buyer therefore uses the threat of contract termination in combination with monitoring to enforce maximum residue level (MRL) compliance. Mango's buyer conducts occasional unannounced testing of the residue content of green beans on his medium and large scale farmers to detect violators. If a farmer is caught in violation, bean collection is suspended. The contract is reinstated only when the farmer provides proof that remedial action has been taken and the buyer is satisfied that the farmer is not likely to repeat the violation. The farmer is however put on heightened supervision in form of more frequent visits by buyer's field TA for a period of time even after the contract has been reinstated. In addition, his/her beans will be subjected to more frequent testing and the pesticide storage area is also subjected to more frequent audit. In 2003 alone, Mango's beans were tested five times for MRL compliance without prior warning. In the same year, her buyer withdrew contracts from three medium scale growers after their beans tested positive for unapproved pesticides. In contrast, Chomba's buyer does not test his farmers' beans for residue content, but noted that his UK buyers occasionally will test random samples and notify him if there are any major problems that warrant immediate attention.

Both Chomba's and Mango's buyers also use price to enforce compliance with residue requirements. They both pay their farmers a price that depends directly on what they earn in the export market. Indeed Mango's and Chomba's contracts promise them fixed prices of Ksh 45/kilogram and 40/kilogram, respectively for beans of "exportable quality". "Exportable quality" beans are defined to be of the length, size and appearance (meaning spotlessness) required by UK customers. However, the price they get is variable. According to Chomba's buyer, Chomba actually gets a percentage of what the UK buyer pays for his beans. That is, Chomba is paid what is left after his buyer deducts his procurement and marketing costs and margin for his profit, which comes to about 20 percent of the price received by the buyer in the UK. The price Chomba actually receives varies with every consignment of beans sold, since his buyer's costs of procurement (including oversight) and marketing change routinely. Paying Chomba a variable price seems contrary to the fixed price stated in his contract. But the practice is consistent with proposition PA1, because the prices Chomba and Mango actually receive depend on the quality of their beans. Both ultimately receive prices that vary depending on what the UK market offers their buyers. Since market price conveys quality signals, pegging Chomba's and Mango's remuneration to the UK market price is one way to motivate them to work hard in meeting IFSS. It makes them the residual claimants of the effort they put towards meeting the international food safety standards. The variability of the price Chomba and Mango get results from two other factors related to quality of their beans. First, since both buyers pass the costs of oversight on to them, they end up shouldering more oversight costs whenever their buyers feel the need to monitor them more closely. Second, unbeknown to the two farmers, whenever their buyers feel unsure about the quality of their beans, the beans are sold in the UK wholesale market or channeled to other European countries with less demanding quality standards (Jaffee, 2003). Such markets typically pay less.

4.4.4 Coping with uninsured risks: the smallholder turns to a farmers' group

Given that buyers do not insure Chomba and Mango against all production and market risks but instead transfer significant market risk to them (by basing their prices on market price), how do they cope with these risks? Mango has diversified her investment portfolio into other farm and off-farm businesses which makes her less vulnerable to income risks than Chomba. She has 12 very productive dairy animals and two farm inputs/equipments business stores in Machakos town. These businesses are her sources of capital for short and long term emergency investments in the green bean business.

By contrast, Chomba has no other sources of income except the farm, so he is vulnerable to income shocks. To insure himself against such shocks, he joined the KHFG because it provided services that can resolve some of his uninsured risks, in addition to helping him meet long-term IFSS investments. Through its savings account, the group advances short-term interest-free cash loans to Chomba whenever he has proven financial difficulties. Second, KHFG loans pesticides to members who are unable to afford them and recovers the loan from members' sales. Third, the group seeks, purchases and stocks locally unavailable inputs (especially new pesticides), making them available to members. Fourth, Chomba has ready access to the group's trained technical assistant, in case there is an outbreak of pest or disease on his farm. Fifth, to address the rising cost of new pesticides, the group is working with the buyer to have farmers' fields sprayed by a team of hired pesticide spray operators in future. The buyer, who sees this as eliminating the problem of use of unapproved pesticides and violation of MRLs, fully supports the plan. Chomba feels that it reduces his exposure to pesticides and eliminates knapsack sprayer and protective clothing expenses.

4.4.5 Victim to beneficiary: Chomba tackles the economies of size hurdle by joining a farmer's group

The threat that smallholder farmers like Chomba face from the introduction of IFSS -- especially the need to undertake lumpy investments -- was aptly captured by the *Daily Nation* newspaper headline, "EU rules could destroy horticulture: the protocol … will have profound impact on both large and small-scale farmers, although the biggest impact will be on the latter[11]". How did Chomba meet the IFSS requirements for a grading shed with cement floor and washable tables, charcoal cooler, toilet and shower room? Like some other smallholder farmers, he joined a farmers' marketing group. Indeed, there has been a rapid increase in the number of smallholder horticultural groups in the last few years coinciding with period during IFSS has been more aggressively enforced by buyers. According to *The Sunday Standard*[12], over 1,400 smallholder horticultural farmers' groups have been formed, most them in the last 10 years. In green beans alone, there were more than 70 smallholder farmers' groups in 2003. Production managers of the leading exporters reported to this researcher that they intended to recruit more groups because their clients are increasingly emphatic about meeting residue limits and traceability. The UK traceability laws that came into effect in January 1, 2005 require buyers to

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[11] Daily Nation, May 7, 2004, p11
[12] Sunday Standard, January 29, 2005, p19

"demonstrate that they have set up systems and procedures enabling them to identify their direct suppliers and customers and to recall products if problems are detected[13]". Leading exporters have therefore turned to farmer groups that can more establish such systems. Chomba's group has already set up a traceability system. When sent to the buyers' packhouse, his produce is accompanied by his membership number, the number of the plot where it was grown, the picking date, and the KHFG group number.

The move by smallholders to form and join producer marketing groups appears to be the major strategy enabling smallholder farmers like Chomba to remain in the fresh export business. Joining a farmers' group enabled Chomba and other members of his group to take advantage of economies of size and remain competitive, which is consistent with proposition ES1. Their producer-level incentive to seek economies of size to comply with IFSS thus led them to the same group organizational form sought by export-oriented buyers to minimize transaction costs (proposition TC2). Evidence from South Africa supports this finding. Smallholders there have been successful in obtaining costly third party EUREPGAP certification by coming together to form producer marketing organizations which then seek certification (Mungai, 2004).

4.5 Conclusion

This case study contributes to the growing literature on food safety standards by elucidating how developing country farmers are meeting developed country

[13] *Sunday Nation*, December 12, 2004, p22-23

(international) food safety standards. It finds that IFSS compliance requires investment in specialized assets and alters the criteria for assessing quality in ways that increase the transaction costs of doing business between green bean farmers and export-oriented buyers.

The case study demonstrates that farmers can safeguard their specialized medium and long-term IFSS investments by using contracting, while buyers can use a combination of closely coordinated contracts, variable pricing, and the threat of contract termination to successfully enforce farmer compliance with IFSS. This case study also demonstrates that smallholders can meet the long-term IFSS investments if they come together to form a group that enables them to achieve economies of size and collectively to insure against idiosyncratic risks.

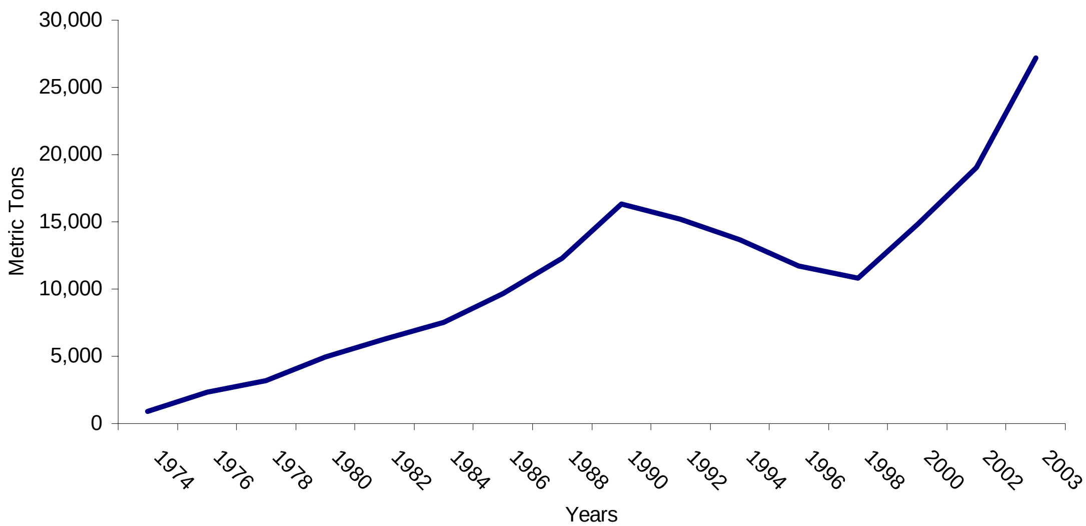
This study implies that there is need to strengthen enforcement of contracts between smallholders and buyers. To do this, third party verifiers need to ensure that contracts written by buyers are enforceable before they are signed. This in turn means that developed country governments should develop effective contract laws that are enforceable in law courts. Evidence from Ghana and Zimbabwe support this. Horticultural exporters there are forced to develop their own systems of enforcing contracts because existing contract laws are poorly developed (Fafchamps, 1996; Coulter, 1999).

Table 4.1: Characterization of the case farmers, Kerugoya District, Kenya, 2004

	Mango	Chomba
Profession	Retired accountant	Farmer
Age (Years)	56	49
Education (years)	14	12
Farm size (acres)	15	2.5
Area under last beans crop (acres)	10	0.5
Sales (Kshs*) from last plot	400,000	30,000
Years of growing beans	6	8
Number of bean plots in 2004	12	5
Non-farm business	Yes	No

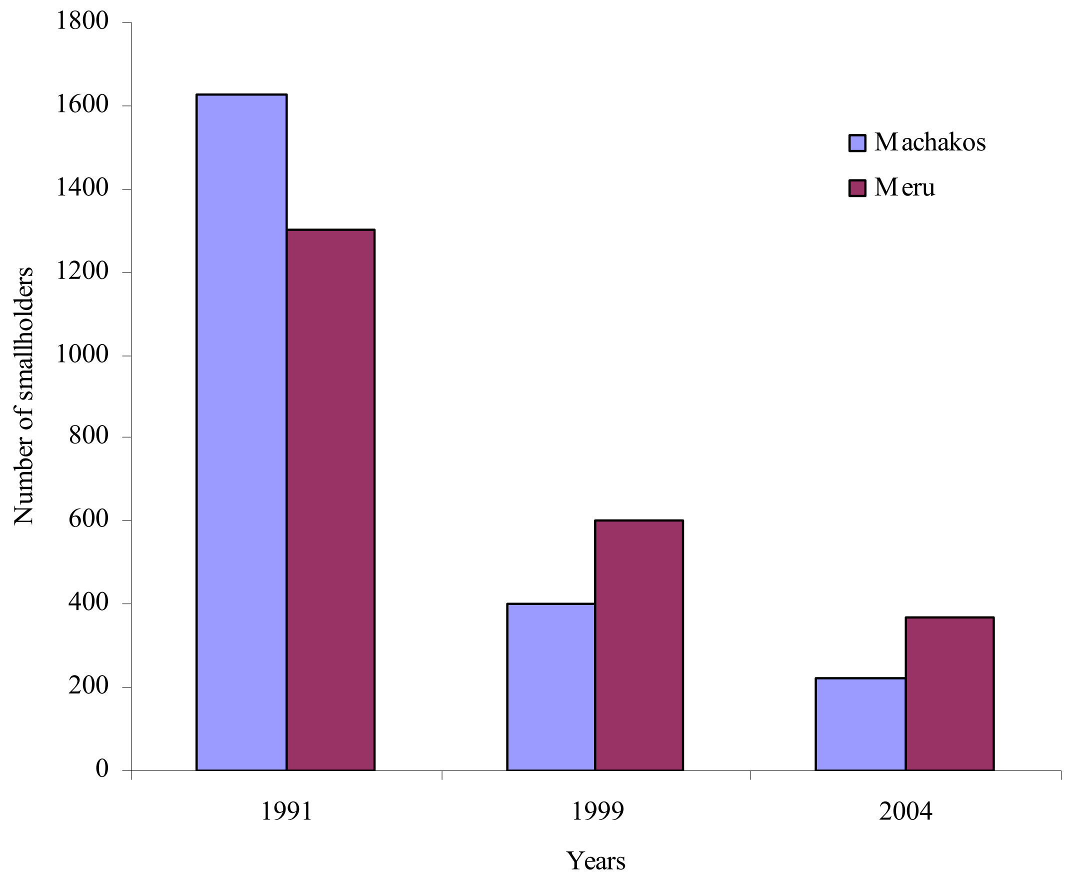
Source: Author's survey, 2004; * U.S $1 = 78 Kenya Shillings (Kshs).

Figure 1: Kenya's green beans exports, 1974-2003 (metric tons)



Source: HCDA trade statistics, various years

Figure 2: Number of smallholders in Meru and Machakos Districts supplying one of Kenya's leading exporters 1991-2004



Source: Author's survey, 2004

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CHAPTER 5

SUMMARY AND CONCLUSIONS

In response to growing consumer and medical health concerns, developed-country governments have been moving to reduce acceptable maximum pesticide residue levels (MRLs) in food products while increasing standards for farmer and packer hygiene. These strictures have been accompanied by intensified monitoring of pesticide residues, microbes and insects in fresh produce at national level. Private companies—especially major European supermarket chains—have responded by enforcing their own (private) food safety protocols relating to i) pesticide residue limits in food, ii) packer hygiene and iii) traceability. In most cases these private protocols are more stringent than official requirements.

What impact do these demanding standards, intensified oversight and traceability requirements have on developing-country fresh export vegetable growers? To begin with, these international food safety standards (IFSS) have raised the need for developing country fresh export vegetable growers to make adjustments in pesticide use, storage and disposal and farm-level post-harvest handling and documentation of production activities. In order to comply with the developed country pesticide standards (DC-PS), developing country farmers have to i) ensure that pesticide mixers and applicators use and dispose pesticides safely which implies the use of protective clothing, secure pesticide disposal pit, ii) mitigate exposure to pesticides by, among others, bathing, washing hands, maintaining sprayers in good conditions, iii) employ integrated pest management techniques to ensure that pesticides are sued only when needed, iv) store pesticides in way that do not threaten the health of family members and non-target plants and animals, and v) hire trained field technical assistant.

Compliance with the farm-level post handling requirements (mainly designed to reduce contamination of produce with microbes and dirt) on the other hand requires that developing country farmers have to invest in i) grading shed with cement floor and washable tables, ii) toilet, iii) charcoal cooler, and iv) trained clerk (whose work is to maintain high level of hygiene within the grading shed). These investments are lumpy and specific to green bean production. They also raise the need for investment capital.

The purpose of this study was to investigate the farm-level effects of international food safety standards on developing country farmers. In particular, the study addressed three broad objectives: i) determine the effects of developed country pesticide standards on the health of Kenyan French bean farmers, ii) investigate the effect of capital endowments on farmer compliance with IFSS, and iii) conduct an in-depth analysis of small and large green bean family farms to assess *how* they are complying with IFSS.

The study focused on Kenyan green bean family farms growing beans for export to Europe. Kenya is one of the leading suppliers of green beans to Europe while major retailers in Europe have for over a decade implemented stringent food safety standards making it a suitable case to study. The study is based on survey data collected during 2003/2004 from 180 Kenyan family green bean growers stratified by compliance with IFSS. The survey data was supplemented with information from detailed interviews with small and large representative family farms, industry stakeholders (government officials, exporters, third party IFSS certifiers, and officials of Fresh Produce Exporters Association of Kenya), and existing sources (e.g., industry reports, journals and local and international newspapers).

Essay 1 (Chapter 2), addresses the effects of developed country pesticide standards on pesticide-induced health and morbidity of Kenyan green bean family farmers. An econometric analysis examines whether transitioning to safer pesticides affects farmers' health costs of pesticide exposure, incidence of acute pesticide-induced illnesses, and the use of protective gear. Results indicate that (enforcing and monitoring) compliance with developed country pesticide standards i) reduces farmers' health costs of exposure to pesticides, ii) reduces farmers' incidence of pesticide-related illnesses, and iii) increases farmers' use of protective gear. Among other factors, education and farmers' ability to read and interpret pesticide labels (label literacy) increase the use of protective gear, which in turn reduces exposure to pesticides and hence pesticide related morbidity. The essay concludes that there are health benefits to Kenyan green bean farmers due to complying with developed country pesticide standards beyond the acknowledged income generation from selling to this premium market. The essay recommends that more effort should be directed at training and educating farmers on safe use of pesticides.

Essay 2 (Chapter 3) investigates whether capital endowments affect Kenyan family farmers' access to contracts for exportable green beans and related compliance with IFSS. The econometric results indicate that physical capital (assets ownership, farm size, and credit), human capital (experience and prior pest management knowledge) and social capital (membership in farmer group) increase the probability that a farmer will obtain a contract from an exporter, as well as the degree of compliance with IFSS among those farmers who obtain contracts. It therefore concludes that there are significant wealth effects in complying with IFSS in Kenyan green bean industry. Drawing on findings of essay 3 (Chapter 4) this essay argues that the resource-poor developing country smallholders can avoid being marginalized by IFSS by banding together in farmer associations (e.g., cooperatives) and collectively investing in costly fixed assets. The essay recommends that the government provides institutional support to green bean family farmers by facilitation the formation of farmer groups/associations.

Essay 3 (Chapter 4), addresses the question of *how* IFSS compliant farmers have gone about meeting these standards. It uses a paired case study of small and large green bean family farms export to major European retailers that demand compliance with IFSS. The essay finds that IFSS increase the fixed and transaction costs of producing beans and make quality verification problematic. As a result, both small and large farmers use contracts to safeguard their specific investments. Buyers, on the other hand, tackle the information asymmetry of enforcing compliance with hard-to-observe IFSS requirements by using closely monitored contracts, the threat of contract termination, and variable product pricing. In addition, buyers have required contracted smallholders to band together into marketing groups in order to reduce monitoring costs. The combined result of producer and buyer behavior has been to increase the scale under which contracted beans are produced in Kenya. The essay concludes that the future of smallholders lies in banding together into cooperative groups that collectively invest in fixed and contract-specific assets in order to attain the scale economies needed to remain viable. The major policy implication of this finding is that there is a need to ensure that i) contracts between farmers and buyers are enforceable, and ii) contract laws are strengthened and strictly enforced.

This dissertation research contributes to two major areas of academic debate. First, it contributes to the debate on pesticide-induced health and morbidity among (high value) fresh export vegetable farmers. Second, it contributes to the hot debate on the impact of international food safety standards on continued participation of smallholders in premium export markets. It demonstrates that enforcing developed country standards that promote safe use, storage and disposal of pesticides reduces farmers' pesticide-induced morbidity. This study also demonstrates that while the fixed investments necessitated by international food safety standards present a major challenge to poor smallholders, such farmers can overcome this hurdle by banding together and meeting the costs of fixed investments as a group.

This study did not examine the effect of developed country food safety standards on fresh produce traded in developing countries' domestic markets. Future research should investigate whether the "good" agricultural practices promoted under DC-PS are being followed in the production of domestic fresh vegetables such as tomatoes. Ignoring the health effects of pesticide exposure overvalues the marginal benefit of pesticides. It is therefore tempting for a farmer who is aware of the health costs associated with exposure to pesticide to transfer these external cost of pesticide use to others, especially hired temporary labor. Although this study did not investigate this subject, future research should do so.

APPENDIX

APPENDIX 6: THE SURVEY QUESTIONNAIRE

COMPLIANCE WITH INTERNATIONAL FOOD SAFETY STANDARDS: THE CASE OF GREEN BEAN PRODUCTION IN KENYAN FAMILY FARMS

1. Name of interviewer______________________ 4. Sublcocation___________

2. Name of respondent_______________________ 5. Subunit _____________

3. Division_________________________________6. Date of interview________

Time start_________________________________ Time end _______________

Dissertation Research Sponsored by Rockefeller Foundation Fellowship and World Bank Short Term Consultancy

Consent Document- on "Compliance with International Food Safety Standards: The case of Green Bean Production in Kenyan Family Farms"

We're from Nairobi University. We are conducting a study on "economics of fresh export vegetable standards in Kenya". The study forms the basis for Doctoral thesis for Julius J. Okello who is a lecturer at University of Nairobi and is currently a PhD student at Michigan State University – USA.

Your participation is entirely voluntary and you can refuse to answer any question at any time. There will be no penalty for withdrawing from the survey (which takes approximately 1hr 30 minutes). If you have questions about the study, contact the responsible faculty, Dr. Scott Swinton, 304 Agriculture Hall, East Lansing, MI 4882; Tel. (517) 353- 7218, email: swintons@msu.edu. In case you have questions or concerns about your rights as a research participant, can anonymously contact, if you wish, Dr. Peter Vasilenko, MD, Michigan State University's Chair of University Committee on Research Involving Human Subjects by phone: (517) 355-2180, fax: (517)432-4503, email : ucrihs@msu.edu, or regular mail: 202 Olds Hall, East Lansing, MI 48824.

The information you provide will be CONFIDENTIAL and findings reported as an aggregate along with those of other farmers like you. Your privacy will be protected to the maximum extent allowable by law. YOUR NAME OR THAT OF YOUR BUYER WILL STRICTLY NOT BE IDENTIFIED IN THE FINAL REPORT (THESIS). You indicate your voluntary agreement to participate in this research by beginning this interview.

Thanks.

Investigator
Julius Juma Okello
Dept. of Agric. Economics
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I would like to start with some questions related to location of your farm

PART I: FARM PHYSICAL, CAPITAL AND LABOR ENDOWMENTS

Please note that last crop of French beans refers to crop harvested up to or before 31st Dec 2003, and does not include crop yet to be harvested or still being harvested.

1. How far is your farm from nearest market center in walking hours?____________
2. How far is your farm from the nearest bean collection center in walking hours? ___
3. How far is your farm from the nearest public health dispensary in walking hrs?____
4. What is the size of your farm in acres?______
5. When did you harvest your last crop of French beans? Month ______________.

PART II: FRENCH BEAN PRODUCTION PRACTICES

1. What was the size of plot used for your last crop of French beans in acres? ______
2. Do you grow French beans under contract with an export company?

   1=Yes　　　0=No *(Go to question 5)*

3. If YES, which exporter(s) did you produce for between 1st Jan 2003 and 31st Dec 2003? (*Tick all that apply*)

1=Homegrown	4=Woni	7=Sacco Fresh
2=Vegpro	5=KHE	8=East Africa Growers
3=Sunripe	6=Greenlands	9=Other (specify)__________

4. What are your 3 main reasons for choosing to produce under contract? Please rank.

1=Assured market for my French beans----	5= Easier access to cash credit---
2=Easier access to current information-----	6=Easier access to quality seed---
3=Higher prices-------	7=Stable prices--------
4=Easier access to new pesticides--------	9=Other (specify)________------

5. Do you irrigate your French beans?

   1=Yes　　　0=No

6. Please indicate below the quantity of each grade of French beans you sold and the price you received for each grade during the last crop season.

Extra fine beans		Fine beans		Bobby beans	
Boxes sold	Price (Ksh/box)	Boxes sold	Price (Ksh/box)	Boxes sold	Price (Ksh/box)

7. In tables a) and b), please provide information regarding the pesticide/chemical remedies you used in your French beans before (10 years ago) and those used now.

Table a): Chemicals used for controlling insects, mites and nematodes

OLD insectides (chemicals used before)			**NEW insecticides (chemical used now)**		
	Qnty (Unit)	**Cost (Kshs)**		**Qnty (Unit)**	**Cost (Kshs)**
Planting to 3-leaf formation					
3-leaf to flowering					
Flowering to harvesting					
Start to end of harvesting					

Table b): Chemicals used for controlling diseases

OLD fungicides (chemicals used before)			**NEW fungicides (chemical being used)**		
	Qnty (Unit)	**Cost (Kshs)**		**Qnty (Unit)**	**Cost (Kshs)**
Planting to 3-leaf formation					
3-leaf to flowering					
Flowering to harvesting					
Start to end of harvesting					

8. Did you apply for credit to use in French beans between 1995 and 31st Dec 2003?

1=Yes 0=No *(Go to question 11)*

9. If YES, did you receive credit?

1=Yes 0=No *(Go to question 11)*

(*In Question 10, in-kind credit credits (e.g seed, chemicals, fertilizer) should be converted into money-value using market prices that prevailed when credit was received. Seasonal inputs = fertilizer, seed, chemical, hired labor, etc; farm equipments = plow, oxen, sprayer, donkey etc.*)

10. Please indicate the amount of credit (in Kshs) received and what you used it for.

Credit source	Cash	In-kind (Kshs)	What was cash credit used for? (*Please tick*)			
			Seasonal inputs	Store/pit construction	Protective clothing	Farm equipments
1.Agric. Finance cooperation (AFC)						
2.Buyer (Exporter)						
3.Farmers group						
4. Bank						
5.Local SACCO						
6.Local trader						
7.Local NGO ___						
8. Relative/friend						
Other						
Other						

11. If you have never obtained credit for use in buying protective clothing, and/or constructing bathroom, chemical store, chemical disposal pit, where did you get the money for doing so from? (*Please tick all that apply*)

Source of cash	**Investment type**			
	Seasonal inputs	**Store/pit construction**	**Protective clothing**	**Bathroom**
1=French bean revenue				
2=Dairy revenue				
3=Other cash crop				
4=Cattle sale				
5=Timber/wood sales				
6=Sale of land				
7=Durable goods (Bike, tv, etc)				
8=Off-farm income				
9=Remittance/gifts				
10=Other				

PART III: HOUSEHOLD DEMOGRAPHIC AND WEALTH INFORMATION

1. Please provide the age, gender and education of all resident members of your household.

Family Member	Age (Yrs)	Gender (M/F)	Education (Yrs)	Highest education level
1=Farmer				
2= Spouse				
3=1st Child				
4=2nd Child				
5=3rd Child				
6=4th Child				
7=1st Relative				
Other				

Educational Level Codes

1=Incomplete primary
2=Completed primary
3=Completed junior secondary
4=Completed O-level
5=Completed A-level
6=Completed college diploma
7=University graduate & above
0=Did not go to school

2. Please indicate the income earned by members of your household from any off-farm employment activities between 1st Jan 2003 and 31st Dec 2003.

Activity	1=Farmer	2=Spouse	3=1st child	4=2nd child	5=3rd child	6=Relative

Codes for off-farm employment activities

1=tomato weeding
2=tomato picking
3=Rice harvesting

4=Coffee pruning
5=Coffee picking
6=Maize weeding
7=Bean weeding
8=Bean harvesting
9=Bean grading
10=

16=Carpentry
17=Basket weaving
18= boarder-boarder

19=Wood carving
20=Salon
21= Running a shop
22=Shoe making
23=Tailoring
24=Rice milling
20=Selling rice

21=Teaching
22= Other govt. jobs
23= NGO employment

24=Mganga
25=Midwife
26=Other__________
27=
28=
29=
30=

3. How much income did you get from sale of cash crops and livestock/ livestock products between 1st Jan 2003 and 31st Dec 2003?

Item	Cash received (Kshs)
1. French beans	
2. Other cash crops (rice, tomato, maize etc)	
3. Food crops (field beans, potato, etc)	
4. Sale of milk	
5. Sale of animals (cow, oxen, bull)	
9. Other	

4. Did you receive some money from relatives or pension between 1st Jan 2003 and 31st Dec 2003? 1=Yes 0=No

5. If YES, what was the total amount between 1st Jan 2003 and 31st Dec 2003?

Ksh_____

6. Please indicate in the table below the quantity, year of purchase and purchase price of the assets you currently own.

Asset type	Quantity	Year it was purchased/constructed	Purchase Price/Cost (Ksh)

Codes for household assets

1=Ox-plough	11=Chemical store	21=Television	31=PSV car
2=Oxen	12=Bathroom	22=Radio	32=M/bike
3= Ox-trailer	13=Grading shed	23=Stove/oven	33=Bicycle
4=Tractor	14=Permanent house	24=Sofa set	34=Truck
5=Hoes/jembes	15=Kitchen	25= Sewing machine	35=Donkey
6= Sprinklers	16=Food store	26= Refrigerator	36=
7=Sprayer	17=	27= Tables	37=
8=	18=	28=	38=

PART IV: PEST MANAGEMENT PRACTICES

1. How do you determine when to apply pesticides to your French beans?

1=Whenever I see a pest	5=When advised by the buyer's staff
2=Only after scouting for pests	6=When a neighbor sprays
3=Using spray calendar/program	7=When advised by other farmers
4=When advised by chemical trader	9=Other (specify)_______.

2. Do you scout for pests in your French bean plot?

1=Yes 0=No (*Go to question 5*)

3. If YES, how many hours did you spend scouting for pests in French beans during your last crop between 1st Jan 2003 and 31st Dec 2003?______________

4. If someone else scouted for pests in your last crop of French beans between 1st Jan 2003 and 31st Dec 2003, indicate how much time the individual(s) spent scouting for pests._______________ hrs.

5. Please provide the following information about chemicals you used to control pests and diseases in your last French bean crop between Jan 1, and December 31, 2003.

Growth stage	Target pest	Pest pressure	Chemical Applied	Quantity of concentrate	Number of Applications	Area covered
Planting to germination						
Germination to 3-leaf formation						
3-leaf to flowering						
Flowering to end of harvest						

Codes for pest pressure:

1. None 3. Medium (noticeable damage) 5. Very heavy
2. Light (Negligible damage) 4. Heavy

6. Did you keep records of the use of chemicals in your last crop of French beans between 1st Jan 2003 and 31st Dec 2003?

1=Yes 0=No *(Go to question 9)*

7. If YES, how many hours did you spend keeping records of chemical use during your last crop of French beans between 1st Jan 2003 and 31st Dec 2003? __________

8. If someone else kept records for you during this period, indicate how much time (hours) the individual(s) spent _____________________

9. How many times did you obtain French bean pest management information/extension advice from the following sources between 1st Jan 2003 and 31st Dec 2003?

Pest management information source	Number of times information was obtained
1.Govt. extension agent	
2. Visit by Buyer's field staff (TA)	
3. Hort. Crop Dev. Authority (HCDA)	
4. Farmers Training Center	
5. Farmers field days	
6. Local pesticide trader	
7. Other French bean farmers	
8. Agrochemical Association of Kenya	
9. Local Newspaper/Magazine	
10. Radio broadcast	
11. Agric. Information Service (AIS)	
12. Other (specify)____________	

10. Indicate below the time spent (hours) by any member of your household in undertaking any of the following activities. (*Ask if required by exporter/buyer*)

Household member	Constructing pesticd disposal pit	Constructing bathroom	Constructing chemical store
1=Farmer			
2=Spouse			
3=1st Child			
4=2nd Child			
5=3rd Child			
6=Relative			
Other			

11. How many times did you grow French beans in the past 5 year? _____________

12. Please indicate if you have been trained on any of the following pest management strategies, year you were trained, cost of training and whether you used it for your last French bean crop between 1st Jan 2003 and 31st Dec 2003.

Pest management strategy	Trained? 1=Yes 0=No	Year trained	Cost (Ksh)	Do you use it? 1=Yes 0=No
Soil testing for pests				
Crop rotation				
Use of resistant variety				
Fallow the plot				
Mulching				
Uproot and burn/burry infected plants				
Alternating pesticide to slow resistance				
Pest scouting				
Use of safer and less toxic pesticides				
Adjusting application rate, timing and frequency to protect beneficial organisms				
Use trap crops				
Use of biological/natural pesticides				
Other(specify)_______________				

PART IV: PESTICIDE HANDLING AND SAFE USE

1. Who is the primary mixer of pesticides used on your French beans?

1=Myself 2=Spouse 3=Child 4=Hired laborer

5=Other_____

2. How does the mixer determine the amount of water to use for mixing pesticides?

1=Extension recommendations 3=From other farmers

2=Using the labels 9=Other

(specify)________________

3. What does mixer use for mixing the pesticide? (*Circle all that apply*)

1= Hand 4=Stick shorter than a ruler

2=Kitchen knife 5=Stick longer than a ruler

3=Machete/panga 9=Other (specify)_____________

4. What container does the mixer use for mixing pesticide? *(Circle all that apply).*

1=Cooking pot 4=Drinking-water bucket

2=Sprayer tank 5=Special container for mixing pesticide

3=Bathing basin/trough 9=Other (specify)____________

5. Who is the primary applicator of pesticides on your French beans?

1=Myself 2=Spouse 3=Child 4=Hired labor 5=Other__

6. What clothing does the applicator wear when applying pesticides? (*Please record responses in the table below*)

Item	Clothing item used (*please check*)	**How often item is used**		
		Never	Sometimes	Always
Long-sleeved overall				
Rubber gloves				
Gumboots				
Nose mask				
Goggles				
Hat/headscarf				
T-shirt				
Short trousers				
Other				

9. If the applicator <u>does not always wear</u> any of the following protective clothing when spraying your French beans, please select the reason(s) why. (*Check all that apply*)

Item	Too hot	Not comfortable	Can not afford	Slows one down	Don't see need for it	Other___
Long-sleeved Overall						
Rubber Gloves						
Gumboots						
Nose mask						
Goggles						
Hat/headscarf						

10. Please indicate the alternative that best describes applicators pesticide application practices in each of the cases below.

Application practice	Never	Sometimes	Always
Ensures that sprayer is in good condition			
Observes the direction of wind when spraying			
Pesticide comes into contact with skin when refilling sprayer			
Sprays even when others are in the plot/field			
Eats food while applying pesticides			
Smokes while applying/handling pesticides			
Drinks in the field while applying pesticides			
Wash hand with soap after applying pesticides			
Keeps in the house clothes worn during spraying			
Washes clothes worn when spraying pesticides			

11. How long do you take before going to your plot to inspect it after spraying was against weeds, insects and diseases? (*please tick the correct answer)*

Pest group	Chemical used	Time allowed before returning to the plot (in hrs)					
		0- 6	6-12	13-48	49-72	> 72	Don't know
Weeds							
Insects nematode & mites							
Diseases							

12. Did the sprayer leaked on the applicators legs, arms or back when spraying last yr? 1=Yes 0=No *(Go to question 14)*

13. If YES, what did he/she do?

1=Finished the tasks then changed clothes 9=Other (specify)______

2=Changed clothes and took a shower 0=Nothing

3=Changed the wet clothes and proceeded to finish the task

14. What time does the applicator take a shower/bath after applying pesticides?

1=Evening 4=In the early morning

2=When I finish field tasks of the day 0=I sometimes don't

3=Soon after pesticide application 9=Other (specify)________

15. What do you do with empty pesticide containers/bottles?

1=Dispose into the disposal pit 6=Destroy and burn or bury

2=Wash and use domestically 7=throw in the toilet

3=Wash and use for paraffin 8=Other (specify)_________

16. Do you have a pit for disposing leftover pesticides/pesticide containers?

1=Yes 0=No (*Go to Question 18*)

17. If YES, indicate if any of the following apply.

1=A "warning sign" is posted on it 4=It is covered with logs/timber

2=It is fenced 5=It is open

3=Both 1 & 2 above 9=Other (specify)_________

18. Please indicate what the following color band (**pictogram**) on pesticide containers mean to you.

Color of the band (warning sign)	Meaning of the color band on the pesticide container				
	Not harmful	Slightly harmful	Harmful	Very harmful	Don't know
Blue					
Red					
Yellow					
Green					

19. Do you know how to offer pesticide poisoning first aid?

1=Yes 0=No

20. Do you have a first aid kit in your house?

1=Yes 0=No

21. Indicate the type of sprayer(s), number owned, year and cost of purchase and whether regularly maintained.

Type of sprayer	Number	Year purchased	Price (Ksh)	Number of maintenance per year?
Knapsack				
Ultra-low volume				
Other (specify)				

22. If you repaired/maintained/recalibrated your sprayer(s) between 1st Jan 2003 and 31st Dec 2003, how much did you pay for it? Ksh_________________

PART V: PESTICIDE STORAGE PRACTICES

1. Where do you store your pesticides? (*Circle all that apply*)

1=Living/sitting room 4=Food store area 7= Animal stall

2= Bedroom 5=Chemical store 8= Grading shed

3=Cattle feed store 6= Kitchen 9=Other (specify)

2. If you have a chemical store, indicate if any of the following apply.

(*Circle all that apply and ask the farmer to show you the store to verify responses*)

1=Has "Chemical store" on the door 4=Remains locked if not in use

2=Has Hazard sign (warning triangle) on it 9=Other (specify)__________

3=Has "No admission" on the door 0=Nothing

3. Do you have a place to wash hands next to where you store your pesticides?

1=Yes 0=No

4. Do you wash your hands with soap every time you come from the store or handle chemicals? 1=Never 2=Sometimes 3=Always

5. Have you ever had some of your pesticides spill on the store floor?

1=Yes 0=No (*Go to Question 7*)

6. If YES what did you do?

1=Swept/mopped it 3=Covered with sand or soil

2=Poured water on it and let it dry 9=Other (specify)______

7. Do you keep a bucket of sand/soil in or near the place you store your pesticides?

1=Never 2=Sometimes 3=Always

8. Do you eat or drink while inside the store or when handling chemicals?

1=Never 2=Sometimes 3=Always

9. Do you smoke while inside the store or when handling chemicals?

1=Never 2=Sometimes 3=Always

PART VI: HOUSEHOLD MEMBER HEALTH

(*Please record only symptoms that occurred soon after exposure [handling, mixing and applying] to pesticides in the questions that follow.*)

1. Please indicate how frequently someone in your family experiences the following acute symptoms after handling or applying pesticides to French beans.

Symptom	Never	Less than half the time	More than half the time
Dizziness			
Vomiting			
Nausea			
Nose bleeding			
Blurred vision			
Common colds			
Headache			

2. Did anyone in your household have stomach irritation after handling/applying pesticides in the last five years?

1=Yes 0=No 99=Can't recall

3. If YES, indicate for each affected person, the number of times the following symptoms of pesticide stomach irritation occurred in the last five years.

Household member affected	Symptom of pesticide poisoning				
	Not severe	Mild/moderate	Severe	Very severe	Lethal
1=Farmer					
2=Spouse					
3=1st child					
4=2nd child					
5=3rd child					
6=Relative					
Other					

4. If any member(s) of your household had eye irritation after handling/applying pesticides in the last five years, please indicate, for each affected person, the number of times these eye irritation symptoms occurred.

Household member affected	Symptoms of eye irritation				
	Not severe	Mild/moderate	Severe	Very severe	Lethal
1=Farmer					
2=1st spouse					
3=2nd spouse					
4=1st child					
5=2nd child					
6=Relative					
Other					

5. If any member(s) of your household had skin irritation after handling pesticides in the last five years, please indicate, for each affected person, the number of times these skin irritation symptoms occurred.

Household member affected	Symptoms of skin irritation				
	Not severe	Mild/moderate	Severe	Very severe	Lethal
1=Farmer					
2=Spouse					
3=2nd spouse					
4=1st child					
5=2nd child					
6=Relative					
Other					

6. Please indicate any member of your household who has/had the following long-term medical condition and duration of illness.

Medical condition	HH member affected	Duration of illness
1=Blindness		
3=Asthma		
4=Lung damage		
5=Back pain from sprayer use		
Other		

Codes for long-term medical condition

1=Head 2=Spouse 3=Child 4=Relative 9=Other______

7. If any member of your household was sick and/or received treatment from a nearby health center/clinic following pesticide poisoning, please complete the table below.

HH member affected	Pesticide ailment	No. of days sickness	Treated 1=Yes 0=N0	No. of visits to clinic	Cost of treatment (Ksh)	No. of days/hrs of work lost
1=Farmer						
2=Spouse						
3=1st Child						
4=2nd Child						
5=3rd Child						
6=Relative						
Other						
Other						

Codes for pesticide ailment

1=Stomach poisoning 3=Skin irritation 5=Back pain from sprayer use

2=Eye irritation 4=Wheezing cough/asthma 9=Other_______

8. If any member of your household had pesticide-related ailment and needed care (nursing) and/or company to the health center/clinic, please indicate who provided care, number of visits, and duration of care.

Care provider	Pesticide ailment	Days of care (at home)	Company on hospital/clinic visits	
			Number of visits	Hours per visit
1=Farmer				
2=Spouse				
3=1st Child				
4=2nd Child				
5=3rd Child				
6=Relative				
Other				

Codes for pesticide ailment

1=Stomach poisoning 4=wheezing cough/asthma 5=Back pain from sprayer use

2=Eye irritation 3=Skin irritation 9=Other________

9. What is your major source of pesticide-use related health/safety information?

1=Village health work 3=Extension worker 5=Other farmers

2=Local media (radio, TV, newspaper) 4=Pesticide trader 9=Other______

10. For each household member that consumes alcohol, please indicate the amount of alcohol consumed, duration of alcohol consumption and whether he/she still consumes alcohol.

Household member	Amount consumed per week (liters)	Duration of alcohol consumption (yrs)	Still consumes? 1=Yes 0=No
1=Farmer			
2=Spouse			
3=1st Child			
4=2nd Child			
5=3rd Child			
6=Relative			
Other			

11 For each household member that smokes, please indicate the number of cigarettes smoked, duration of smoking and whether he/she still smokes.

Household member	No. of cigarettes smoked per week	Duration of smoking (yrs)	Still consumes? 1=Yes 0=No
1=Farmer			
2=Spouse			
3=1st Child			
4=2nd Child			
5=3rd Child			
6=Relative			
Other			

Finally……..

12. How long does the applicator take to spray your field? -------------------- hrs

13. Do you find new chemicals for controlling beanfly more expensive than old ones?

1. Yes 0. No

14. If YES, what have you done about it?

1. Increased number of weedings 3. Increased number of pest scouting

2. Increased crop rotation 0. Nothing

Thank you!