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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

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Full Length Research Paper

Viability of tobacco production under smallholder farming sector in Mount Darwin District, Zimbabwe

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Smallholder commercial agriculture in developing countries is hinged on cash crop production and in Zimbabwe tobacco is increasingly becoming an important smallholder cash crop. This study therefore, analyzed the viability of tobacco production by smallholder farmers in Zimbabwe. Cross sectional survey data was collected for the 2010 and 2011 production season from 60 smallholder households in the Mount Darwin District of Mashonaland Central Province in Zimbabwe. Data were analyzed using descriptive statistics, gross margin analysis, breakeven analysis and ordinary least square (OLS) criterion to determine the viability and determinants of income earnings from tobacco by farmers. The study revealed that, smallholder tobacco production was viable, with farmers achieving average yield of 2052 kg/ha, average price of US $2.45 per kilogram and earning, on average, about US $2352 per hectare as gross margin. Break-even analysis revealed a margin of safety of 50% with respect to both yield and prices, indicating that, small-scale tobacco production will remain lucrative even at much lower prices and yields. Regression analysis showed that, off farm employment was inversely related to revenue earnings from tobacco with coefficient (-0.058) and the relationship was significant at 5%. Price and yield were positively related to tobacco gross margins with coefficients 0.865 and 1.001 and the relationship was significant at 1%. It is therefore concluded that, tobacco production is viable and can improve incomes for smallholder farmers. To improve income earnings from tobacco, there is a need for farmers to focus on farm production for better yields and improve quality for better prices.

Key words: Break even, gross margins, income, off farm employment, yields, quality.

INTRODUCTION

In Zimbabwe, the 2000 fast track land reform has been characterised by radical reconfigurations of land, production, economy and livelihoods in the rural landscape (Mavedzenge et al., 2008) and brought about benefits and opportunities as well as costs, challenges and pitfalls (Scoones et al., 2010). What is clear is that, there is a move to commercialise small-scale production, and integrate more effectively black indigenous farmers into the national economy, hence the increased participation of smallholder farmers, who now command the majority of the land used for agricultural purposes in Zimbabwe (Shumba and Whingwiri, 2006).

"Smallholder farmers" is used more generally to describe rural producers, predominantly in developing countries, who farm using mainly family labour and for whom the farm provides the principal source of income (Ellis, 1988) and in Zimbabwe it is used loosely to define indigenous black farmers. In Zimbabwe smallholder

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agriculture has been traditionally based on a wide range of rain fed, seasonal food crops for balanced household nutrition and risk aversion. Small scale farming has been important for food security, contributing 42% of total maize production (the staple in Zimbabwe) in 1980 increasing to 60% in 1985 and then 70% in 1999 (Rukuni, 2006). Commercial agriculture in Zimbabwe is important for generating raw materials for the manufacturing industry, generation of foreign earnings, and ultimately economic growth. In addition, commercial production mainly focuses on year round production of high value cash and export crops, using production systems based on modifications of the natural environment and use of highly mechanised machinery.

The new agrarian structure in Zimbabwe entails commercialisation of smallholder agriculture, hence the need for smallholder diversification into high value crops like tobacco. Tobacco "the golden leaf" has been the single most important export commodity in Zimbabwe. Tobacco generates in excess of USD650 million in foreign revenue annually, by 1991 Zimbabwe had become the world leading exporter of flue cured tobacco, accounting for around 40% of its foreign currency earnings and contributing approximately 10% of country's GDP (Muir-Leresche, 2006). Tobacco generates employment more than any other crop in the country. It directly employs over a million people, and many more in the downstream industries. The area under flue cured tobacco increased from 61 180 ha in 1950 to 84 857 ha in 2000, the quantity of tobacco produced also increased from 47 294 tonnes in 1950 to a peak of 236 946 tonnes in 2000 (Cole and Cole, 2006).

The 2000 agrarian reforms also transformed the structure of the tobacco sub-sector. There were 15000 registered tobacco growers in 1998, currently there are more than 64 000 predominantly smallholder tobacco growers in Zimbabwe (Tobacco Industry and Marketing Board (TIMB), 2011). The increase in the number of producers has been accompanied by decline in the area grown per farmer and of concern is also the decline in productivity. Tobacco productivity declined from 2200 kg/ha in 1998 to about 700 kg/ha in 2001(Ministry of Lands and Agriculture, 2005). Tobacco output plummeted from a record level of 267 million kg in 2000 to 73 million kg in 2007 (Dawes et al., 2009). There was a marked decrease in the value of tobacco exports in 2001 from US $640 million to US $204 million in 2002 and US $396 in 2004 (FAO, 2004), weakening Zimbabwe's competitive position in the world market for flue cured tobacco in favour of China, India, and Brazil. Tobacco has been a highly profitable and lucrative crop for commercial farmers in Zimbabwe (Rukuni, 2006) however for smallholders there is need for research based inquiry to ascertain economic benefits of choosing tobacco as a cash crop enterprise.

In Zimbabwe as in many developing countries, smallholder agriculture was viewed as a failed sector, and smallholder farmers as severe degraders of the environment. This notion is however debatable. For example in Zimbabwe prior to the fast track land reform program, and because of colonial injustices, smallholders typically occupied communal areas in more fragile and marginal environments. In addition Zimbabwe has a well-documented post-independence smallholder productivity success story, though some argue that the drastic increase in output from the smallholder sector has been largely a result of the increase in areas planted while crop yields have remained almost static (Takavarasha, 1994). Smallholder farmers in Zimbabwe now have access of land in high potential areas and questions regarding potential of small scale commercial agriculture to successfully produce cash crops of economic importance and their potential in improving smallholder household incomes remain unanswered. This study was therefore designed to (i) investigate viability of tobacco as a smallholder cash crop in Zimbabwe and (ii) determine the determinants of viability.

MATERIALS AND METHODS

Study area

The study was carried out in Mount Darwin, a District in the Mashonaland Central province of Zimbabwe. Mashonaland Central province accounts for about 30% of Zimbabwe's tobacco output (TIMB, 2011) and Mount Darwin is in Natural region III, a semi-intensive farming region with moderate rainfall. The study area comprises mainly of small scale farmers who are into cash and food crop production.

Sampling and sample size

Using a two-stage-selection approach, a random sample was selected. The first stage identified all smallholder tobacco farmers in Mount Darwin using the TIMB database. The second stage identified, from a list of all smallholder tobacco farmers, all newly resettled farmers. Finally the identified farmers were stratified in to 3 main tobacco growing areas based on information provided by district extension workers from which a random sub-sample of 20 was drawn from each for an in-depth study.

Data collection

A structured questionnaire was used to interview the selected farmers. Secondary data for each household on yield, credit provided to the household, price, area, average weight of tobacco bales delivered and total sales revenue was obtained from TIMB. Secondary data was considered to be more reliable than the primary data obtained from interviewing the smallholders. Data from the structured questionnaire was therefore cross-referenced with secondary data and in cases of discrepancies, secondary data was given in preference.

Data analysis

Data analysis methods used were descriptive statistics, gross margin analysis, break even analysis and regression analysis. Details of these analytical techniques are given in this section.

Descriptive statistics

Descriptive statistics were used as a preliminary investigation procedure to gain an understanding of inherent significant socio-economic characteristics of the smallholder farmers.

Gross margin analysis

Johnson (1985) defines the gross margin as, the gross income from an enterprise less operating (variable costs) of production. Although a gross margin is not profit as it does not include fixed or overhead costs such as depreciation, interest payments, rates and permanent labour, which have to be met regardless of enterprise size. Gross margin serves as the unit of analysis in evaluating the economic performance of an enterprise and gives an indicator of the viability of an enterprise and its potential contributing to household income. Gross margins are generally quoted per unit of the most limiting resource, for example, land, hence crop gross margins are provided on a per hectare basis.

Gross margins were computed as follows:

$$GM = P_q Q + \sum_i PiXi$$

Where, GM is gross margin in US dollars per hectare for the tobacco crop enterprise; P_q is the price of tobacco per kg; Q is the quantity of crop output per hectare in kg; *Pi* is the price of the i^{th} variable input used in tobacco production; and Xi is the quantity of the i^{th} variable input per hectare.

Breakeven analysis

The breakeven price is the minimum price per unit required to cover all production costs at the anticipated yield and was computed as follows:

$$Breakeven\ Price = \frac{\text{Anticipated Total Production Costs}}{\text{Anticipated Yield}}$$

The breakeven yield is the minimum yield required to cover all costs at the anticipated price per unit and was computed as follows:

$$Breakeven\ Yield = \frac{\text{Anticipated Total Production Costs}}{\text{Anticipated Price}}$$

Ordinary least square (OLS) analysis

For the study the dependant variable was total tobacco gross income (US$/ha). Though profit maximisation is the objective in smallholder cash crop production and ideally, one would wish to model profits directly through the incorporation of variable costs, fixed costs and revenues pertaining to the input-output relationship. Profit is difficult to measure for a single crop in a smallholder setup due to unavailability of records on crop-specific inputs (Fulginiti and Perrin, 1998). In addition the dependence on family labour often makes it difficult to disaggregate and allocate it for specific intra-household cropping activities. The Cobb Douglas functional form was used for its simplicity, flexibility and also the empirical support it has received through wide applications on data for various industries and countries.

$$\text{LogY} = \beta_0 + \beta_1\text{Log}X_1 + \beta_2\text{Log}X_2 + \beta_3\text{Log}X_3 + \beta_4\text{Log}X_4 + \beta_5\text{Log}X_5 + \beta_6\text{Log}X_6 + \beta_7\text{Log}X_7 + \beta_8\text{Log}X_8 + \beta_9\text{Log}X_9 + \beta_{10}\text{Log}X_{10} + \beta_{11}\text{Log}X_{11} + \mu$$

Where, Y = Tobacco Gross Income/ha; X_1 = Tobacco area; X_2 = Variable costs/ha; X_3 = Labour; X_4 = Cattle; X_5 = Employment off farm; X_6 = Training in Agriculture; X_7 = Sex; X_8 = Age; X_9 = Price/kg; X_{10} = Yield/ha; X_{11} = Maize area; $\beta_0,\ldots,\beta_{11}$ = Parameters to be estimated; u = Random error.

Tobacco area

Tobacco area is the total area allocated for tobacco cultivation by the household in hectares. Increasing the area under cultivation can possibly bring about economies of scale associated with efficient use of fixed and highly specialised assets required by tobacco, for example curing barns and grading sheds. The expected effect on revenue is positive.

Variable costs

Variable costs in US dollars were computed by summation of expenditure on all variable inputs for the tobacco enterprise per hectare. A household spending more on fertilisers, crop protection chemicals, fuel and seeds can be expected to achieve high yields and better quality. Revenue from the tobacco enterprise is expected to thus increase with intensity of variable input use.

Labour

This is the number of hired workers engaged by the household specifically for tobacco production. Tobacco competes with maize for labour as the two crops are grown in the same season, and many key operations like planting, weeding and harvesting coincide. In smallholder agriculture family labour is usually prioritised for food security crops, therefore engaging hired labour thus, reduce loses due to weed competition, pre and post harvesting loses for cash crop enterprises. The expected effect on revenue is positive.

Cattle ownership

Cattle ownership was measured by the number of cattle belonging to the household. Addition of cattle as a variable in the model was justified for smallholders as cattle are a source of draft power and just like labour, cattle can be considered as direct inputs. A household endowed with more cattle can timely execute key operations such as, land preparation, weed control, harvesting and transportation, all of which require cattle draft power. The expected impact on revenue is positive

Off- farm employment

Some small-scale farmers are full time farmers while some have full time formal employment in urban areas, hence are part time farmers. The expectation was that full time farmers (X_5 = 1) could realise more revenue from their farming operations, as they are resident on their farms. Full time farmers allocate more time to their farming operations and accord more attention to their farming enterprises than those having off farm formal employment (X_5 = 2). Off farm employment was therefore anticipated to negatively impact tobacco revenue.

Training in agriculture

Training in agriculture was regarded as any form of training in agriculture by the household head. Training brings about better decision making, better use of production technology, adoption of appropriate technology and adherence to recommended production practices. Those trained in agriculture (X_6 = 2) were therefore expected to be more productive than those without any training in agriculture (X_6 = 1). Tobacco is a highly specialised crop whose yield and quality is very sensitive to quality of management and hence, training in agriculture was expected to impact tobacco revenue positively.

Sex

Tobacco has high labour and capital demands. Crop ownership and gender are therefore important in Zimbabwe, where men control all important household resources and make decisions on family labour and household resource allocation. If the tobacco crop belongs to men (X_7 = 2) it was anticipated that, productivity will be high and if the tobacco crop belongs women (X_7 = 1), productivity was expected to be low.

Age

Age was measured by the number of years for the household head. Even though accumulation of farming experience and production capital comes with age. In Zimbabwe older farmers have bigger household sizes and are more worried about food security. When food crop production takes precedence, efficiency in cash crop production can be compromised. Furthermore, in developing countries age is usually negatively correlated to education and literacy levels. The younger being likely more educated and literate, the expectation was age negatively impact productivity.

Price

In tobacco production, price varies with quality. Farmers achieving better quality attain better prices and ultimately high revenue. Agronomic practices as well as the curing process influence leaf quality. The expectation was that, price positively impact tobacco revenue.

Yield

Marketable yield in smallholder tobacco is dependent on agronomic practices and more important for smallholder farmers are post-harvest loses. Yield was expected to positively impact revenue.

Maize area

Maize is the staple in Zimbabwe and competes with tobacco for land, labour and other production inputs. The expectation was that, as the area under maize cultivation increases, tobacco revenue would be reduced.

RESULTS

General socio-economic characteristics

According to results in Table 1 the mean age of surveyed farmers was 40.58 years indicating that, most smallholder tobacco producers were fairly middle aged farmers. Farmers had an average 6.4 ha and most (5.1ha) of it was being cultivated. The average area under maize and tobacco were 1.41 and 1.3 ha, respectively. On average farmers had about 15.8 years of experience in general farming but had fewer years of farming tobacco (7.1 years). Employment of permanent workers was very minimal with an average of 0.8 per household; however farmers relied more on seasonal workers who averaged 6.22 per household per season. Ownership of equipment such as tractors and cars was very low with an average of 0.01 and 0.2, respectively. On average household ownership of cattle was 5.95 indicating that most farmers had cattle. The average price of tobacco per kilogram was US $ 2.45 and the average yield was 2052 kg/ha.

There was a lot of private sector support and involvement in tobacco production as most of the households received inputs on credit and hence, used very high rates of fertiliser, applying 321 kg/ha mean basal fertiliser, and on average 86 kg/ha of top dressing. All farmers reported using firewood for curing their tobacco and only 30% reported using firewood in combination with coal. Many of the small scale farmers were full time farmers and only 25% of the farmers had formal employment and farming was part time. More than half of the farmers had never been exposed to any form of training in agriculture and only 45% of the farmers had received training in agriculture. Tobacco production was dominated by males and in 82% of the households the tobacco crop belonged to a male household member.

According to results in Table 2 the mean total revenue from tobacco per hectare was US $5120 and the mean total variable costs per hectare were US$2768 resulting in average gross margins of US$ 2352 per hectare. This outcome shows that tobacco production by smallholder farmers was viable. From Table 3, the computed breakeven yield was 1100 kg/ha and the breakeven price was 1.21/kg. The margin of safety was 46 and 50% with respect to both yield and prices respectively (Table 3).

Determinants of income earnings from tobacco

Regression analysis showed that off farm employment was inversely related to revenue earnings from tobacco with coefficient (-0.058) and the relationship was significant at 5%. Price and yields were positively related to tobacco revenue with coefficients 0.865 and 1.001 and the relationship was significant at 1% (Table 4).

The coefficient of determination (R^2) of 90.7% indicated the strong explanatory power of the model with only 9.3% of the variation in the dependent variable (income earnings from tobacco) being explained by other factors nor specified in the model.

DISCUSSION

Viability of tobacco production

Tobacco production was observed to be an important

Table 1. Descriptive analysis of the general socio-economic characteristics.

Variable	Minimum	Maximum	Mean	Standard deviation
Age of household head	26	71	40.58	10.40
Total land area (ha)	2	13.5	6.4	6.9
Area under cultivation (ha)	1	9.5	5.1	3.4
Farming experience (years)	3	45	15.8	8.9
Tobacco experience (years)	2	25	7.1	5.8
Permanent workers	0	4	0.8	1.1
Tractors	0	1	0.01	0.2
Cars	0	2	0.2	0.4
Seasonal workers	0	15	6.22	3.69
Number of cattle	1	18	5.95	3.88
Area under maize (ha)	.5	4.0	1.41	0.62
Area under tobacco (ha)	1	3	1.3	0.51
Price/kg (USD)	1.18	3.63	2.45	0.50
Variable costs/ha (USD)	2365	3139	2768	206
Yield/ha (kg)	207	3938	2052	1
Total revenue/ha (USD)	370.2000	11037.26	5120.06	3
		Frequency	**%**	
Formal employment	Yes	45	75	
	No	15	25	
Training in agriculture	Yes	27	45	
	No	33	55	
Sex of household head	Male	49	82	
	Female	11	18	

Table 2. Smallholder tobacco gross margin analysis.

Variable	Minimum	Maximum	Mean	Standard deviation
Gross margin/ha	-2397	8269	2352	2.20
Total revenue/ha	370	11037	5120	2.89
Total variable costs/ha	2365	3139	2768	206

Table 3. Breakeven analysis.

Variable	Yield kg/ha	Price US $/kg
Achieved	2052	2.45
Breakeven	1100	1.21
Margin of safety (%)	46	50.6

smallholder enterprise, as farmers allocated approximately equal land areas to tobacco and maize (the staple in Zimbabwe). The primary objective in smallholder tobacco production is profit maximization. This is because tobacco smallholder is strictly a cash crop and about 98% of the tobacco produced in Zimbabwe is exported (TIMB, 2011). The mean gross margin was US $2352 per hectare, indicating that, tobacco is a viable smallholder cash crop and contributes significantly to rural household income. This finding has been acknowledged by a number of authors. Keyser (2002) noted that, tobacco generated direct income for commercial farmers and indirect (wage) income for smallholder farmers, though the current study showed a transition of smallholder tobacco income from being indirect to direct income.

Table 4. Regression results to determine factors affecting income earnings from tobacco production.

Variable	Beta	Standard error	Significance
Constant	-0.040	0.101	0.690
Sex	-0.013	0.026	0.613
Age	0.021	0.032	0.528
Training in agriculture	0.011	0.021	0.596
Labour	0.010	0.010	0.315
Cattle	0.010	0.012	0.412
Off farm employment	-0.058	0.026	0.027
Maize area	-0.026	0.018	0.164
Tobacco area	-0.006	0.024	0.802
Price	0.865	0.034	0.000
Expenditure on variable inputs	0.019	0.030	0.531
Yield kg/ha	1.001	0.011	0.000

R Square 0.907.

From break even analysis, the margin of safety in tobacco production was more than 50%. This implies that, tobacco will remain relatively profitable even at lower yields and prices. This notion has also been supported by Rukuni (2006), though on large scale farming. For large scale commercial farmers' tobacco was observed to offer good financial returns even after a large drop in yield and price and would continue to be attractive even under progressively difficult conditions.

Determinants income earnings from tobacco production

It was also revealed from the study that, the majority of the respondents (75%) were full-time farmers, while others engaged in other occupations apart from farming and there was a negative correlation between off-farm employment and tobacco income. The finding of the study is consistent with Deiniger and Olinte (2001) who, studying data from Colombia found that, specialisation in either farm or non-farm activities increased wealth and income levels. However, this is not consistent with general findings in Africa that households that engage in both agricultural and non-agricultural activities are richer, both in income flows and in endowments of assets (Piesse et al., 1999). Diversification caters for livelihoods security, by spreading risk and uncertainties of agriculture; it however compromises on time allocation on various farm enterprises especially for high value crops like tobacco.

Leaf quality and yield had a significant positive effect on tobacco returns. Total revenue from a cropping enterprise is a product of yield and price. Leaf quality for tobacco is reflected in the price per kg achieved. Smallholder farmers achieving higher prices and high yields therefore achieve better returns. Yield and quality depend on good agronomic practices, proper curing and minimisation of post harvesting losses and leaf spoilages.

Age of the household head had the expected effect (negative sign) on tobacco farm returns, implying that, younger tobacco farmers had more income than older farmers. Though not significant the notion of age being negatively correlated to performance is however supported in literature. Yaron and Dinar (1992) argued that, old aged farmers generally tend to resist change than young farmers who quickly adopts new appropriate technology. Training in agriculture as expected was positively correlated to tobacco revenue though not significant at 5% level. Similar conclusions were also observed by Mutandwa et al. (2008), who in an attempt to ascertain whether training in tobacco farming influences tobacco yields and returns among smallholder farmers concluded that, returns for trained farmers were greater than untrained farmers though statistically insignificant.

Conclusions

Gross margin analysis revealed that, tobacco production is a viable smallholder enterprise, and therefore has potential to contribute towards improving incomes and livelihoods of rural small scale farmers in Zimbabwe. From break even analysis, tobacco will remain relatively profitable even at lower yields and prices. The study therefore concluded that, farmers should consider tobacco production as a crop of choice as it is a viable crop and its returns remains favourable under diverse conditions.

All the farmers reported to be using firewood in tobacco curing. This brings about questions regarding long run sustainability of smallholder tobacco production. Deforestation implies switching over to coal and electricity for tobacco curing. In the long run, small scale tobacco production costs are therefore expected to rise and profitability will decline. There is therefore need for government intervention to raise awareness about the negative effects of deforestation. Apart from enforcing environmental protection laws, there is need to ensure each tobacco farmers establish replacement wood lots.

The observed negative significant relationship between off farm employment and revenue from tobacco reveals that, farmers in formal employment are not productive. There is therefore need for government policy reconsiderations in land allocations, and input support to prioritise productive full time farmers. To improve income earnings from tobacco, there is also a need for farmers, government and other interested stakeholder to focus on improving yield and quality of the crop for better prices. There is also a need to strengthen education, extension, research and development of appropriate technologies for smallholders given that previous research and development efforts were targeted on large scale farming.

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The implications of refuge requirements for Bt cotton in India on world cotton markets

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The study evaluated the potential impacts of refuge requirements for Bt cotton in India on world cotton markets. The objective was accomplished by estimating regional cotton yield functions in the Indian fiber model, and connecting it with rest of the world fiber model. Results revealed that the refuge requirements have potential to impact world cotton markets; magnitudes of impacts are smaller, however. The world cotton trade would be lower, and the cotton prices would be higher under higher refuge requirements, and vice versa. As the refuge requirements for an insecticidal Bt technology depend on its replacement rate, the time spent in R&D and regulation of the technology has implications for Bt crops refuge requirements and world commodity markets.

Key words: Bt cotton, India, refuge requirements, world cotton markets, world fiber model.

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INTRODUCTION

A large number of studies reported that insect-resistant Bt crops (such as Bt cotton and Bt corn) have led to significant productivity gains, reductions in insecticide use, or both throughout the world. Some examples of these studies describing the farm-level impacts of Bt crops are: James (2009), Bennett et al. (2004, 2006), Purcell and Perlak (2004), Huang et al. (2002), Qaim (2003), Yorobe and Quicoy (2006), and Brookes and Barfoot (2007). Other than these farm-level studies, there are studies (Pekaric-Falak et al., 2001; Brookes et al., 2010; Frisvold and Reeves, 2007; Frisvold et al., 2006; Elbehri and Macdonald, 2004; Anderson et al., 2008; Falck Zepeda et al., 2000) that examined the trade, price and welfare effects of Bt crops adoption on world markets. These studies reported an increase in agricultural trade, a reduction in prices, and an increase in welfare of people all over the world after commercialization of Bt crops.

Despite the aforementioned positive impacts of Bt crops, one of the primary concerns in adopting Bt crops is the potential resistance by insects to the Bt toxin present in the Bt crop (Shelton et al., 2000). To address this concern, Environmental Protection Agency (EPA) established a mandate requiring Bt growers to grow a proportion of non-Bt refuge[1] along with Bt crop. The mandate provides farmers choice of a sprayed refuge option and an unsprayed refuge option. With sprayed refuge option, growers may plant up to 80% of their total acres to Bt varieties and at least 20% to non-Bt varieties and they are allowed to use conventional pesticide throughout. With the non-sprayed option, producers may plant 95% of their acres to Bt varieties, and spray Bt acres as needed with conventional insecticides; however, no insecticide may be used on 5% of refuge acres.

There are some studies (Livingston et al., 2004; Qiao et al., 2009, 2010; Singla et al., 2012; Hurley et al., 2001) that challenged the efficiency of EPA's universal mandate

[1]Refuges allow susceptible pests to thrive so they can mate with resistant pests that survive in the Bt crop fields thus extending the efficacy of the insect-resistant varieties.

on refuge requirements for Bt cotton and Bt corn. These studies provided some evidences of sustainability of productivity effects of Bt crops under a scenario of potential resistance development by various pests to the Bt toxin. Livingston et al. (2004), Qiao et al. (2009, 2010), and Singla et al. (2012) examined the refuge requirements for Bt cotton in the U.S., China, and India, respectively, in a bio-economic modeling framework. Livingston et al. (2004) found optimal structured refuges of 16%[2] for eleven year planning horizon for the U.S. cotton. Qiao et al. (2009, 2010) findings supported a 'zero refuge' policy for Bt cotton in China. Singla et al. (2012) found optimal refuge requirements of 42, 19, and 0% for North, Central, and South India, respectively, for a 15-year time horizon. Hurley et al. (2001) also examined Bt corn refuge requirements in the U.S. by employing a bio-economic model; they recommended optimal refuge requirements between 20 and 40%. All the refuge requirements discussed previously, however, were found sensitive to some biological parameters used in the model.

Frisvold and Reeves (2008) examined that any mandates on refuge requirements have potential to decrease the production and profitability of cotton in the short run because of lower yields of cotton planted in refuge area. Their study, however, was at micro level and did not estimate how a change in refuge requirements could potentially affect the global trade and prices. The current study contributes to the literature by estimating the impact of various refuge requirements for Bt cotton in India on world trade and prices. It is important to examine the impact of refuge requirements In India as it is one of the largest[3] producers of cotton in the world, and changes in proportion of area under Bt and non-Bt cotton has potential to alter world cotton trade flows and prices. We are considering only the impact of change in refuge requirements in India because the governments of two other major cotton producing countries, that is, the U.S. and China have already announced zero refuge policies for Bt cotton. The zero-refuge requirement for Bt cotton China is based on the idea that the abundant non-Bt host plants of the target pest provide sufficient natural refuges to delay resistance in the pest (Qiao et al., 2010). In case of the U.S., the stacked Bt varieties have replaced a significant portion of single-gene Bt varieties (USDA, 2012), and there is zero refuge requirements for stacked varieties (EPA, 2012). There is relatively a small portion of area left under single-gene Bt varieties, and it is likely to be replaced by stacked varieties in the near future. So, virtually, there are no refuge requirements for Bt cotton in China and the U.S. This article, therefore, evaluates trade and price impact of Bt cotton refuge requirements in India only.

There is no study that examined the potential impact of refuge requirements for Bt crops on world markets. However, there are many studies[4] examining the trade, price and welfare effects of Bt crops adoption on world markets. The studies by (Falck Zepeda et al., 2000; Frisvold et al., 2006; Pekaric-Falak et al., 2001) examined the trade, price and welfare effects of Bt cotton using partial equilibrium model. Brookes et al.. (2010) used similar methods to examine the production and price impact of biotech corn, canola, and soybean crops. The studies conducted by Pekaric-Falak et al., (2001) and Frisvold and Reeves (2007), however, employed general equilibrium modeling framework to estimate the economy-wide impact of Bt cotton on trade, prices and welfare. Elbehri and Macdonald (2004) also used general equilibrium framework to examine the trade and price impact of Bt corn.

The current study examines the potential impact of various refuge requirements for Bt cotton in India on world cotton markets by estimating the regional cotton yield models in the Indian fiber model, and then connecting the Indian model to rest of the world fiber model. The specific objectives of this study are (1) to estimate the cotton yield models for the three cotton growing regions in India (2) to estimate and compare the trade and price impacts under status quo; under efficient Bt cotton refuge requirements in India for 10- and 15-years planning horizons; and the refuge requirements mandated by EPA.

CONCEPTUAL MODEL

The conceptual analysis presented here provides the expected directional change in the world fiber market, with a change in refuge requirements in India. It can be hypothesized that increased refuge requirements for Bt cotton varieties in India would decrease the world cotton supply because of lower yield of cotton planted in refuges. A decrease in world cotton supply could potentially increase world cotton prices, ceteris paribus. Given that the demand for cotton is rising rapidly in India after the elimination of import quotas under the Multi-

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[2]Optimal/efficient refuge requirements vary with the length of planning horizon, that is, number of years it would take for a new technology to replace an existing technology. Here, a refuge requirement of 16% is based on the assumption that a new technology (such as stacked varieties) would replace the existing single-gene Bt technology in 11 years. Lower refuge requirements will be required if a technology get replaced earlier, and vice-versa. EPA has announced zero structured refuge requirements for stacked Bt cotton varieties in the U.S. in 2007. Since then the adoption of stacked varieties increased. They cover 63% of total cotton area in 2012 (USDA, 2012).

[3]India accounted for about 23% of world cotton production from one-third of world's cotton acreage it possesses (USDA, 2009). Once upon a time a net importer of cotton, India is now the second largest exporter of cotton in the world after the U.S. (National Cotton Council, 2009; USDA, 2009). The introduction of Bt cotton in India in 2002-03 is considered as the primary reason of India's transition from a net importer to a leading exporter of cotton (James, 2009; Choudhary and Gaur, 2010).

[4]Bt adoption and refuges go hand in hand because of a presence of complementarity between them. An increase in area under Bt crops decreases refuge area and vice-versa. Methods used to examine the trade and price impact of Bt crops adoption can be used to examine the impact of planting refuges.

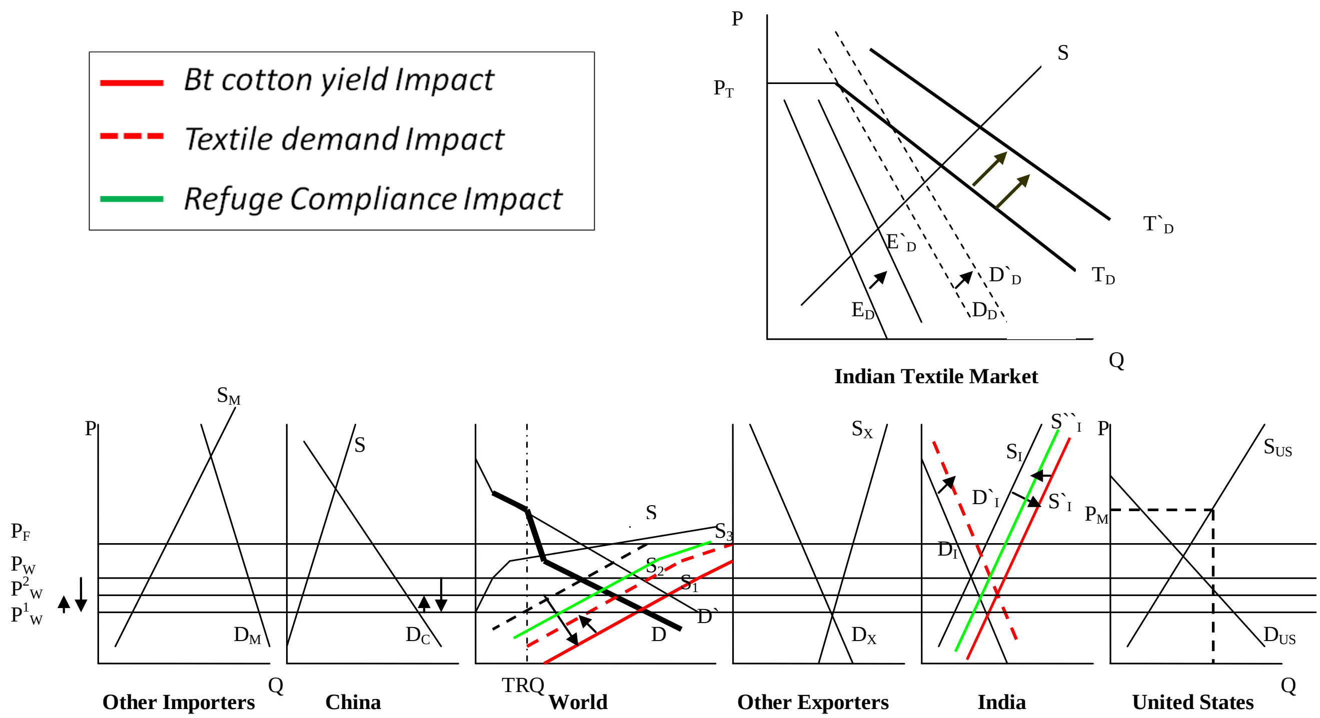

Figure 1. Impacts of refuge requirements on the U.S., India and world cotton markets

Fiber Arrangement (MFA)[5], a decrease in supply could have implications for the future trade flows of cotton.

A partial equilibrium analysis of a hypothesized cotton trade scenario including India, the U.S., China and the rest of the world (ROW) cotton importing/exporting countries is presented in Figure 1. India and the U.S. are presented as net cotton-exporting countries, implying that domestic supply is greater than the domestic demand for cotton. China is assumed to be a net cotton-importing country.

The conceptual analysis shows that the world price is P_W after considering the Chinese Tariff Rate Quota (TRQ) and the U.S. marketing loan program. The free trade price is shown as P_F. The conceptual model suggests that an increase in the supply of raw cotton in India (as a result of increased adoption of Bt cotton) would shift the supply curve from S_I to $S`_I$, which would shift the excess supply curve upward in the world cotton market from S to S_1. This should result in a decrease in world price from P_W to P^1_W and an increase in the quantity traded. It can be inferred that an increase in the world supply of cotton does not necessarily translate into sustained higher revenues/profits for adopters of Bt cotton as prices for cotton could fall worldwide (Bennett et al., 2004; Huang et al., 2002), provided there is not a concurrent increase in demand.

The rising domestic demand for textiles in India because of an increased standard of living in recent years, coupled with increased exports of cotton-based textiles associated with the elimination of import quotas under the multi-fiber arrangement (MFA), could increase demand for domestic and imported cotton in India. This is represented by the total demand for textiles increasing from T_D to $T`_D$ in Figure 1. Due to this increase in demand for textiles, the derived demand for cotton in India is expected to increase from $D_I$ to $D`_I$. This would result in a decrease of the excess supply in the world market from *S1* to *S2*, and an increase in the price from P^1_W to P^2_W, and a decrease in the quantity traded.

With an increase in refuge requirement, the supply of cotton is expected to decrease because of lower yield of cotton planted in refuges. In Figure 1, this is represented by a shift in the supply of cotton in the Indian market from $S`_I$ to $S``_I$. A decrease in supply would shift the excess supply curve to the left to S_3, resulting in a world price between P_W and P^2_W. Nevertheless, the net change in world price and trade is an empirical question and can only be determined by the various elasticities of demand and supply involved (Landes et al., 2005).

METHODS

The conceptual analysis suggested that the expected impact of increase in refuge requirements would be to alter cotton trade flows and increase world prices of cotton. The empirical model allows testing this hypothesis as well as the estimation of the magnitude of the change in price and trade flows. This is achieved by estimating regional cotton yield response models in the Indian fiber model

[5]MFA governed the world trade in textiles and garments from 1974 to 2004. MFA imposed quotas on the amount of textiles and garments developing countries could export to developed countries. It expired on 1 January 2005.

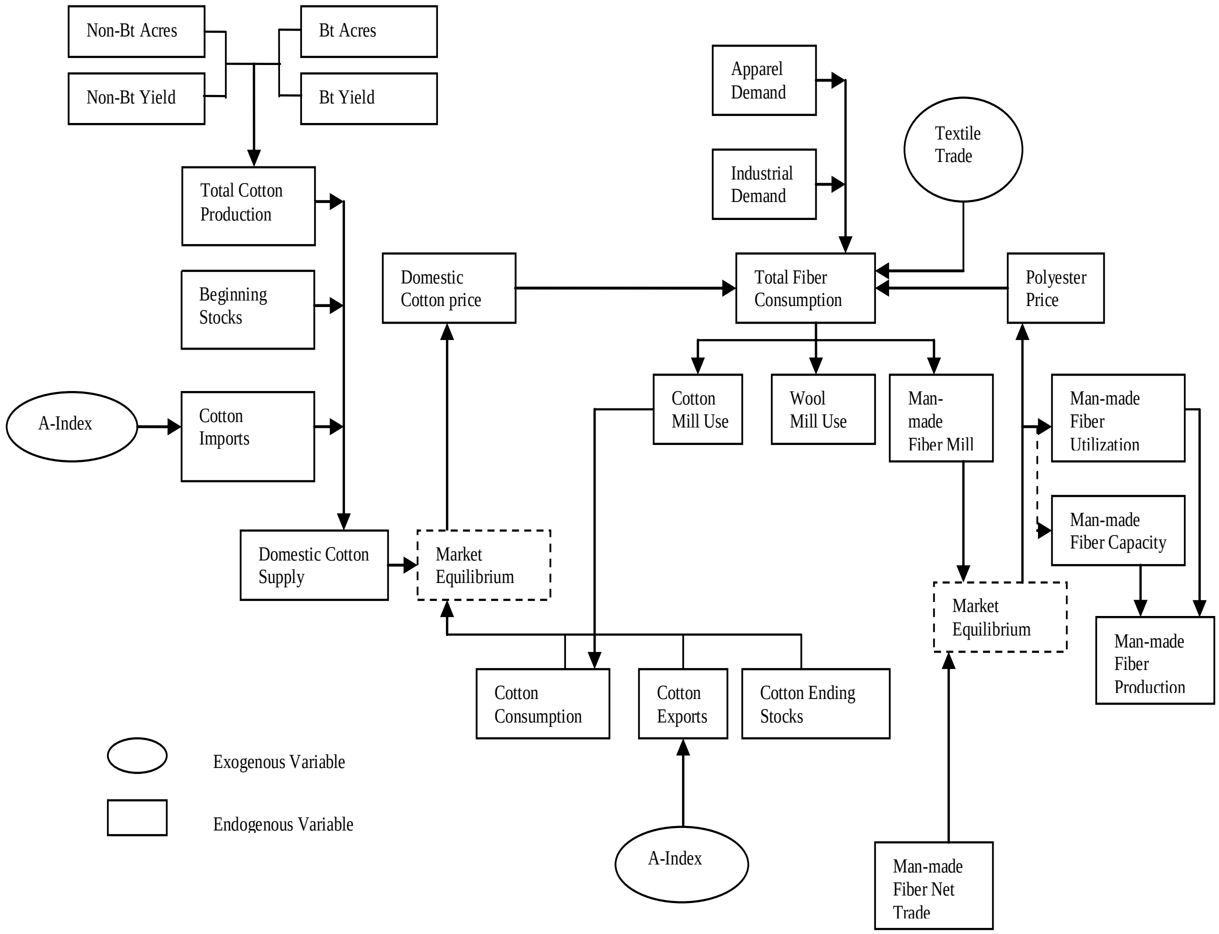

Figure 2. Indian fiber model.

component of the WFM[6], where proportion of area under Bt varieties is considered among one of the exogenous factors. The calibrated Indian Fiber model is then connected to the WFM to simulate the potential impact of various refuge requirements on world cotton markets.

To estimate the cotton yield models, cotton area in India is first divided among three regions based on differences in agro-climatic conditions across regions (Chaudhary et al., 2008; Chaudhary, 2005). Then cotton yield models for the three regions in India were estimated as a function of proportion of Bt area after controlling for other regional factors. The cotton yield model for j^{th} region can be specified as follows:

$$Y_{j,t} = f\,(Y_{j,t-1},\, q_{j,t},\, FU_{j,t},\, Irri_{j,t},\, t)^{7}$$

where $Y_{j,t}$ represents cotton yield in the j^{th} region at time t; $Y_{j,t-1}$ is lagged cotton yield in the j^{th} region; $q_{j,t}$ is the proportion of refuge a farmer is growing in the j^{th} region at time t; $Irri_{j,t}$ is the area under irrigation for the j^{th} region at time t, $FU_{j,t}$ is the fertilizer use in the j^{th} region at time t; and t is the time trend. The cotton yield models were used to estimate the Bt and non-Bt cotton yields that along with the respective acreages under Bt and non-Bt cotton determine cotton supply in the Indian fiber model as shown in Figure 2. As shown in the Figure, Bt and non-Bt cotton areas and yields contribute to total cotton production in India after accounting for beginning stocks and imports. The model also takes into account competition among fibers such as cotton, man-made fibers, and wool at the mill level.

The baseline projections for supply, demand, and prices of cotton, man-made fibers, and textiles in the Indian fiber market were generated under status quo conditions where the acreage under Bt cotton is expected to rise. The baseline projections assume the continuation of current policies such as China's TRQ and U.S. marketing loan program for cotton. The policy scenario projections were made by shocking the Indian Fiber model with efficient refuge requirements for Bt and non-Bt cotton for 15- and 10-years planning horizons as examined by Singla et al. (2012), and the refuge requirements mandated by EPA. The refuge requirements for a 15-year planning horizon were 42%, 19% and 0% for North, Central and South India, respectively. The refuge requirements for a 10-year planning horizon, however, were 29%, 4% and 0% for North, Central and South India, respectively. The EPA refuge requirements used in the model were for those mandated for sprayed refuges, which is 20% for all the three cotton growing regions. Both baseline and policy scenario projections were developed for a 14-year time period beginning in 2012-2013 and ending in 2025-2026. The Indian Fiber model was connected

[6] WFM is a partial equilibrium structural econometric model developed by Pan and Mohanty (2004). A brief description of the model along with data used is given in Appendix A. Two major applications of world fiber model are presented in Chaudhary et al (2008) and Pan et al (2007).

[7] The regional time-series data (on cotton yield and other factors) used to estimate this model were obtained from Indiastat.com.

Table 1. Regression estimates of regional cotton yield models in India.

Independent variable	North	Central	South
Intercept	144.05 (90.01)	2212.54 (1059.31)*	268.99 (19.87)***
$q_{j,t}$	249.67 (246.69)	243.05 (64.42)***	204.55 (55.82)**
$Y_{j,t-1}$	0.62 (0.24)**	-	-
$FU_{j,t}$	-	-6.52 (3.11)*	-
$Irri_{j,t}$	-	-11439 (5986.81)*	-
$FU_{j,t}$* $Irri_{j,t}$	-	38.37 (17.25)**	-
t	-	-	9.27 (2.21)***
R^2	0.54	0.89	0.86
DW statistic	1.80	1.92	2.02
Number of observations	18	18	18

Figures in the parentheses are the standard errors. *, ** and *** indicate significance at 10, 5 and 1% levels, respectively.

to the World Fiber model to estimate the impacts on the world and the U.S. cotton markets. The policy effects were measured by comparing the differences between the policy scenario and baseline projections.

RESULTS AND DISCUSSION

The estimated coefficients of cotton yield equations for the three regions are presented in Table 1. The coefficient of proportion of area under Bt cotton ($q_{j,t}$) represents the yield difference between Bt and non-Bt cotton; and it was found to be statistically significant in Central and South India after controlling for several factors such as fertilizers, irrigation, time trend and lagged yield. The $q_{j,t}$ was not statistically significant for North India due to lack of a sufficient number of observations for Bt cotton because of its late adoption. The coefficients of determination (R^2) for the North, Central, and South regions were 0.54, 0.89 and 0.86, respectively. A low value of R^2 in the North region may be due to erratic monsoon rainfall and high weather variability, which was not being captured by the model.

The estimated regression coefficients were used in estimating cotton production and supply in the Indian fiber model, which was further connected to WFM to develop baseline projections of the potential impacts on world cotton trade and prices assuming current trend in area under Bt cotton (and refuge). Also the baseline projections assumed a continuation of current policies including MFA quotas elimination and China's TRQ, which are based on World Trade Organization (WTO) commitments. The projections for fiber demand, supply and prices were developed for 14-year period under a set of assumptions for exogenous variables. After developing the baseline, three alternate scenario projections were developed for three different levels of refuge requirements. These include regional refuge requirements under 15-year planning period (Scenario 1), under 10-year[8] planning period (Scenario 2), and those under EPA mandate (Scenario 3). Baseline and scenarios projections were made for India, the U.S., and world cotton markets as shown in Tables 2, 3 and 4, respectively. Average trade and price effects under the three scenarios are compared in Figures 3 and 4.

As shown in Table 2, average cotton yield in India would decline with an increase in refuge requirements for Bt cotton in India. Yield would decrease by an average of 1.89, 0.86 and 1.04%, for refuge requirements under 15-year planning period, under 10-year planning period, and under EPA mandate, respectively. Average reduction in cotton yield under 15-year refuge requirements was the highest followed by EPA and 10-year refuge requirements. Cotton yield reductions were found to be larger than cotton area expansions thus resulting into a decreased cotton production under the three refuge requirements scenarios. A decreased cotton production led to lower mill use, lower exports and lower ending stock on average. Negative impacts on mill use, exports and ending stock were highest under 15-year refuge requirements followed by EPA and 10-year refuge requirements. Impacts of various refuge requirements on the U.S. cotton market are reported in Table 3. Farm price of cotton in the U.S. would increase on average by 0.48% under 15 year refuge requirements, 0.18% under 10-year refuge requirements, and 0.29% under refuge requirements mandated by EPA. Cotton production would also increase in the U.S. because of expectations of expansion and yield increments. Average mill use was almost unaffected under the three refuge requirements scenarios. Net cotton exports from the U.S. would rise on average because of a decrease in exports from India.

[8]A long term planning horizon assumes a longer period for a new technology to replace existing technology. A longer time in technology replacement corresponds to higher refuge requirements.

Table 2. Estimated effects of efficient Bt cotton refuge policy compliance in India on Indian cotton market.

Parameter	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	2023/2024	2024/2025	2025/2026	Avg.
Area								**000 Acres**							
Baseline	29776.03	28559.67	28037.13	28836.89	29923.74	31544.69	31679.84	31836.54	31944.74	32266.15	32413.36	33769.29	33776.36	33907.84	31305.16
Scenario 1 (%)	0.00	0.26	0.46	0.73	1.14	1.45	1.78	1.47	1.15	0.87	0.85	0.38	0.37	-0.14	0.77
Scenario 2 (%)	0.00	0.10	0.19	0.35	0.59	0.79	0.99	0.78	0.55	0.38	0.35	0.05	0.04	-0.28	0.35
Scenario 3 (%)	0.00	0.16	0.27	0.40	0.58	0.71	0.85	0.73	0.60	0.48	0.48	0.29	0.28	0.07	0.42
Yield								**Bales/Acres**							
Baseline	0.94	0.99	1.01	1.02	1.02	1.02	1.03	1.05	1.07	1.11	1.11	1.13	1.14	1.15	1.06
Scenario 1 (%)	-1.44	-1.71	-2.27	-3.10	-3.58	-3.89	-3.08	-2.25	-1.68	-1.60	-1.01	-0.76	-0.20	0.12	-1.89
Scenario 2 (%)	-0.55	-0.72	-1.10	-1.64	-1.96	-2.17	-1.64	-1.08	-0.72	-0.66	-0.27	-0.13	0.23	0.43	-0.86
Scenario 3 (%)	-0.88	-0.99	-1.22	-1.56	-1.75	-1.88	-1.53	-1.19	-0.95	-0.90	-0.67	-0.56	-0.32	-0.19	-1.04
Production								**000 Bales**							
Baseline	28005.47	28344.79	28190.04	29305.40	30608.35	32159.23	32504.24	33569.34	34077.29	35846.54	36101.56	38069.63	38534.12	38854.32	33155.02
Scenario 1 (%)	-1.44	-1.45	-1.82	-2.39	-2.48	-2.50	-1.36	-0.81	-0.55	-0.74	-0.16	-0.38	0.17	-0.02	-1.14
Scenario 2 (%)	-0.55	-0.63	-0.91	-1.30	-1.38	-1.40	-0.67	-0.31	-0.17	-0.29	0.08	-0.08	0.27	0.15	-0.51
Scenario 3 (%)	-0.88	-0.83	-0.95	-1.17	-1.19	-1.18	-0.70	-0.48	-0.35	-0.42	-0.19	-0.27	-0.04	-0.12	-0.63
Mill Use								**000 Bales**							
Baseline	20835.15	21977.75	24313.19	25061.34	25276.15	25520.99	25556.29	26095.42	27046.58	28216.76	29422.71	30958.35	31644.92	32630.71	26754.02
Scenario 1 (%)	-0.14	-0.12	-0.14	-0.19	-0.19	-0.18	-0.04	0.01	0.02	-0.02	0.06	0.01	0.10	0.04	-0.06
Scenario 2 (%)	-0.05	-0.05	-0.07	-0.11	-0.11	-0.11	-0.01	0.02	0.02	0.00	0.05	0.01	0.07	0.03	-0.02
Scenario 3 (%)	-0.08	-0.07	-0.07	-0.09	-0.09	-0.08	-0.02	-0.01	0.00	-0.01	0.02	0.00	0.04	0.01	-0.03
Net Export								**000 Bales**							
Baseline	7217.60	6355.20	6326.55	6025.92	6687.38	7718.51	7844.53	8245.86	7724.98	8253.13	7256.56	7651.99	7414.95	6735.40	7247.04
Scenario 1 (%)	-4.58	-5.72	-7.52	-10.73	-10.70	-9.90	-5.85	-3.54	-2.63	-3.17	-1.22	-1.92	0.37	-0.28	-4.81
Scenario 2 (%)	-1.76	-2.44	-3.69	-5.76	-5.90	-5.54	-2.95	-1.44	-0.89	-1.25	0.10	-0.43	1.06	0.72	-2.15
Scenario 3 (%)	-2.81	-3.30	-3.98	-5.30	-5.15	-4.69	-2.98	-2.02	-1.61	-1.82	-1.10	-1.33	-0.40	-0.74	-2.66
End Stock								**000 Bales**							
Baseline	8504.68	8971.78	6978.06	5651.18	4749.24	4120.11	3672.39	3346.85	3095.87	2912.94	2772.52	2665.89	2570.14	2484.45	4464.01
Scenario 1 (%)	-0.53	-0.75	-1.01	-1.39	-1.60	-1.73	-1.25	-0.85	-0.56	-0.50	-0.13	-0.12	0.24	0.24	-0.71
Scenario 2 (%)	-0.20	-0.32	-0.48	-0.73	-0.87	-0.97	-0.67	-0.41	-0.23	-0.20	0.04	0.03	0.25	0.24	-0.32
Scenario 3 (%)	-0.32	-0.44	-0.55	-0.71	-0.79	-0.83	-0.62	-0.46	-0.32	-0.29	-0.13	-0.12	0.03	0.04	-0.39

Table 3. Estimated effects of efficient Bt cotton refuge policy compliance in India on the U.S. cotton market.

Parameter	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	2023/2024	2024/2025	2025/2026	Avg.
Farm price								**$/Bale**							
Baseline	75.23	74.53	75.89	77.20	78.02	78.61	78.80	79.09	79.93	79.92	81.01	82.67	85.08	85.63	79.40
Scenario 1 (%)	2.34	1.50	1.77	2.49	2.07	1.78	-0.85	-0.94	-0.70	0.14	-1.29	0.02	-1.44	-0.17	0.48
Scenario 2 (%)	0.90	0.69	1.00	1.47	1.24	1.08	-0.62	-0.73	-0.49	0.01	-0.90	-0.03	-0.96	-0.13	0.18
Scenario 3 (%)	1.43	0.83	0.84	1.12	0.91	0.77	-0.32	-0.33	-0.28	0.09	-0.48	0.04	-0.57	-0.05	0.29
Area								**000 Acres**							
Baseline	9725.79	9550.88	9686.34	9810.76	9886.45	9921.40	9987.91	10201.97	10240.74	10320.14	10384.52	10395.27	10480.64	10549.21	10081.57
Scenario 1 (%)	0.00	0.31	0.20	0.24	0.34	0.29	0.25	-0.10	-0.12	-0.09	0.02	-0.16	0.00	-0.19	0.07
Scenario 2 (%)	0.00	0.12	0.09	0.13	0.20	0.17	0.15	-0.08	-0.10	-0.07	0.00	-0.11	0.00	-0.13	0.03
Scenario 3 (%)	0.00	0.19	0.11	0.11	0.15	0.13	0.11	-0.04	-0.04	-0.04	0.02	-0.06	0.01	-0.08	0.04
Yield								**Bales/Acres**							
Baseline	1.60	1.63	1.63	1.63	1.65	1.66	1.68	1.72	1.72	1.72	1.72	1.73	1.73	1.74	1.68
Scenario 1 (%)	0.00	-0.02	0.14	0.09	0.10	0.15	0.13	0.13	-0.04	-0.05	-0.04	0.02	-0.08	0.01	0.04
Scenario 2 (%)	0.00	-0.01	0.05	0.04	0.06	0.09	0.08	0.08	-0.03	-0.04	-0.03	0.00	-0.06	0.00	0.02
Scenario 3 (%)	0.00	-0.01	0.09	0.05	0.05	0.07	0.06	0.06	-0.01	-0.02	-0.02	0.01	-0.03	0.00	0.02
Production								**000 Bales**							
Baseline	15602.13	15576.02	15813.50	16009.82	16346.16	16471.85	16815.58	17497.11	17568.33	17732.89	17886.74	17954.09	18143.37	18313.88	16980.82
Scenario 1 (%)	0.00	0.29	0.34	0.33	0.44	0.44	0.38	0.02	-0.16	-0.14	-0.02	-0.14	-0.08	-0.19	0.11
Scenario 2 (%)	0.00	0.11	0.15	0.17	0.26	0.26	0.23	0.00	-0.13	-0.11	-0.03	-0.11	-0.06	-0.13	0.04
Scenario 3 (%)	0.00	0.18	0.20	0.16	0.20	0.20	0.17	0.02	-0.05	-0.05	0.00	-0.05	-0.02	-0.07	0.06
Mill Use								**000 Bales**							
Baseline	3640.43	3559.65	3486.49	3472.98	3386.03	3366.43	3284.86	3275.69	3048.80	2918.03	2812.47	2798.62	2763.08	2523.93	3166.96
Scenario 1 (%)	0.01	0.02	0.02	0.03	0.02	-0.04	-0.05	-0.05	-0.07	-0.05	0.00	0.05	0.07	0.14	0.01
Scenario 2 (%)	0.00	0.01	0.01	0.02	0.02	-0.01	-0.02	-0.03	-0.05	-0.04	-0.01	0.02	0.03	0.06	0.00
Scenario 3 (%)	0.00	0.01	0.01	0.01	0.00	-0.03	-0.03	-0.02	-0.02	-0.01	0.01	0.03	0.04	0.08	0.01
Net Export								**000 Bales**							
Baseline	11569.71	12012.94	12308.14	12514.99	12874.97	13158.22	13588.23	14152.76	14582.30	14871.81	15155.91	15251.71	15492.86	15953.27	13820.56
Scenario 1 (%)	0.43	0.26	0.47	0.53	0.49	0.51	0.10	0.00	-0.15	-0.06	-0.18	-0.04	-0.26	-0.13	0.14
Scenario 2 (%)	0.17	0.12	0.23	0.30	0.29	0.30	0.04	-0.03	-0.11	-0.06	-0.13	-0.04	-0.18	-0.09	0.06
Scenario 3 (%)	0.27	0.14	0.24	0.25	0.23	0.23	0.06	0.01	-0.06	-0.01	-0.06	-0.01	-0.10	-0.05	0.08
End Stock								**000 Bales**							
Baseline	4092.00	4095.43	4114.31	4136.17	4221.34	4168.55	4111.05	4179.71	4116.94	4059.99	3978.34	3882.10	3769.52	3606.20	4037.98
Scenario 1 (%)	-1.23	-0.88	-0.98	-1.33	-1.11	-0.95	0.30	0.45	0.36	-0.03	0.57	0.05	0.68	0.24	-0.27
Scenario 2 (%)	-0.47	-0.40	-0.54	-0.78	-0.67	-0.58	0.23	0.35	0.25	0.02	0.40	0.05	0.46	0.17	-0.11
Scenario 3 (%)	-0.75	-0.49	-0.47	-0.60	-0.49	-0.42	0.11	0.16	0.14	-0.03	0.21	0.00	0.27	0.07	-0.16

Table 4. Estimated effects of efficient Bt cotton refuge policy compliance in India on the world cotton markets.

Parameter	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	2023/2024	2024/2025	2025/2026	Avg.
A-Index								**$/Bale**							
Baseline	93.26	90.95	90.84	93.08	93.80	94.12	94.19	94.45	96.48	96.29	97.43	98.29	102.16	104.89	95.73
Scenario 1 (%)	2.71	1.57	2.01	2.80	2.28	2.01	-0.98	-0.97	-0.77	0.17	-1.47	0.06	-1.68	-0.20	0.54
Scenario 2 (%)	1.04	0.74	1.13	1.66	1.37	1.21	-0.72	-0.77	-0.53	0.02	-1.03	0.00	-1.12	-0.15	0.20
Scenario 3 (%)	1.66	0.86	0.95	1.26	1.01	0.88	-0.36	-0.33	-0.30	0.11	-0.55	0.06	-0.67	-0.06	0.32
Area								**000Acres**							
Baseline	85300.79	83472.69	83104.56	84474.07	85877.64	87826.65	88593.82	89388.31	90017.00	90935.60	91634.47	93587.23	94188.46	94788.31	88799.26
Scenario 1 (%)	0.00	0.24	0.29	0.42	0.62	0.74	0.85	0.58	0.41	0.29	0.32	0.07	0.11	-0.16	0.34
Scenario 2 (%)	0.00	0.09	0.12	0.20	0.33	0.41	0.48	0.30	0.18	0.11	0.12	-0.04	-0.01	-0.18	0.15
Scenario 3 (%)	0.00	0.15	0.17	0.22	0.31	0.36	0.40	0.29	0.22	0.17	0.18	0.08	0.10	-0.01	0.19
Production								**000Bales**							
Baseline	120605.30	120927.88	122311.45	125578.19	127996.65	130512.48	133042.25	135854.90	137922.23	141335.58	143190.21	146780.31	148790.68	150282.66	134652.20
Scenario 1 (%)	-0.32	-0.14	-0.22	-0.32	-0.27	-0.28	-0.01	-0.08	-0.08	-0.14	0.03	-0.12	0.07	-0.09	-0.14
Scenario 2 (%)	-0.12	-0.07	-0.12	-0.18	-0.15	-0.16	0.02	-0.02	-0.03	-0.07	0.05	-0.06	0.07	-0.03	-0.06
Scenario 3 (%)	-0.20	-0.07	-0.10	-0.15	-0.13	-0.13	-0.02	-0.05	-0.05	-0.08	0.00	-0.06	0.01	-0.05	-0.08
Mill Use								**000Bales**							
Baseline	115928.42	118949.01	123157.17	125731.44	127682.14	129530.85	132202.64	134752.82	137822.67	140858.31	142891.53	146528.35	148789.98	150592.46	133958.41
Scenario 1 (%)	-0.16	-0.16	-0.20	-0.27	-0.29	-0.31	-0.16	-0.11	-0.08	-0.11	-0.03	-0.07	0.01	-0.04	-0.14
Scenario 2 (%)	-0.06	-0.07	-0.10	-0.15	-0.16	-0.17	-0.08	-0.04	-0.03	-0.05	0.01	-0.02	0.03	0.00	-0.06
Scenario 3 (%)	-0.10	-0.09	-0.11	-0.14	-0.14	-0.15	-0.09	-0.06	-0.05	-0.06	-0.03	-0.05	-0.01	-0.03	-0.08
Net Trade								**000Bales**							
Baseline	39264.63	39439.31	40723.83	41353.28	43015.40	45038.72	46203.04	47837.11	47995.14	49374.03	48869.12	50095.06	50603.24	51190.85	45785.91
Scenario 1 (%)	-0.48	-0.61	-0.74	-0.99	-1.08	-1.10	-0.70	-0.40	-0.25	-0.27	-0.06	-0.05	0.14	0.16	-0.46
Scenario 2 (%)	-0.19	-0.26	-0.36	-0.53	-0.59	-0.61	-0.37	-0.17	-0.08	-0.10	0.04	0.03	0.15	0.16	-0.21
Scenario 3 (%)	-0.30	-0.35	-0.39	-0.49	-0.52	-0.52	-0.35	-0.22	-0.16	-0.16	-0.07	-0.06	0.02	0.03	-0.25

The estimated effects of refuge requirements on the world cotton market under baseline, and under three alternate policy scenarios are presented and compared in Table 4. The top set of numbers represents the world cotton price (A-Index) under the baseline scenario, as well as the projected world price under the policy scenarios. The world cotton price (A index) is expected to increase by 0.54, 0.20 and 0.32% for refuge requirements under 15-year, under 10-year, and under EPA mandate, respectively. Higher refuge requirements would decrease the world cotton production, which would push the cotton prices up. Although the area under cotton cultivation would increase in the future, the total production would decline because of relatively lower overall cotton yield resulted from planting refuges. A lower cotton production would pull down mill use and net cotton trade in the world.

Thus higher refuge requirements would decrease world cotton production and trade, and would increase world cotton prices. In the U.S., however, the net export of cotton would increase because of relatively lower export competition from India,

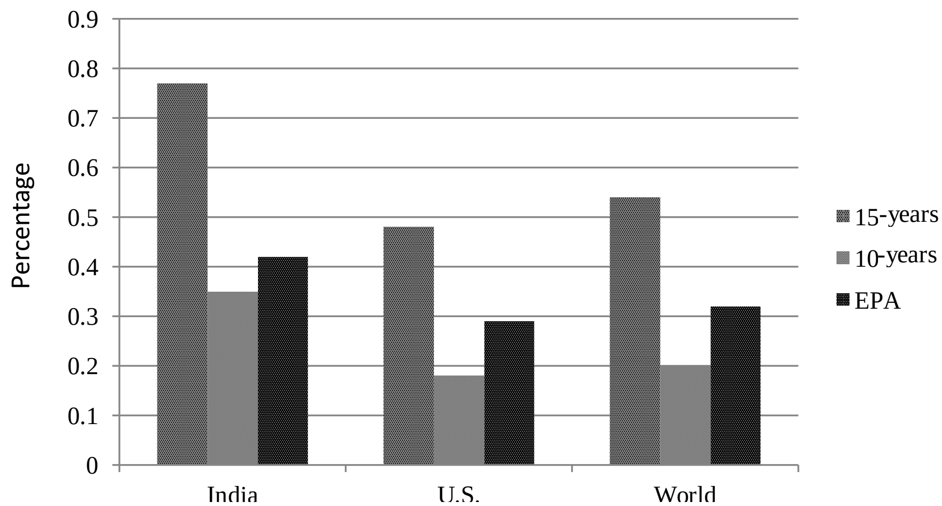

Figure 3. Average price effects of refuge requirements on world cotton markets.

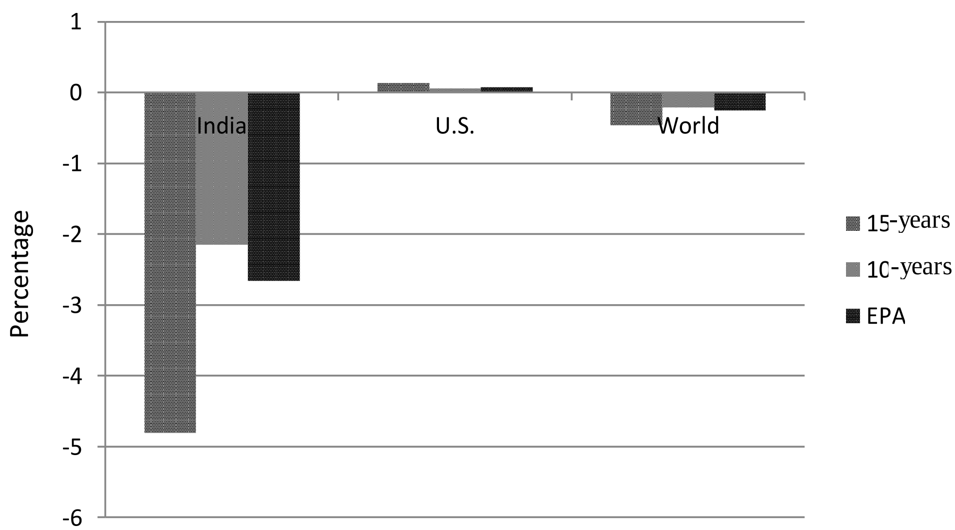

Figure 4. Average trade effects of refuge requirements on world cotton markets.

which stems from a decrease in cotton supply in India resulted from planting refuges. Although the magnitudes of trade and price effects on world markets look dwarf, the impact could sum up to a significant number at an aggregate level given the fact that India occupies 33% of total cotton area and contributes 23% to total cotton production in the world.

SUMMARY AND CONCLUSIONS

The study evaluates the potential impacts of refuge requirements for Bt cotton in India on world cotton markets by using a partial equilibrium world fiber model. The regional cotton yield models in the Indian fiber model were estimated using proportionate area under Bt cotton as an exogenous factor in the model. The Indian fiber model is then connected to an existing WFM to conduct baseline and scenarios projections. Three scenarios were considered, which includes optimal refuge requirements under 10-year and 15-year planning period; and refuge requirements under EPA mandate.

Simulation results reveal that cotton refuge requirements in India have potential to affect the domestic market as well as world cotton markets; the magnitude of impact is lower, however. World cotton trade is expected to decrease, and world prices of cotton are expected to rise under higher refuge requirements. In the U.S., however, the net export of cotton is likely to increase because of a decrease in cotton production and exports in India resulted from planting refuges. Although the percentage trade and price effects on world cotton markets look smaller, the impact could sum to be a larger amount at an aggregate level given the fact that Indian farmers cultivate about one-third of total cotton area and contributes about one-fourth to total cotton production in the world.

Comparisons of impacts under the three scenarios reveal that magnitudes of impacts depend on length of planning horizon or, in other words, replacement rate of insecticidal Bt technology. If an existing insecticidal technology is expected to be replaced by a new insecticidal technology early then there are lower refuge requirements and lower negative impacts, and vice versa. Technology replacement rate further depends on time spent in R&D and regulation to commercialize a new insecticidal technology; a significant time is spent on regulatory approval, however. Thus the time spent in R&D and regulations of an insecticidal crop technology is an important factor contributing indirectly to determine refuge requirements and their impacts on world commodity markets. A decrease in time in R&D and regulatory affairs of a new insecticidal agricultural technology has implications for refuge requirements and the world commodity markets.

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Abbreviations: EPA, Environmental Protection Agency; **USDA,** United States Department of Agriculture; **WFA,** World fiber model; **MFA,** multi-fiber arrangement; **ROW,** rest of the World; **TRQ,** tariff rate quota; **WTO,** World Trade Organization.

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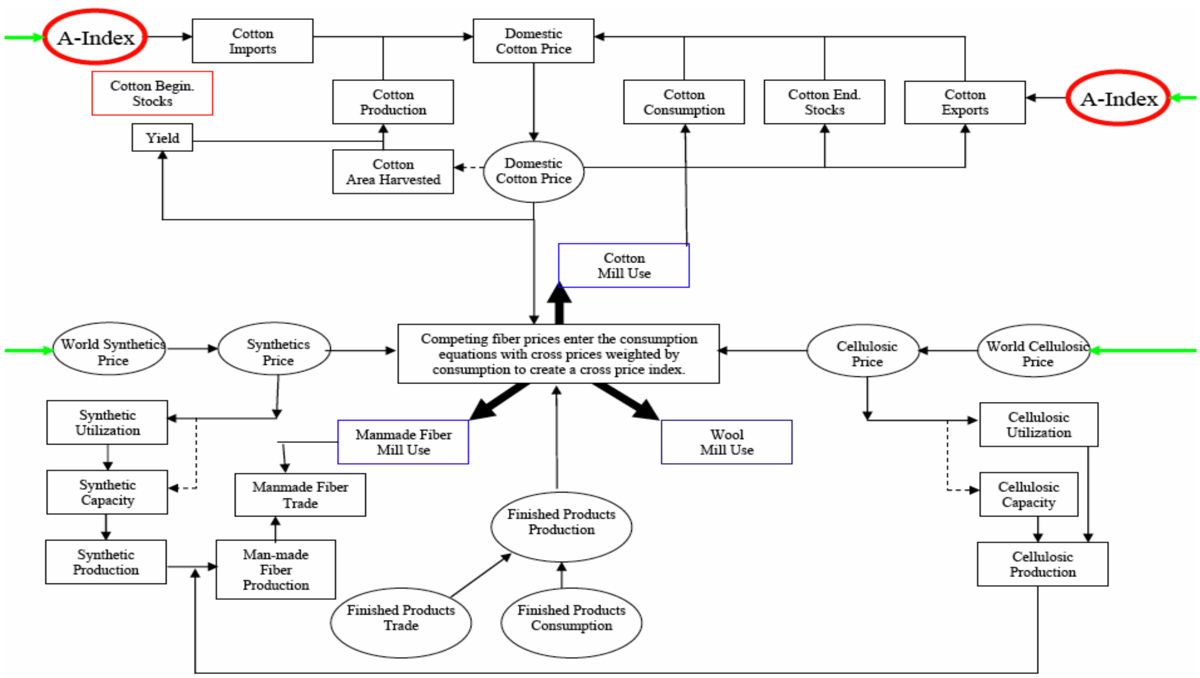

Figure A1. Representative country model.

APPENDIX A

World fiber model

The empirical world fiber model is a partial equilibrium structural econometric model developed by Pan and Mohanty (2004) at Cotton Economics Research Institute (CERI), Texas Tech University. The model includes supply, demand and market equilibrium for the cotton and man-made fibers for the U.S., India, China, and 21 other major cotton producing and consuming countries. A representative country model is presented in Figure A1.

Cotton production in each country and region defined in the model is derived from behavioural equations of area and yield. For geographically large cotton-producing nations such as the United States, China and India, cotton production is estimated in a regional framework to capture regional differences in climate, water availability, and other natural resources that influence crop planting decisions in different parts of each country. The manmade fiber production is derived from estimates of manmade fiber production capacity and utilization rates.

The textile sector in the model is used to determine the mill use of each fiber (cotton, manmade fiber, and wool). It is estimated using a two-step process. In the first step, total fiber demand (cotton, wool, and manmade) is calculated by summing fiber demand in apparel, home furnishing, floor covering, and other industrial sectors. In the second step, total fiber production is divided among cotton, manmade, and wool fibers based on the relative price of each as well as other non-price factors.

Two major applications of world fiber model are presented in Pan et al. (2007) and Chaudhary et al. (2008). While Pan et al. (2007) analyzed the effects of Chinese currency revaluation on world fiber markets, Chaudhary et al. (2008), on the other hand, examined the effects of MFA quota elimination on Indian and world fiber markets. Full explanation of the world fiber model is documented in Pan and Mohanty (2004).

The world fiber model uses data from various sources. Macroeconomic variables for India such as gross domestic product (GDP), population, exchange rate, GDP deflator and the average spot price of crude oil were obtained from International Financial Statistics published by the IMF. Cotton A-index price, US 1.5 denier polyester price, and US farm price sheer wool were collected from Cotton and Wool Yearbook of Economic Research Service, United States Department of Agriculture (ERS, USDA). Prices of polyester staple fibre and cotton fibre, and cotton tariff/duty in India were obtained from Foreign Agricultural Service, USDA and the Textile Commissioner's Office, Government of India (GOI). Minimum support price for cotton and competing crops were obtained from Ministry of Agriculture, India. The textile price index was gathered from the Handbook of Industrial Policy and Statistics 2001, India; at the same time, wholesale price index for food was obtained from the Handbook of Statistics on Indian Economy, 2001 on CD-ROM. Both indices were originally available on 1970/1971 and 1981/1982 base years, which were converted to1993/1994 base year for consistency. The textile price index for the year 1982 to 1984 was missing and had to be interpolated. The producer price for cotton and competing crops was obtained from the database of Food and Agricultural Organization (FAO). The consumer price index was gathered from the Ministry of Finance, GOI. Total fibre consumption, total cotton consumption and total man-made fibre consumption were obtained from the FAS/USDA, and the Textile Commissioner's Office, GOI. Wool and other fibre consumption were calculated by subtracting cotton and man-made from total fibre consumption. Similarly, man-made fibre capacity, utilization and man-made fibre production were also collected from the same sources. Data for cotton supply and demand were obtained from the FAS/USDA. The database consists of cotton area, yield, production, imports, exports, ending stocks and total domestic consumption.

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Determinants of smallholder sweet potato farmers' participation in different market options: The case of Vihiga County, Kenya

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Market participation has a potential to increase farmers' rural incomes and employment opportunities especially if farmers concentrate on production and marketing of local crops requiring low inputs such as sweet potatoes. The purpose of this research was to investigate the factors that determine farmers' shift in market participation from village to regional market in Vihiga County. Cross-sectional data was collected and a multinomial logit model was used for the analysis. Participation in local town market rather than village market was influenced by credit access, total income, transport mode to market, access to extension services, age, value addition done and the quantity of sweet potatoes supplied, while; transport mode, land size, quantity of sweet potatoes and gender determined participation for the regional option. It is recommended that the local and national government should: Increase its support in the establishment of sweet potato market; improve the rural road networks to cut down transport costs, and increase support to farmer groups or associations to increase farmers' market participation.

Key words: Determinants, smallholder sweet potato farmers, participation, market options.

INTRODUCTION

Poverty in Africa has been found to be predominantly a rural phenomenon. About 75% of the world's poor are believed to work and live in rural areas, and it is estimated that, by the year 2020, 60% of the poor will still be rural (Olwande and Mathenge, 2010). According to Omiti et al. (2009), agriculture supports the livelihoods of about 80% of the rural population in Kenya (about 85% of them being small-scale farmers). Only 22% of land in Kenya is arable though another 40% has potential for irrigated agriculture. The agricultural sector employs 70% of the national labor force through forward and backward industrial linkages, thus providing food and incomes to individuals and households (Omiti et al., 2009). Small-scale agriculture in Kenya is characterized by landholdings of less than 5 acres and no more than 20 ruminant animals (mainly cattle, sheep and goats) and a few chickens per farming household (Omiti et al., 2009). Crop-livestock production systems on small scale farms often entail very little use of purchased inputs and limited application of modern technology with majority of farmers producing for subsistence. Meeting the challenge of reducing poverty and improving rural incomes in Kenya

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will require some form of transformation out of the semi-subsistence production systems that currently characterize much of rural Africa to a more commercialized agriculture (Komarek, 2010). Omiti et al. (2009) in their study were of the opinion that commercial orientation of smallholder agriculture leads to a gradual decline in real food prices due to increased competition and lower costs in food marketing and processing.

Vihiga is one of the poorest and densely populated Counties in Kenya with an average household land size of 0.4 ha (FAO, 2007). According to Karanja (2006) the main food crops grown in the area are maize, beans, sorghum, finger millet, Irish potatoes, sweet potatoes, cassava and vegetables, while the main industrial ones are coffee, tea and sugar cane. The causes of poverty could be attributed to limited land, high poverty levels, and limited off-farm incomes. According to MOPND (2005), about 62% of the population (in what was by then) Vihiga District lives in absolute poverty and about 60% of the population is poor. Maize is the staple food for the residents of Vihiga thus its insufficiency is synonymous to food insecurity. Over the decade (1997 to 2006), the County's demand for maize outpaced the production level, worsening the already bad food situation (Nyangweso, 2007). This could be attributed to diminishing land sizes because of the increase in population, high costs of inputs for maize production thus making it uneconomical for production.

With the growing food crisis and high prices of mainstream food crops such as maize, there is a growing recognition of the importance of local crops such as sweet potatoes in supporting livelihoods for the poor. Rono et al. (2007) in their study in the North Rift Valley region of Kenya, which has almost similar agro-climatic conditions as Vihiga, found that 75% of the farmers get sweet potatoes from their own farms, 22% from the market and 1% get from their neighbors.

This crop has the potential to diversify the farming systems, spread risks, contribute to food security, and provide income opportunities for the most vulnerable and women in particular. If sweet potato commercialization efforts are to be put in place then a majority of the farmers would be better off. According to CPPMU (2010), the area under sweet potato production in Kenya in 2009 increased by 24%, production in tones by 16% while the unit price per 100 kg bag in Kenya shillings in various markets increased by 43%.

Despite this increase in production and prices, not all farmers participate in markets. According to Omiti et al. (2009), 52% of rural farmers, sweet potato included, participate in markets where they sell only less than 50% of their produce to the various market options. The factors that make the sweet potato farmers not to increase their participation especially in the regional market options are not clear and hence the need to investigate them through establishing the market options available and further determine what socio-economic characteristics determine participation in the different market options.

MATERIALS AND METHODS

Econometric model

To analyse the choice of market option, the multinomial logit model, whereby the dependent variable is the choice of market option while the independent variables are the explanatory variables predicted to have an influence on the choice of the market option, was used. According to Greene (2002), the model has a single decision among two or more alternatives. Unordered choice models can be motivated by a random utility model. For the i^{th} farmer faced with j choices, suppose that the utility of choice j is:

$$U_{ij} = Z_{ij}^{'}\beta + \varepsilon_{ij} \quad (1)$$

If farmer makes choice j in particular, then we assume that U_{ij} is the maximum among the j utilities. Hence the standard model will be driven by the probability that choice j is made which is,

Probability ($U_{ij} > U_{ik}$) for all other k ≠ j (2)

Assuming that Yi represents the choice taken, then with J disturbances being distributed identically and independently, the multinomial logit model will be represented as follows:

$$\Pr ob(Yi = j) = \frac{e^{\beta jxi}}{\sum_{k=0}^{J} e^{\beta kxi}} \text{, where j = 0, 1………J} \quad (3)$$

Equation 3 represents a multinomial logit model, that can provide a set of probabilities for the J+1 choices for the decision taker with characteristics x_i. This means that we can compute J log-odds ratio as in equation 4 below. From the point of view of estimation, it is useful that the odds ratio Pj/Pk does not depend on other choices which follow from the independence of disturbances in the original model (Greene, 2002).

$$In\left(\frac{Pij}{Pik}\right) = x_i(\beta_j - \beta_k) = x_i\beta_j \text{ if k = 0} \quad (4)$$

Based on Equation 4, according to Greene (2002) and Mugisha et al. (2004) and the fact that farmers participate some times in more than one market option, their participation in different market options are categorized into alternatives, using those who participated in the village market option as the base alternative because it was common. The other alternatives include selling to neighbors (immediate neighbor with buyer and seller sharing a common boundary), local town and regional market options. Therefore, the multinomial logit regression model estimated 3 Equations (5, 6 and 7) simultaneously (Studenmund, 1992). The 3 equations are specified as:

$$ln\left(\frac{p_i}{p_o}\right) = Z_i = \alpha_o + \alpha_1 X_1 + \alpha_2 X_2 + \ \dots\dots\dots \alpha_{11}X_{11} + \varepsilon_i \quad (5)$$

$$ln\left(\frac{p_e}{p_o}\right) = Z_e = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ \dots\dots\dots \beta_{11}X_{11} + \varepsilon_e \quad (6)$$

$$ln\left(\frac{p_u}{p_o}\right) = Z_u = \gamma_o + \gamma_1 X_1 + \gamma_2 X_2 + \ \dots\dots\dots \gamma_{11}X_{11} + \varepsilon_u \quad (7)$$

Table 1. Variables used in multinomial logit model.

Variable	Description	Unit of measurement	Expected signs
Totinc[a]	Monthly total income	Kenya shillings	(+)
Sacks[a]	Sacks of sweet potatoes taken to market option	100 Kg bags	(+)
Vadon^	Value addition done to sweet potatoes	Dummy (1 = sorting, washing and packing, 0 = otherwise)	(+)
Acext^	Access to sweet potato extension services	Dummy (0 = no, 1 = yes)	(+)
Accrdts^	Access to credit	Dummy (0 = no, 1 = yes)	(+)
Educ[a]	Education level	Years	(+)
Age[a]	Age	Years	(+)
Totassbas[a]	Total asset base	Kenya Shillings	(-)
Trusop^	Transport used to option(s)	Dummy (1 = better, 0 = otherwise)	(+)
Totland[a]	Total land owned	Acres	(+)
Gend^	Gender of farmer	(1 = male, 0 = female)	(+)
Hhsize[a]	Household size	No of males/females	(-)

[a] = Natural logarithm, ^ = dummy variables.

Where *po* = probability that a household chose to participate in the village market option (base alternative); *Pi, Pe* and *Pu* = the probability that a household chose to participate in the local town, regional and neighbor market options respectively; Z*i, Ze* and *Zu* = household participates in the local town, regional and neighbor market options, respectively (1 if household participates, 0 otherwise); α*o,* β*o* and *γo* = intercepts showing probability of participating in the local town, regional and neighbor market option respectively, if all other explanatory variables are kept constant at zero; *αi*, *βi* and *γi* = parameters of the *i*th set of local town, regional and neighbor market options respectively that are estimated, and *Xi* = explanatory variables of the market option participation *εi*, *εo,* and *εu* are the error terms.

Data collection

The data used in the analysis was collected between the months of May and June, 2011 in 3 divisions, Vihiga, Luanda and Sabatia in Vihiga County which were selected based on the population density. Random samples of 38, 48 and 34 sweet potato farmers both participating in markets and otherwise were selected from Luanda, Sabatia and Vihiga respectively, resulting to a total sample size of 120. Data was collected using interview schedules collecting information on farm and farmer characteristics, transaction costs and market related factors. Table 1 presents definitions for the variables used in the multinomial logit model.

RESULTS

Table 2 presents the descriptive statistics of the sweet potato farmers found to participate in the different market options available in Vihiga County. Sweet potato farmers who mainly sell their produce to the regional markets have the largest average land acreage of 4.03, followed by 3.03, 2.1 and 2 acres for local town, village and neighbor market options, respectively.

Land size was found to significantly vary across participants of the different markets options. Farmers owning larger farms engaged more in a wider market ranging from participant in neighborhood market with land size of 2 acres to that in the regional market of 4.4 acres. Income from sweet-potatoes and value addition were positively related to market participation thus explaining the monetary incentives that make the larger market other than the village market attractive to the farmers.

Table 3 presents a cross-tabulation of the market options and socio-economic characteristics of the farmers in discrete values such as gender, access to credit and extension. With regards to gender, 50% of female and 50% of males participated in the market. Majority (57.1%) are participating in the village market with females being 34.3% while males are 22.9%.

The socio-economic characteristics determining the various market options which farmers participate in are given in Table 4. According to the results from the multinomial logit model, 60.9% of the variation in the categorical dependent variable was explained by the model. The village market option is chosen as the base market option since it is common across all the 3 options and every other choice is then compared to the base.

DISCUSSION

Analysis of the data show that, total land ownership was significantly different at 10% level hence influencing choice of the farmer’s market option. Land was a critical production asset having a direct bearing on production of a marketable surplus (Machethe et al., 2008). Means of the average distance to the farmers’ market option was also significantly different with the farthest market option being regional with an average distance of 257, followed by 27.21 and 4.7 km for local town and village. The distances represent the geographical coverage of the market with the regional market being the largest and the village market being the smallest.

Table 2. Descriptive statistics of the participant farmers in the different market options.

Variable	Overall mean (n = 70)	Main market options				
		Means				
		Neigh (n = 1)	Village (n = 40)	Local town (n = 24)	Regional (n = 5)	F-Test
Age	45.23 (12.92)	48	44.22(13.52)	47.75(12.91)	40.60(7.99)	0.604
Household size	5.16 (2.50)	5	5(2.48)	5.54(2.73)	4.6(1.82)	0.316
Total land owned	2.58 (1.87)	2	2.1(1.32)	3.03(2.14)	4.4(3.05)	3.239*
Education	10.24 (3.03)	8	9.73(3.19)	10.83(2.93)	12(0)	1.462
Months per season	3.99 (0.53)	4	4.03(0.62)	3.96(0.20)	3.805(0.84)	0.296
Distance	30.4 (76.5)	0	4.7(5.2)	27.21(39.07)	257(144.5)	52.26*
Sweet potato income	2074(1868)	750	1477(1377)	2764(2090)	3805(2448)	4.705*
Cost of value addition	283.28(479.9)	25	127(148)	526(714)	420(435)	4.221*

*Significance level of 10%.

Table 3. Descriptive statistics of the participant farmers in discrete variables.

Variable		Market options					
		Farmers' percentage frequencies					
		All (n=70)	Neighbor (n=1)	Village (n=40)	Local town (n=24)	Regional (n=5)	Chi-square
Gender	Female	50	.0	34.3	12.9	2.9	0.231
	Male	50	1.4	22.9	21.4	4.3	
	Total	100	1.4	57.1	34.3	7.1	
Extension services	No	58.6	1.4	41.4	11.4	4.3	0.017*
	Yes	41.4	.0	15.7	22.9	2.9	
	Total	100	1.4	57.1	34.3	7.1	
Credit	No	77.1	1.4	45.7	25.7	4.3	0.711
	Yes	22.9	.0	11.4	8.6	2.9	
	Total	100	1.4	57.1	34.3	7.1	

*Significance level of 10%.

Mean income from sweet potato across the market options was statistically different at 10% level. This income influences the choice of market option because it increases the farmers' cash resources and hence could result in investment of sweet potato marketing. The highest average income, Kshs. 3805, was received by farmers selling to the regional market probably because of the good sweet potato prices. The mean cost of value addition is Kshs. 283.28 which is inclusive of water fees, labor for sorting the sweet potatoes and packaging materials for majority of the farmers. The cost was statistically different across the groups with those preferring local town markets incurring the highest average of Kshs. 526, followed by regional (Kshs.420) and Kshs. 127 for village.

Access to credit gives the farmer more cash resources hence it has an effect on his/her sweet potato marketing activities. According to the results, access to credit was significant at 10% level and negatively influences local town market participation. As the credit status of the sweet potato farmer changes from not accessing it to accessing, the probability of participating in the local town market than village reduces by 34.3% implying that the farmer will sell fewer sweet potatoes in the local town market as compared to the village market. This is inconsistent with the priori positive sign (Asfaw et al., 2010) likely because the farmer may increase participation of other farm and off-farm activities which are perceived to be more lucrative such as cash crops and dairy products. The margins from these alternatives are likely larger than sweet potatoes thus enabling the farmer to meet repayment of the credit and have some savings for his needs. Additionally, the study population was made up of smallholder farmers who have so diverse

Table 4. Model Estimates of the determinants of market option participation by farmers.

Variable	Coefficient	Z	p > |z|	Marginal effects
Local town market option				
Household size	0.99 (0.89)	1.12	0.262	0.224
Credit access	-1.94 (1.14)	-1.70	0.088*	-0.343
Total asset base	-0.48 (0.47)	-1.02	0.310	-0.108
Total income	0.99 (0.57)	1.73	0.084*	0.222
Transport mode to option	1.28 (0.49)	2.62	0.009*	0.287
Access to extension	2.04 (0.92)	2.23	0.026*	0.446
Total land owned	0.75 (0.81)	0.93	0.352	0.168
Education	-1.41 (1.07)	-1.31	0.191	-0.316
Sacks taken to option	1.05 (0.63)	1.68	0.094*	0.235
Value addition done	0.98 (0.49)	2.02	0.043*	0.220
Age	-3.24 (1.49)	-2.17	0.030*	-0.727
Gender	0.98 (0.88)	1.11	0.266	0.218
Regional market option				
Household size	1.33 (3.44)	0.39	0.699	3.49e-06
Access to credit	-0.92 (4.26)	-0.22	0.830	1.28e-06
Total asset base	-5.02 (3.27)	-1.53	0.125	-0.00002
Total income	2.37 (2.83)	0.84	0.401	7.16e-06
Transport mode to option	6.52 (3.25)	2.00	0.045*	0.00002
Access to extension	-9.18 (7.11)	-1.29	0.196	-0.00022
Total land owned	9.40 (5.45)	1.73	0.084*	0.000032
Education	-5.51 (5.44)	-1.01	0.310	-0.000017
Sacks taken to option	5.87 (3.03)	1.94	0.053*	0.0000194
Value addition done	-3.35 (2.84)	-1.18	0.238	-0.0000129
Age	4.42 (8.08)	0.55	0.584	0.0000194
Gender	8.50 (4.71)	1.80	0.071*	0.0002025
MAINMKT = Village market outlet is the base outcome				
Number of observations = 68				
LR chi 2 (20) = 91.05				
Log likelihood = -29.179805				
Prob> X^2 = 0.0000				
Pseudo R^2 = 0.6094				

*Significance levels at 10%; Figures in parentheses () are standard errors.

household needs to be met from the same limited resources, such that their behavior may not be identical to that of a firm. This implies that other studies of different populations may be needed to understand better this unique behavior.

The results indicate that the number of sacks taken to the market positively influences local town market participation. As the number of sacks the farmer takes to market increases by 1 bag, the probability of participating in local town than village increases by 23.5%. The increase in sacks taken to the market will make the farmer sell his produce in the local market which has a larger population of buyers hence increasing his chances of selling most or all of his produce as compared to the village which has less.

Total income which is a summation of both farm and off-farm sources positively influences local town market participation. An increase in the monthly income by 1% increases the probability of participating in the local town market than village by 22.2%. The increase in cash resources will make the farmer invest more in sweet potato production and marketing activities resulting to more surplus driving him to sell to local town which is a larger market compared to village.

On transport mode used to reach the market, the results show that it positively influences local town market participation. As the transport mode becomes better in terms of quick access to the market, affordability and convenience (collecting produce from home and carrying many bags at a time), the probability of participating in local town than village increases by 28.7%. Good transport reduces transportation costs for the farmer and hence makes it easy and cheaper for him/her to access local town market which has better market conditions in terms of big population of buyers and sellers and better prices compared to the village market option (Machethe et al., 2008).

Access to extension positively influences local town market participation such that, a change in a farmer's status from no access to extension to access increases the probability of local town market participation than village by 44.6%. This implies that extension will make the farmer participate more in the local town than the village market option. Extension services enable the farmer to improve his production methods hence leading to more output which in turn increases his/her marketed surplus hence market participation (Lapar et al., 2002), especially in larger markets such as local town.

Value addition done by the farmer does positively influence participation in local town market. If the farmer changes his value addition activities to include sorting, washing and packaging from otherwise, the probability of participating in local town market than village increases by 22%. Because of presence of many sellers in the local town compared to village, farmers have to ensure that their products are appealing to the buyers and hence have competitive advantage over other sellers.

Age of the farmer negatively influences local town market participation. This implies that an increase in the age by 1 year decreases the probability of participating in the local town than village market by 72.7%. This is inconsistent with the expected positive priori sign according to Machethe et al. (2008) such that, as the farmer gets old he will choose to participate less in the local town market than the village market option because of the loss in energy to sell in distant markets.

Results for the socio-economic factors determining participation in the regional markets, show that transport used to reach the regional market positively influences participation. An improvement in transport increases probability of participation in the regional market than the village market. Good transport acts as an incentive for farmers to sell to distant markets, which usually have better market conditions, because it reduces the cost of transportation and hence increases the farmers' profit margins.

Total land owned positively influences participation in the regional option. An increase in land owned increases the probability of participating in regional as compared to the village market. This is consistent with Machethe et al. (2008) who find that larger land sizes raise the probability of market participation for sellers since land is a critical production asset having a direct bearing on production of a marketable surplus, *ceteris paribus*. This implies that those with large tracts of land are likely to participate more in markets especially larger ones such as regional.

The sacks taken to the market positively influences regional market participation. An increase in the number of sacks increases the probability of farmers participating more in the regional market than village. As the number of sacks increases, farmers are likely to participate more in the regional than village market option because more sacks implies more economies of scale and hence it is better to sell to far away markets where prices are good.

Gender positively influences participation in the regional option and is significant at 10% level. As the gender of the participant changes from female to male, the probability of participating in the regional option being higher for male, implying that male farmers are likely to participate more in the regional market option than the village. Despite sweet potato production and marketing being mainly done by women (Nungo et al., 2007), men usually influence participation in distant market options such as regional.

In conclusion it can therefore be stated that the shift in participation of smallholder sweet-potato farmers from village market to a more income generating regional market is determined by; increased household income, land size, transport mode, gender of farmer, output of sweet-potato, extension services and value addition made.

Policy implications

Sweet potato production and marketing activities are mainly done by women in Vihiga County. To reduce poverty, the Government through agricultural officers, Non-governmental organizations and other stakeholders should first identify which member of the household has control over the crop in question then offer interventions which will take into consideration the gender of the person. For instance, if the interventions include programs such as giving financial aid to the farmers, they ought to take into consideration that most of these female farmers do not have collateral since title deeds and other property in most cases are in the name of their husbands who are less likely to allow the titles to be used as collateral.

The most common market option for majority of the farmers is the village market because of its close proximity that makes farmers to incur lower transportation costs. Consequently, the prices and income in this market are low because of the excess supply. Formal or informal institutional arrangements such as farmer groups or organizations should be encouraged through which farmers can collectively access distant markets which have good prices. The arrangements will facilitate: use of common transport; exchange of marketing information while strengthening negotiation; bargaining position of farmers, and; also make contracting and enforcement of contracts easier.

The size of the land owned was found to be low while the population in the area is high hence putting pressure on the land resources. To increase land productivity, the government needs to provide farmers with high yielding and disease resistant sweet potato varieties. The government also needs to avail extension officers in the area so as to advice farmers on new farming techniques.

Since transport costs reduce market participation, the government should increase investment in the rural road transport network so as to ease movement of goods and reduce the transportation costs.

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Econometric estimation of herd stocking decisions in South Ethiopia

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This paper aims to share knowledge and the theoretical basis for understanding herd dynamics in pastoral communities of Hadiya, Southern Ethiopia, with the intention that it may improve effectiveness of development interventions. The study is based on data collected from two districts considering 160 pastoral households. Focus group and key informant discussions were also made to generate data to supplement the personal interviews. A Probit model was utilized for analyzing factors that determine cattle stocking. The Hadiya pastoralists stock cattle not mainly as a security against risks but it is also the cultural obligation to attain the cultural titles to some clans. Social interaction expressed as marriage bond and social capital as well as herding experience determines willingness and intensity of herd stoking, besides natural factors. However, financial factors have little effect on cattle dynamics. The results imply that, if any kind of development interventions is planned to improve the livelihood of the community and or the environment, strategies related to optimal stocking rates (considering cultural dimension of stocking) should be developed.

Key words: Ethiopia, herd stocking, Hadiya, pastoralism.

INTRODUCTION

Livestock make an important contribution to most economies, especially in developing countries. Addressing poverty (income and non-income) is an imperative development agenda of the developing countries. Owen et al. (2005) estimated that 76% of people in developing countries are poor rural dwellers and 2/3 of these people are livestock keepers. Ethiopia, among the least developed countries in the world, aspires to become a middle income country in 2025. The government formulated several ambitious national growth strategies in order to realize this vision, the latest being the Growth and Transformation Plan (GTP: 2011-2015). Considering that agriculture accounts for some 40% of GDP, 80% of employment and 90% of all exports, it is inevitable that a rapid commercialization of this sector is a key priority.

Ethiopia is an agrarian, landlocked country characterized by high population growth, huge dependence on erratic rainfall, low agricultural productivity and structural bottlenecks (Ministry of finance and Economic Development (MoFED, 2006). However, it also has the largest number of livestock in Africa with a total of about 47 million head of cattle, 26 million head of sheep 24 million goats, 49 million chicken, 6 million equines (donkey, horses and mules) and 2 million camels Central Statistical Authority (CSA, 2007). The richness of

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the country is both in terms of large number and diversity of livestock population. Like the human population the cattle distribution in the highlands is three times greater than the lowland area. Although the lowland has fewer animals than the highlands, the lowlands, which are mainly pastoral, play an important role in the livelihood of the highlanders. The highland is considered as livestock deficit, the lowlands being a major source of supply, for instance 20% of the highland draught animals come from the lowlands (Kejela and Bezahih, 2006).

According to the International Department for Environment and Development (IIED, 2009), pastoralism is still a way of life and an essential livelihood for a substantial part of East Africa's population, up to 20 million people. With all its critics and ailing livelihood pastoralism has sustained itself because of its basic features: flexibility, low costs, freedom of movement, light regulatory environment and operation in regions that are unsuitable for agriculture. Pastoral areas remain the least developed part of Ethiopia despite the fact that the sector supports over 40% of the country's livestock, 61% of the total area of the country of which 46% is arable land, and 12% of the population (CSA, 2007). Livestock define the lives of pastoralists, being means of fulfilling and satisfying nutritional, social and cultural needs of the family.

The purpose livestock serves varies across economies, ecologies and cultures. Livestock farmers keep cattle for multiple purposes including milk, meat, blood, hides, horns and income (Sharon et al., 2003). Socio-cultural functions of cattle include their use as dowry and to settle disputes (as fines) in communal areas (Chimonyo et al., 1999). They are reserved for special ceremonial gatherings such as marriage feasts, weddings, funerals and circumcision. They are also used to strengthen relationships with in-laws and to maintain family contacts by entrusting them to other family members (Bayer et al., 2004; Dovie et al., 2006). Sacrificial offering of cattle also play an important role in installation and exorcism of spirits.

Review of literatures on pastoral studies indicates many of the previous studies have been undertaken mainly to inform institutional analyses of pastoralism and of common property resource management. Other studies have been undertaken mainly by anthropologists, focusing on social and cultural changes and challenges facing pastoralists (Michael, 2006). Little is known about the relationship between cultural and economic variables of the system. Pastoralism has immense potential value for reducing poverty, managing the environment, and promoting sustainable development. Pastoralism as a system is a complex production system; furthermore the available information on the subject is not substantial. Therefore this paper adds to the understanding of the social and economic features of pastoralism. Besides, it brings to light the nature and feature of herd stocking in Hadiya Pastoral production system because the nature of herd dynamics affects commercial off-take and therefore response for the increasing demand for meat.

METHODOLOGY

Data and data sources

Both desktop and primary research methods were employed for this study. Information was collected from a variety of sources such as Government publications, nongovernment organization publications and journals. Primary data were collected using both formal and informal methods. The primary data sources include individual pastoral households, traders, and key informants. Individual interviews using a pre-tested questionnaire generated household level data.

Data were collected by means of structured and pretested questionnaire between September and December 2009. For the overall understanding of the study area's production and marketing system, Participatory Rural Appraisal (PRA) tools were used (experts and knowledgeable elders of pastoralists, consumers and traders) using the checklist prepared for the purpose. Field observations and Rapid Market Appraisal were also been made to observe the overall features of the selected Peasant Association (PAs) markets and to pre-test the questionnaire (to make sure that important issues had not been left out).

Sample size and method of sampling

The survey districts were selected based on secondary information from Central Statistical Authority, Socioeconomic profile bulletin of the zone and expert knowledge. Six major pastoral PAs from Soro district and three PAs from Gombora district (one third pastoral PAs from each district) were then identified based on season the pastoralists available in the PAs; besides, accessibility, clan distribution, neighboring ethnic groups and area of production were also considered. From total of these nine PAs, proportional to the pastoral population, totally 160 pastoral household heads were selected, 108 from Soro and other 52 from Gombora districts. The respondents were informed of the purpose of the research, and assured that their responses would be treated confidentially.

Method of data analysis

Descriptive statistics analysis

To describe some of the variables of interest and their interrelationship descriptive and inferential statistics were applied in the documentation of the basic characteristics of the sampled households. These include use of ratios, percentages, means, and standard deviations and related tests of student's t and chi square. With the hypothesis that herders stock mainly to hold cultural titles, the producers are categorized according to their production behavior as title holders (those with 1000 cattle attain *Kuma,* and with 100 cattle attaining *Abagaz/Gerad* titles) and non-title holders.

Econometric method of data analysis

The modeling methodology used to analyze the factors decisive in attaining the cultural title (by cattle stocking) is probit regression that allows the prediction of discrete variables by a mix of continuous and discrete predictors (McCullagh and Nelder, 1983). The probit model constrains the estimated probabilities to be either 0 or 1, relaxes the constraints that the effect of independent variables is constant across different predicted values of the dependent variable. The probit model assumes that while only the values of 0 and 1 are observed for the variable Y , there is a latent, unobserved continuous variable Y* that determines the value of Y. It is assumed that ε_i is normally distributed across observations, and the mean and variance of ε are normalized to 0 and 1. The Y* can be specified as follows:

$$Y^*_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k x_{ki} + \varepsilon_i \qquad (1)$$

and that:

$Y_i = 1$ if $Y^*_i > 0$
$Y_i = 0$ otherwise

As with logit model, it is assumed that y_i^* is a function of observed and unobserved variables

$$y_i^* = \beta_0 + x_{1i}\beta_1 + x_{2i}\beta_2 \ldots. + x_{ki}\beta_k + \varepsilon_i \qquad (2)$$

$$y_i^* = x_i\beta + \varepsilon_i \qquad (3)$$

Where y_i^*= latent and measure of level/ of herd stocked by i th household, Xi = a vector of explanatory variables describing the personal, social, economic and environmental factors, β_i= a vector of parameters to be estimated, and ε_i = a random error term (assumed to follow a standard normal distribution).

The model is determined by the assumed distribution of ε. The observed and coded discrete herd stocking variable, y_i^*, is determined from the model as follows:

$$\Pr(y_i=1)$$
$$= \Pr(\varepsilon i \geq -(\beta_0 + x_{1i}\beta_1 + x_{2i}\beta_2 \ldots. + x_{ki}\beta_k))$$
$$= 1 - \Pr(\varepsilon i \leq -(\beta_0 + x_{1i}\beta_1 + x_{2i}\beta_2 \ldots. + x_{ki}\beta_k))$$
$$= 1 - \Phi(-x_i\beta)$$

Where, Φ represents the cumulative normal distribution function. The interpretation of this model's primary parameter set, β, is as follows: positive signs indicate likely factor for title holding/herd stocking as the value of the associated variables increase, while negative signs suggest the converse.

The model considers pastoral households as utility maximizers who compare and rank level of utility that they get by securing the traditional title against its reservation utility attained without the title. In general, the effect of a change in one of the explanatory variables (say the *j*-th variable) on the choice probability is given by the derivative.

RESULTS AND DISCUSSION

Demographic characteristics of pastoral households

All respondents were male. Title holders, who attained the traditional title by accumulating at least 100 cattle, and non-title holders on average have 2.23 and 1.17 wives respectively. This indicates that a woman cannot be household head, even if widowed; they then need to marry someone from the family, at least as polygamy because resource governance in the community is totally a male responsibility. It is also possibly one means to protect clan's wealth by not letting a widow marry someone out of the clan and take herds. However, the case is totally different for girl's first marriage, where marriage into larger clans establishes a marital tie which serves as a security against all sorts of risks. There is significant difference (P<0.01) in the age of the household heads between the title holders and non-title holder. Household heads who have secured the traditional title (*Kuma, Gerad/Abagaz*) are significantly older (average 45.68 years) than that of the non-title holders (32.7 years). This implies a strong relationship between age, wives and title holding; probably, labour contribution of wives (and hence their children) as well as pre marriage herd of the wife boosts herd size. The dependency ratio, proportion of dependents to 100 working age population of the sample respondents was 160%. This ratio is possibly attributed to polygamous nature of the pastoralists. Statistically there is a significant mean difference in terms of dependency ratio between the two positions 32% for the title holders and 43% for non-title holders. In regard to their religion, 93% of the title holders follow the traditional *Wa'a* religion while 71% of the non-title holders are protestant Christians (Table 1). The average year of schooling 1.54 years for both groups is not significantly different. The result would imply the entire reliance of the producers on traditional knowledge.

Cattle production and marketing system

For a considerable part of East Africa's population, pastoralism remains a way of life and an essential livelihood with cattle production being a major part of the system. There are a wide range of reasons for which households keep cattle in different communities. Cattle production in the community is a family business where every capable member participates based on the division of labor in the community. Normally stronger family members take care of stronger cattle. In Hadiya pastoral system herders give name to cattle based on either behavior or color. The cattle are trained to respond to particular names and this is important in managing large number of cattle. The Hadiya Pastoralists are also experienced in breeding. Every traditional breeder seeks parameters that the community wants to have in his herd: First, milk ability; second, walking ability: the ability to walk long distances over rugged terrain and third coat color (it enables cattle to stand desert flies and heat besides the aesthetic value of the skin).

In this pastoral system, nomads, transhumant and the agro pastoralists are known to co-exist[1].The survey revealed that livestock production system in the area is characterized by cattle–dominated livestock production and rainy season transhumance. Pastoralism in this community is characterized by entire dependence on naturally growing pasture via mobility. In addition to pasture and conflict avoidance, traditional beliefs and faith determine where and with whom to migrate. The

[1] Though it was only the nomads considered in this study.

Table 1. Demographic characteristics of the pastoral households by traditional title.

Variable	Title holder	Mean(Std. deviation)	t- value
Age	H	45.68(8.7)	9.19***
	NH	32.67(9.2)	
Education level (years of formal schooling)	H	1.54(1.3)	0.009
	NH	1.54(1.4)	
Dependency ratio	H	0.32(0.1)	-6.28***
	NH	0.433(0.1)	
Number of wives	H	2.23 (0.9)	8.36***
	NH	1.17(0.7)	
TLU[2] (Tropical Livestock Unit)	H	101.3(14.6)	18.23***
	NH	57.2 (15.9)	

***, statistically significant at 1%, level of significance, N=160, title holder (H)=78, non-title holder (NH)=82. [2]One tropical livestock unit is roughly equal to 250 kg of live animal weight.

peak months when the herders migrate are June (24.7%), December (36.6%), and March (38.7%). Reasons for migration vary with season. For instance in June 61% migrated due to disease, 24% wild life attack and the remainders because of bad feeling (traditional belief). In December 50.6% ranked traditional belief (worship and inauguration of the *Tibima/Kumima* ceremony), 32% pasture depletion and 17.4% due to conflict (mainly between clan conflict). The title holding ceremony takes place in river areas where the clan congregates. In March 66.5% move due to feed and water, 17.3% due to traditional faiths and ceremonies, the remaining 6.2% caused by conflicts (both between clans and Human- wild life conflicts). Participants of the focus group discussion confirmed that mortality because of different factors is predictable (both with respect to occurrence and magnitude of loss) which determines herd dynamics/stocking-destocking/ decision. There are different factors which determine their precision of prediction. The survey result implied that 57% of the respondents anticipated 10 to 15% of loss, 34% less than 10% and the others anticipated more than 15%. According to focus group and key informants' discussion this estimation is mainly based on past experience on cyclic prevalence of drought and disease.

Conflicts are among the common phenomena characterizing the pastoral system. In some cases it becomes more destructive even than the drought and disease since these factors have limited affect on human life. Among all sorts of conflicts, the respondents ranked the Human-policy conflict as the worst, mainly because it is non avoidable. For instance, the construction of the huge *Gilgel Gibe III* hydro electric power dam evicted them from their grazing land and left them vulnerable to risks. Besides its migration the pastoral system is also characterized by herd species composition; on average the surveyed pastoralists possessed 78 Tropical Livestock Unit (TLU) and standard deviation of 14 where all pastoralists rear cattle and donkey, with a varying intensity of small ruminants. According to the focus group and key informants' discussions the herd composition is a function of 'risk mitigating' nature of the pastoralists', topography and tradition (cow is the symbol of the spirit of *wa'a* (traditional God). Hadiya pastoralists do not rear camel, 44.6% think it is Islamic, 43% suspect it does not adapt the rugged topography in the *Gibe-Omo* basin, and the remainders do not even know the animal. This is possibly because the community entire on own knowledge and the 'within' the system information for livelihood decisions.

Determinants of pastoralist's herd stocking decision

In order to analyze factors determining securing cultural title (stocking herd), seven variables were used in Probit regression model. With the knowledge that his/her decision making is invariably surrounded by uncertainties and, risks; different classes of variables are considered based on socio-economic, demographic and cognitive factors. The analysis was made using STATA version 12 statistical software. Before conducting the analysis multicolliniarity among the explanatory variables was checked so that the parameter estimates will not be seriously affected by the existence of multicolliniarity among variables. The variables were also tested for hetroskedastisity and the test rejected for all variables the null that there is a significant difference among the variables in the same group variances (Table 2). The likelihood ratio chi-square of 194.32 with a p-value of

Table 2. Determinants of Pastoralist's herd stocking.

Variable	Estimated coefficient (B)	Odds ratio	Wald	Standard error	p-value
Number of wives (NWV)	0.959	1.632	9.26	0.315	0.006*
Herding experience (HE)	0.114	1.919	1.032	0.083	0.310
Education level (EDUCLVL)	0.255	0.775	0.246	0.513	0.620
Net social transfer (NST)	1.167	0.846	0.758	0.991	0.384
Access to market (ACMKT (1))	0.407	1.503	0.100	1.289	0.752
Modality of payment (MOP)	0.238	0.788	7.866	0.085	0.005**
Mortality (MORT)	-0.66	-0.96	6.96	0.25	0.02*
Constant	24.154	308897	9.038	8.034	0.003

Number of observation = 160, chi^2 (10)=194.320, Prob > chi^2=0.0001, Pseudo R^2=0.1831, ***, **,* statistically significant at 1%, 5% and 10% level of significance respectively,

0.0001 tells us that the model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors. The significant variables and possible reasons are discussed thus.

Herding experience (HE)

This variable is used as a proxy to age, traditional knowledge and or social capital of the household head. Pastoralists in southern Ethiopia do not have access to any research, extension or modern veterinary facilities. Therefore grazing area selection, breed and herd composition selection, replacement decision and medication are indigenous to the herder's experience and naturally increase with age. In this model, the variable is found to be significantly and positively related to stocking cattle (to attain cultural title). The coefficient of HE suggests that an increase in the herding experience of the household head is likely to increase the probability of title holding, keeping all other variables constant. Increases in age of the household head accompanied by increase in responsibility (social/family) helps the household head to accumulate experience. Besides, at older ages either through birth or extended family the household would have enough labor, which is the major and irreplaceable input of cattle production in such system of production. The increase in the herding experience of the household head by a year increases the likelihood of becoming title holder by 11% as compared to the other alternative.

Modality of payment (MOP)

This is whether the payment is made on cash or credit basis. The positive relationship shows that, other variables held constant the likelihood in favor of being non-title holder increases if the payment is made on credit than on cash basis. Therefore if the payment is made on credit the seller wouldn't have the chance to make immediate replacement. By implication the ones with the purpose of stocking their herd have lesser interest to sell on credit. Since their sale's purpose is mainly either to replace older staff or to expand herd size the non-title holders prefer to widen their liquidity by selling on cash. They are reluctant to sell unless they can replace the herd. Beside the "on credit sale'' is at least one third greater than the "on cash sales", this gives additional income for the sellers. In this drylands the sellers do not have other options to invest their money, but to purchase additional cattle. This implies that the pastoralists do not have other means to invest their money but to expand their herd size. The evidence from the model shows that a shift from 'on credit' to 'on cash sale' increases the probability of the household to be a title holder by 23%.

Number of wives (NWV)

The number of wives the household head had has positive and significant relation with title holding option. In regard to the casual link of wives and title holding, additional wife provides two things, first, additional cattle as a marriage gift and second, security in case of any risk, that is, restocking gifts from her clan. This positive relationship entails that, keeping all other variables constant the odd in favor of holding the traditional title increases. The possible explanation for this is that those who have more wives have access to cattle first as (beginning capital) marriage gift that is, in this community when a daughter leaves her parents because of marriage she will be given her share to begin her new life, and second because of marital ties relatives help her restock cattle during shocks. Moreover, polygamy in this community is a source of social security during conflicts and natural hazards. This is mainly due to the fact that Hadiya pastoral communities more often than not do not fight with the clan they get married. As the number of *wives* increase by one the probability of securing the traditional title increases by 9.9% rather than being non-title holder.

Besides, marriage in this pastoral community is the most effective diplomatic means to secure peaceful relation with the neighboring tribes/clans. Because, raiding has already been identified as restocking strategy in case of disease/drought, according to the PRA result, however raiding may not always serve as presupposed and in most case it inflict more damage than the natural disaster. A positive coefficient says the log-odds of title holding are increasing as a function of number of wife (the more wives got, the more likely the household is to secure the cultural title (stock cattle).

Mortality (MORT)

Mortality in this model is used to represent effects of natural calamities on herd stocking (Getachew and McPeak, 2004). This variable is a proxy for herd loss due to drought, disease and wild life attack. So that it can help estimate the intensity of loss, the variable is used in the model as ratio of total loss due to the above mentioned causes to total herd owned. As it is shown in the table a percentage increase in mortality rate decreases the likelihood of holding the cultural title by 66% as compared to the non-title holding option. A previous study by Ayana (2011) showed that rainfall variability greatly influenced herd dynamics under communal and ranch managements in terms of herd die-offs and lower birth rates, which also considerably affected milk production for household consumption. The result implies that management of herd size is therefore a compromise between harvesting production in average years and the risk of losses in a drought.

Access to market (ACMKT)

It is a dummy variable taking a value of 1 if the pastoralist has access to market and 0 otherwise. The access to market variable considers the distance to the market, language, cultural and other barriers to the market. It has been hypothesized not to have clear effect on herd stocking but markets may help pastoralists to stock back. Because, producers that have access to market are likely to supply more and buy larger than the ones not having access to the market. Goetz (1992) noted that better market significantly raises the probability of market participation (both as a buyer and seller) for households. However, evidence from Table 2 establishes that markets do not have a significant effect on title holding decision. This finding is in line with the works of Sharon et al. (2003) and Getachew and McPeak (2004) that social purposes of cattle by far outweigh the monetary ones.

Net social transfer (NST)

The net transfer is a continuous variable measured in TLU. It is the difference between herd given/loan in and given/loan out divided by total TLU, in the study period. As shown in Table 2, the variable has positive and significant relation with the title holding position. It means that 1% increase in NST will raise the likelihood of herd stocking (title holding) by more than 16% as compared to non-title holding option. Probably the cattle given out in this way may serve multiple purposes like security against risks in case of disaster, save labor and strengthen social bond which might be source of assistance in case of crises. Hence, the number of cattle given out in this way is believed to have a positive effect on the rate of herd stocking decision. The net transfer increases (other things being fixed) the chance of holding the traditional title, this is primarily because, the household has the right to return back his cattle whenever needed. It points to social transfers being the main sources of herd stocking (social security) after crises because of natural and human factors.

CONCLUSION AND RECOMMENDATIONS

This study has significant implications for pastoral development and environmental initiatives. Its findings will enable development practitioners to better understand the needs and wants of the pastoral community, and offer a useful reference point for future studies. One major viewpoint revealed by this study is that the Hadiya pastoralists stock large number of cattle not only as a security against risks but also for social reasons. This might imply that some development initiatives, for instance, settlement, may not suit the pastoralists' purposes of cattle production. The research also identified that net social transfer, herding experience, market access, and number of wives positively affect herd stocking. It has also been observed that monetary factors have little effect on herd dynamics.

The results indicate that the system relies entirely on traditional knowledge for all decisions made, possibly expansion of formal education and extension services might be way out for some of the problems the system faced. Therefore, for any development intervention to be effective in improving the livelihood of the community and or the environment, strategies related to optimal stocking rates (considering cultural dimension of stocking) should be developed.

Finally, what need to be focused on is any development effort in this area need to match the belief and attitude of the community, at least for efficiency and sustainability. Future research should also look into how the pastoral community's attitudes towards herd stocking changes as a result of climate change, and what factors govern the relationship. Researchers may also investigate the impact of cultural values on multifaceted developmental endeavors in pastoral areas.

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