Crop diversification decisions: the case of vanilla in Uganda

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Abstract

This article provides a micro-level foundation for the analysis of crop diversification decisions in a semi-subsistence banana farming community in Uganda. A two-crop agricultural household model is developed to show that credit rationing and crop price movements influence vanilla adoption decisions. The analysis is based on survey data from 70 households. Household welfare improves by 16%, without raising food security concerns, when vanilla is grown. Results imply that the benefits of functioning credit markets, and crop quality improvement strategies that lift farm-gate vanilla prices, are important to consider when developing pro-poor growth strategies at the farm level.

Keywords: agricultural household model, crop diversification, credit, Uganda
JEL: Q12

1. Introduction

Vanilla is known to many farmers as Uganda's green gold. However, uptake rates appear low given the crop's potential benefits. Quantitative evidence on the constraints facing potential vanilla growers is particularly important as pressure to reduce poverty rises. The premise of this article is that semi-subsistence farmers do not respond to price shocks by increasing crop areas in a continuous manner, and that access to credit can increase household price responsiveness. This idea is illustrated by applying a multi-period agricultural household model to banana growers in southwestern Uganda to answer the following question: Under what conditions can households successfully diversify production into vanilla?

Crop diversification has many known benefits, including income enhancement and reducing income variance (VON BRAUN, 1995; DORWARD et al., 1998; COELLI and FLEMING, 2004; JOSHI et al., 2007). Moreover, there is broad agreement that non-food crops do not compete with food production and intensify food insecurity (GOVEREH and JAYNE, 2003). An often overlooked and less well-understood issue is the responsiveness of household crop patterns to changing prices and credit availability.

When households have limited cash incomes, or there are time lags between crop planting and production, credit may be required for diversification. The theoretical benefits of access to credit have been well documented by CONNING and UDRY (2005), and a growing empirical literature suggests credit constraints have adverse effects on agricultural household welfare (SINGH and NASIR, 2003; FOLTZ, 2004; GUIRKINGER and BOUCHER, 2008). SINGH and NASIR (2003) find that more diversified cropping patterns improve access to credit. However, does the reverse hold: can access to credit increase the level of diversification?

Much of the crop diversification literature focuses on econometrically estimating marginal increases in the area or yield of alternative crops (GOVEREH and JAYNE, 2003; CADOT et al., 2006; KIJIMA et al., 2008). While marginal changes in cropping patterns highlight the benefits of diversification, the discrete decision of commencing a new activity should not be overlooked. There have been few attempts to use agricultural household models to explain crop diversification patterns. One exception is HOLDEN et al. (1998) who quantify the marginal impact of input subsidies on established cash crop and subsistence farming practices. This article builds on previous econometric analyses by using an agricultural household model to quantify the discrete choice of vanilla adoption.

Banana and vanilla growing in Uganda

Approximately half the banana-growing households in southwestern Uganda live below the poverty line (EMWANU et al., 2004). To address this concern, various development pathways and technical assistance programs have been proposed and/or implemented. For example, PENDER et al. (2004) encourage increased specialisation in already dominant crop activities and NBRP (2006) promote the development of banana genotypes with resistance to Black Sigatoka. An alternative method to reduce poverty could be through diversifying growers' production. This method reflects the 21st century paradigm of food reliance, not food self sufficiency. Households can buy in part of their food requirements in exchange for diverting resources out of subsistence production (PINGALI and ROSEGRANT, 1995).

Three reasons have brought vanilla into the spotlight as a potential crop to help improve banana-grower welfare. Firstly, Uganda has two dry seasons, therefore the benefits of two annual vanilla harvests can be realised, unlike in other export nations. Since vines must be pollinated by hand, adoption favours labour-abundant households, not capital-intensive agribusinesses. Finally, cyclones in 2003, 2004 and 2005 decreased the supply capability of the world's largest producer, Madagascar. These supply shocks have created potential economic opportunities for nations like Uganda to help meet global demand. Multinational companies have begun to seek supply contracts elsewhere, and Uganda is well positioned to increase its share of world trade.

Despite being labour intensive vanilla has the highest gross margin in table 1. This labour intensity may affect uptake decisions if households are not solely profit maximisers, for example, if they value leisure time. Fixed costs of establishing vanilla are 810,000 Ush/acre (ADC, 2004).[1] These costs will have implications for adoption, especially in an environment characterised by missing credit markets. Despite households often requiring credit, up to 40% do not apply due to a lack of knowledge about the application process or because of insufficient collateral (UBOS, 2004). Access to credit usually implies borrowing small amounts of money from friends or relatives (OKURUT et al., 2004). Often these amounts are insufficient in helping cover the costs of establishing vanilla.

Table 1. Ugandan crop gross margins

Crop	Gross margin (000 Ush/acre)
Maize	109
Beans	154
Cassava	198
Coffee	409
Bananas	547
Vanilla	2,200

Source: BAGAMBA et al. (1999) and ADC (2004)

A lack of data makes it difficult to assess production trends. FAOSTAT (2009) data indicate that production remained relatively constant from 1998 to 2004. This contradicts data collected by the Agricultural Productivity Enhancement Program (a United States Agency for International Development (USAID) funded program), who report production increased from 303–845 tonnes between 2000 and 2004 (UEPB, 2005). The source of this reported increase is unclear. In 1995, USAID established an export enhancement program, and this may partially explain the increase. With the USAID program ending in November 2007, the question of how to increase the uptake of vanilla in the absence of donor partnerships brings us to the role of output prices.

Vanilla has recently been plagued by price fluctuations, with Ugandan farm-gate prices varying from 1,440–30,000 Ush/kg between 2001 and 2007 (UEPB, 2005; S. Tamale, personal communication, 2007). Similar vanilla price volatility has been observed in other nations, for example, MINTEN and BARRETT (2008) report farm-gate

[1] Ush denotes Ugandan Shilling.

vanilla prices in Madagascar increased by 600% during 1997–2001, then dropped by 50% from 2001-2002. In 2007 prices of 2,500-3,000 Ush/kg have been reported in Uganda (NYAPENDI, 2009). Global price spikes should, in theory, see increased vanilla production. However, with consumption and product decisions being made simultaneously, and missing markets for credit, price theory may only be one element in our understanding of diversification decisions.

2. Analytical framework

In this section, an agricultural household model, following the key exposition of SINGH et al. (1986), is presented to help examine under what conditions households commence vanilla production. The model has a planning horizon of eight years, corresponding to vanilla's commercial life. Households have a risk-neutral utility function in which utility gains are derived from consuming home-produced bananas, market-purchased goods (M) and leisure time (Z) (equation 1). In period t, utility is discounted by the discount rate (δ), which is set at 30%. This discount rate reflects the high value households place on current consumption (HOLDEN et al., 2005).

$$(1) \qquad \sum_{t=1}^{8} \frac{U_t(Z,M,B)}{(1+\delta)^t}$$

Households are constrained by cash, land area, time and their production technology. The cash constraints differ between years, and are expressed in equations (2). Cash inflows and outflows equate across all years. In year one (t=1) total expenditure on market-purchased goods and agricultural inputs, manure (V) and hired labour (HL), matches sales of the banana marketable surplus (S) plus net labour income (OFL). In years 3–8 the possibility of growing vanilla exists, with Av representing land devoted to vanilla and Va the per acre yield. The effective price received for selling bananas and vanilla is the market price (p_b, p_v) less any transport costs (tc_b, tc_v). The prices of market-purchased goods, manure, hired labour and off-farm labour are respectively (m, v, w_{hl} *and* w_{ofl}).

Set-up costs (I) incurred in the first year of establishing a vanilla plantation are added to the budget constraint. Access to credit is built into the model, with an annual interest rate of r charged on the outstanding loan. Credit availability changes the multi-period budget constraints to equations (2), with the loan size (L_t) declining with time. Each year one-third of the principal is repaid, along with interest owing on the outstanding loan. Payments on interest and the principal are made at the end of each year.

$$
(2)\quad
\begin{aligned}
t = 1 \quad & v\,V + m\,M + w_{hl}\,HL + I + L_t r \\
& = (p_b - tc_b)\,S + w_{ofl}\,OFL + L_t \\
t = 2 \quad & v\,V + m\,M + w_{hl}\,HL + L_t(1/3 + r) \\
& = (p_b - tc_b)\,S + w_{ofl} OFL \\
t = 3 \quad & v\,V + m\,M + w_{hl} HL + L_t(1/3 + 2/3r) \\
& = (p_b - tc_b)\,S + (p_v - tc_v)\,Va\,Av + w_{ofl}\,OFL \\
t = 4 \quad & v\,V + m\,M + w_{hl} HL + L_t(1/3 + 1/3r) \\
& = (p_b - tc_b)\,S + (p_v - tc_v)\,Va\,Av + w_{ofl}\,OFL \\
t = 5, 6, 7 \text{ and } 8 \quad & v\,V + m\,M + w_{hl}\,HL \\
& = (p_b - tc_v)\,S + (p_v - tc_v)\,Va\,Av + w_{ofl}\,OFL
\end{aligned}
$$

In equation (3), T represents the household's time endowment. Available cash rations the amount of hired labour. Time is divided between banana (BFL) and vanilla (VFL) activities, leisure and off-farm work.

$$(3)\qquad BFL + VFL + Z + OFL = T$$

Labour can be hired for either banana (BHL) or vanilla (VHL) activities.

$$(4)\qquad HL = BHL + VHL$$

To reflect the search and travel costs associated with off-farm employment, off-farm wages are set at 90% of the hired labour wage rate (equation 5). HOLDEN et al. (2005) use a similar cost structure. This new price ratio substitutes into the cash constraints.

$$(5)\qquad 0.9 w_{hl} = w_{ofl}$$

The maximum area of vanilla is set to one acre (equation 6). Large-scale vanilla plantations are rarely observed. Fieldwork in Masaka, a Ugandan vanilla growing district, reveals that farms are on average 3.97 acres, with plantations occupying 0.56 acres. The maximum amount of credit that can be obtained equals the cost of establishing one acre of vanilla.

$$(6)\qquad Av \leq 1$$

A Cobb–Douglas technology describes banana production. Three inputs are used to grow bananas: family labour, hired labour and manure, given household technological capabilities (β). Area devoted to banana production is incorporated in β, thus equation 7 represents total output of banana, not per acre yield. Equation 7 states production equals consumption plus marketable surplus.

(7) $$\beta\, BFL^{\beta bfl} BHL^{\beta bhl} V^{\beta bv} - C - S = 0$$

As farming systems in Ntungamo are relatively simple, a Leontief production technology describes vanilla production. In equation (8), *a, b, c, d* and *e* are the production parameters for vanilla's family labour, hired labour, manure, area planted and Ush invested, respectively.

(8) $$Va = Min\left(\frac{VFL}{a}, \frac{VHL}{b}, \frac{VV}{c}, \frac{Av}{d}, \frac{I}{e}\right)$$

The optimisation problem facing households is to maximize intertemporal utility (equation 1) given household constraints (equations 2-8).

3. Study site and data

The majority of data used in this article come from a survey of 70 banana-reliant households in Ntungamo, with the survey being executed by the author in 2006. Prior knowledge of biophysical information suggests that Ntungamo is suited to vanilla production. Annual rainfall of 1,525–1,829mm exceeds the minimum 1,250mm/year that vanilla requires. Fieldwork indicates that soils and temperatures in Ntungamo are suitable for vanilla vines. As Ntungamo households are not currently growing vanilla, data on vanilla are derived from secondary sources (ADC, 2004; BASHIR, 2006) and fieldwork observations in Masaka. The survey targets three sub-counties, with households in each sub-county being randomly selected.

Variables of interest for the agricultural household model are summarised in table 2. Bananas and off-farm wage employment are the households' source of income. Standard deviations reported in table 2 illustrate that households are heterogeneous. Two-thirds of households grow between 3 and 6.2 acres of banana. Household objectives are not purely financial with approximately one quarter of banana production going to home consumption. The average household spends approximately 350,000 Ush each year on hired labour. Seasonal labour shortages and off-farm migration are two reasons for hiring labour. Off-farm employment provides households with 28% of their income, and includes casual work in the non-farm sector and employment on other farms. While labour is hired in, potential exists for labour to return to the farm if new enterprises arise where the opportunity costs of time are low. With bananas comprising 72% of household income, crop failure will have significant impacts on welfare. Beans and millet are also grown to provide alternative sources of calories (both under 5% of total area).

Table 2. Summary of model variables

Variable	Description	Mean	SD
Banana consumption	kg/year/household	4,064	5,080
Banana production	kg/year	18,888	17,277
Marketable surplus	kg/year	14,824	13,140
Area planted	acres	4.6	3.2
Hired labour	hours/year	1,739	1,149
Family labour	hours/year	3,942	1,856
Manure applied	kg/year	530	798
Off-farm labour	% of total	27.9	11.9
Market purchases	million Ush/year	1.8	0.9
Banana price	Ush/kg	154	35.9
Transport costs	Ush/kg	13.3	5.1
Wage rate	Ush/hr	200	50.6
Manure price	Ush/kg	97	111

Note: number of observations equals 70

Source: author´s calculations

Establishment costs, outlined in table 3, are broken into four categories: support trees, vanilla vines, manure and labour. Vanilla and bananas are intercropped in the same plot of land, therefore the number of vanilla trees per acre is scaled back from the monoculture density (625 vines/acre) to the recommended intercropped planting density of 440 vines/acre (ADC, 2004). The total cost of support trees and vines is based on 100 trees and vines, thus per acre costs are the total cost multiplied by 4.4. Manure application is greater at establishment than in subsequent years, with annual manure costs being 83,333 Ush. The 1,500 Ush/day labour wage exceeds wages observed in the field (table 2), with the average day being six hours. Vanilla production requires better skill levels, thus attracting a higher wage rate. Annual operating labour costs are double the set-up labour cost as harvesting, pruning and extra crop maintenance increase labour requirements. Despite limited data and inherent price variability, a farm-gate price of 2,500 Ush/kg is used, consistent with observations in ADC (2004). Each vine yields 1.5kg per year.

Evaluating data in tables 2 and 3 suggests credit may be required to establish vanilla plantations. While concrete evidence on rural Ugandan interest rates is limited, rates of approximately 2.5% per month have been reported (OKURUT et al., 2004). Based on this evidence, an annual interest rate of 30% is used.

Table 3. Vanilla set-up costs

	Amount	Unit cost (Ush)	Total cost (Ush)	Total cost/acre (Ush)
Support tree – *Jatropha*	100	500	50,000	220,000
Vines	100	500	50,000	220,000
Manure			100,000	100,000
Labour planting and cultivating (days)	450	1,500	675,000	270,000

Source: ADC (2004) and BASHIR (2006)

4. Empirical findings

The household effects of two different market and institutional changes are quantified in this section: changing vanilla prices and providing access to credit. Higher farm-gate vanilla prices induce growers to commence vanilla production, and this has significant welfare benefits. However, changes in cropping patterns only occur when vanilla prices double. Access to credit reduces the price rise required to grow vanilla. The model is solved using the What's Best! program. As vanilla data are not household specific, the model is solved for a representative household using the data described in section 3.[2]

4.1 Base case

To permit analysis of different scenarios, data from the survey and secondary sources are used to calibrate the model and establish the base-case scenario. Consumption demands are calculated using a linear expenditure system. Banana consumption is valued at the market price, while leisure time is valued at the off-farm wage rate. The base-case scenario validates that the model is representative of Ntungamo households, with results being representative of observed data (table 4). Households use more family labour than hired labour in cropping activities. Estimated and observed expenditures are similar, 1.6 vs. 1.8 million Ush. Not all income is spent on market-purchased goods, hired labour and manure costs make up the gap between estimated income and market-purchased goods.

[2] Standard deviations in table 2 suggest households may have different responses to changes in vanilla prices and access to credit, however, to focus the analysis on the adoption decision, results are reported for the average household.

Table 4. Base-case scenario results

Variable (per year)	Solution	Variable (per year)	Solution
Manure used (kg)	218	Banana consumption (kg)	3,776
Vanilla produced (kg)	0	Bananas produced (kg)	15,737
Market purchases (million Ush)	1.6	Leisure time (hrs)	1,794
Income (million Ush)	1.9	Labour family (hrs)	2,064
Work off-farm (hrs)	1,439	Hired labour (hrs)	1,292

Source: author´s calculations

Vanilla production does not enter the base-case optimal farm plan (table 4), as households allocate their working time to banana production and off-farm employment. The average household produces 15,737kg of bananas per year and consumes 23% of their production. Daily per capita banana consumption exceeds the national average observed in ROBINSON (2000) (1.8kg and 1.25kg, respectively).

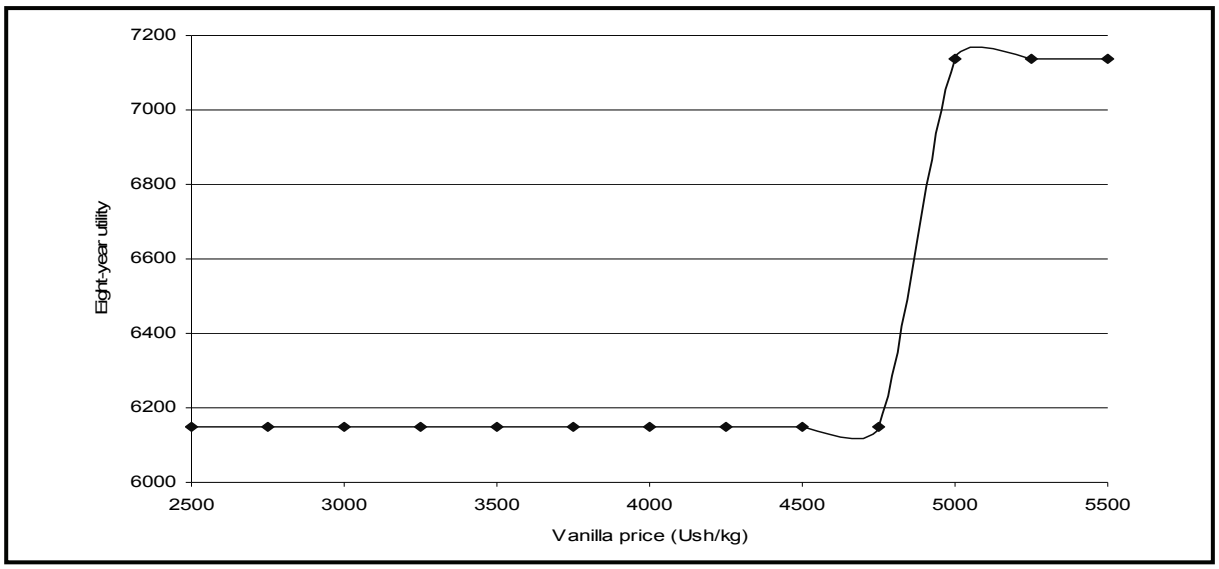
4.2 Vanilla price changes

Vanilla prices are altered from the base-case price of 2,500 Ush/kg to determine how resource usage changes.[3] Changing vanilla prices alters crop production, profits and welfare in a discrete, not continuous manner. Despite lower profits in the first few years, owing to vanilla establishment costs reducing consumption, growing vanilla increases overall household utility by 16% (figure 1). Households only shift their application of inputs towards vanilla production when prices reach 5,000 Ush/kg (figure 1). The discrete shift in production highlights how households do not respond to price changes in a continuous manner. A price must be reach before new crops become viable as the fixed establishment costs must be paid.

At 5,000 Ush/kg labour is substituted from off-farm employment into vanilla production. Labour to grow vanilla is sourced from the family pool, this results in no more off-farm employment. This may increase the price of hired labour (however, endogenous determination of wage rates is beyond the scope of this article). This shift in labour usage implies that the value of labour's marginal product in vanilla production exceeds off-farm wage rates.

[3] Ideally, price sensitivity analysis would be based on household responsiveness when prices move one or two standard deviations from the mean. However, as household prices are not observed, the analysis is restricted to measuring increases from the mean. Growers in Masaka were not selling vanilla, therefore, no vanilla price variability could be captured.

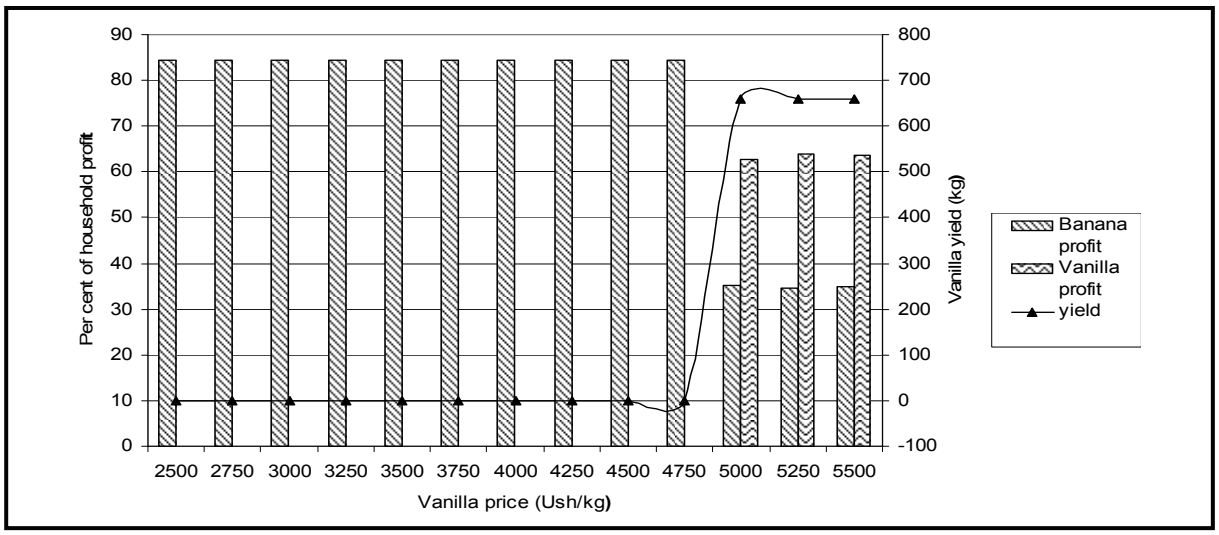
Figure 1. Discounted eight-year utility with varying vanilla prices



Source: author's calculations

Once prices increase from 4,750 Ush/kg to 5,000 Ush/kg vanilla output increases from zero to 660kg (figure 2). This discrete shift in production, from zero to maximum area permitted, illustrates that growers do not respond to price movements in a linear manner. Often a choke price exists for a new enterprise, in this instance it is 5,000 Ush/kg.[4] This shifts the source of farm profits towards vanilla (figure 2).

Figure 2. Changing cropping patterns under different vanilla prices



Source: author's calculations

[4] The responsiveness of households at prices above 5,000 Ush/kg was modeled. Figure 2 illustrates that no extra labour or manure is applied to vanilla at prices above 5,000 Ush/kg.

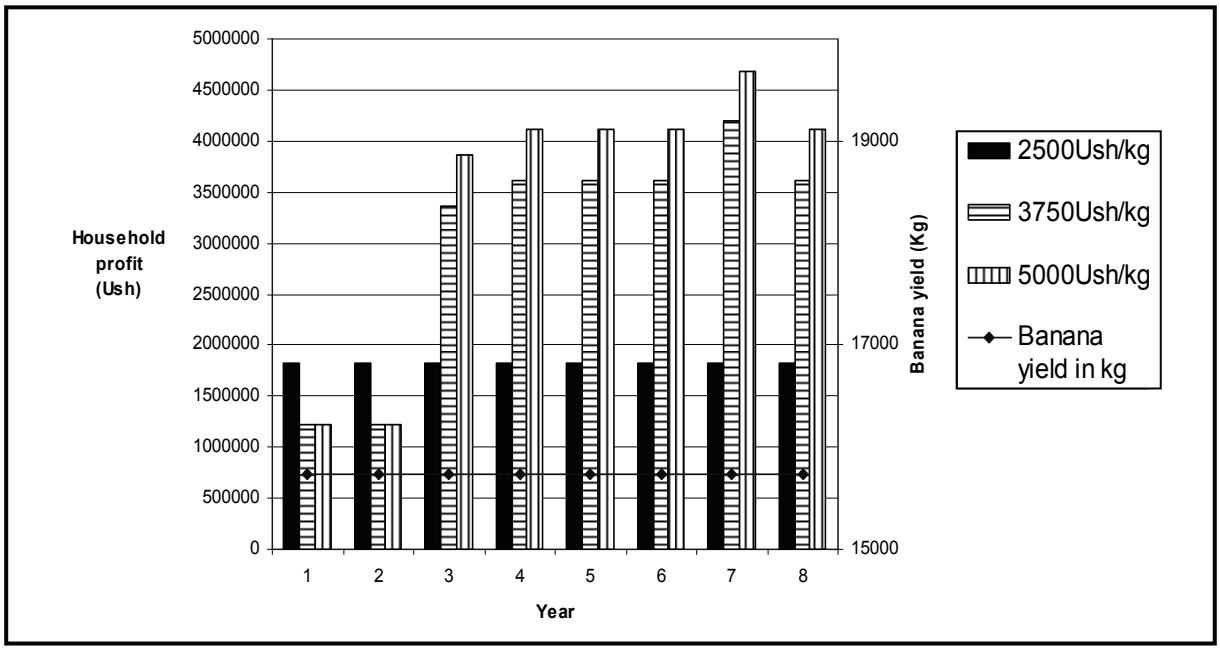
4.3 Credit constraint

In the base case, a credit market does not exist, and establishment costs are funded from internal sources (through reduced consumption of market-purchased goods or additional off-farm employment). Despite reduced consumption negatively affecting utility in early years, the net effect of growing vanilla is positive (figure 1).

To pursue the idea that a lack of credit restricts vanilla adoption, a credit market is introduced. In order to compare the effect that access to credit has on vanilla establishment, prices are increased from 2,500 Ush/kg and are compared to being credit constrained. When households have access to credit, vanilla growing becomes viable at prices above 3,750 Ush/kg, and profits across the eight year period increase by 88% (figure 3). With a missing credit market, prices must reach 5,000 Ush/kg before vanilla enters the optimal plan. Results imply significant changes in household cropping patterns could occur with improved access to credit.

With vanilla being grown in a mixed plot setting, banana production still occurs. Food security issues arising from switching production to non-food crops do not appear to be a concern as banana production does not decline (figure 3).

Figure 3. Household profits and vanilla prices (with credit available)



Source: author's calculations

5. Policy implications

The findings presented in this study hold several implications for the design of welfare improvement strategies. Access to credit and an increase in farm-gate prices will potentially see the estimated gains from vanilla adoption realised. While large price fluctuations in an already volatile market imply caution must be exercised when drawing conclusions from the modelling results, the credit market experiment results can be assessed from a *ceteris paribus* stand point (at a specific price credit affects diversification decisions).

5.1 Price policies

When prices are constant across the eight years and households are credit constrained, the model predicts that vanilla production commences at 5,000 Ush/kg. However, it is evident that inherent price instability exists. If vanilla is commenced under the guise of prices remaining at 5,000 Ush/kg any price reduction will render the initial investment a poor choice. Rather than attempt to stabilise prices, governments can minimise the impacts of price instability through facilitating an effective extension service, with private sector linkages.

Delivering better quality beans is a proactive approach to stimulating price growth, thus raising average returns and providing partial insulation from price shocks. The price effects of production in Madagascar returning to pre-cyclone levels signify improving bean quality should be the strategic focus of policy interventions. Ten exporters and processors meet regularly, as members of the Ugandan National Vanilla Association (UNVA), to set harvesting dates and quality parameters. Field days and training sessions funded and conducted by USAID and UNVA have facilitated improvements in management practices, and hence vanilla quality. The establishment of 60 vanilla demonstration sites exemplifies this work, and a continued operation of these sites will ensure growers have access to knowledge of how price premiums can be obtained. Processors offer higher prices for better quality beans, and one method to achieve quality gains is through harvesting at appropriate moisture content levels. There may be a temptation to harvest beans too early when prices are high. Emphasising the importance of following the Code of Practice for the Vanilla Industry will heighten awareness of the downside of early harvesting, and having beans discounted by European and US buyers.

The benefits of public policy interventions need to be assessed in conjunction with the opportunity costs of diverting government resources. With the exit of USAID, a role has arisen for private or public institutions to provide much needed extension services to the relatively new vanilla industry. With vanilla's high economic value and its well

defined management protocols, private industry could complement public sector policy involvement, and reduce reliance on overseas development aid agencies. Government spending on agricultural research and extension in western Uganda has a low opportunity cost, it has a benefit-cost ratio of 14.7, compared to 3.8 for education and 9.2 for feeder roads (FAN and ZHANG, 2008). Specific training in vanilla production is an area where joint private, public and donor partnerships could emerge with large payoffs. For example, the Ugandan Government could provide grants to the UNVA to increase their extension services and provide post harvest bean analyses. In return a formal commitment to implement specified elements of a vanilla quality improvement strategy would be required.

5.2 Credit

Access to credit smooths consumption as investment costs are spread across three years, and this has implications for the uptake of vanilla. Moreover, the results have broad implications for semi-subsistence households in similar markets throughout the developing world. Results suggest credit markets can help unlock the benefits of growing vanilla.

Formal banks are averse to lending to agricultural households for three reasons: households can not meet bank collateral requirements, high transaction costs are involved in managing a large portfolio of small loans and the uncertain nature of farm incomes makes the probability of payment defaults unacceptably high. This reluctance to lend to agricultural households results in rural households being dependent on informal credit markets. Friends and relatives comprise two-thirds of all informal loans, with non-government organisations and co-operatives comprising 13% and 7%, respectively (OKURUT et al., 2004).

A shift from obtaining credit from friends and relatives to non-government organisations and co-operatives appears sensible. Average loan amounts from friends and relatives are 80,807 Ush (OKURUT et al., 2004), this can cover 0.1 acres of vanilla. Government can play a role in increasing the rural outreach of microfinance institutions. Effective physical infrastructure - roads and communication systems - need to be in place to encourage a greater presence of microfinance institutions in rural areas. Continued support of the Minister of Finance funded Matching Grant Facility for Capacity Building Design Scheme is vital. The scheme could be used to subsidise first year relocation costs for microfinance institutions, thus making relocation a more attractive option. Greater competition between institutions may further increase access to credit by improving institution efficiencies, thus lowering interest rates.

It may be advantageous for individuals to form groups to obtain village loans. In these situations, all members are jointly liable for each others' loans. New group members are not formally screened, and current group members select members of the community to join the group based on whom they will accept liability for. Village banking schemes established through the Foundation for International Community Assistance (FINCA) have been successful in many areas of Uganda, with over 1,000 village banks operating in 2006 (MCINTOSH, 2008). Having specific loan officers employed by local government districts, and by village banking officers employed by FINCA, to raise awareness and facilitate the formation of groups, may improve usage of village banking schemes. These mechanisms aimed at primarily developing credit associations will have the additional benefit of increasing loan sizes, thus potentially enticing lenders to offer lower interest rates.

6. Conclusion

Results suggest more attractive vanilla prices and addressing credit market failures will assist banana growers adopt vanilla. The objectives of Ntungamo's semi-subsistence households create a situation where farmers do respond to market incentives, but still maintain food security objectives. Specifically, in response to increased prices, farmers commence vanilla production by diverting labour from off-farm sources, whilst retaining labour in banana production. In an environment characterised by vanilla price volatility and missing credit markets, addressing banana productivity will be critical, however any long-term strategy focused on improving bean quality and providing access to credit will assist in crop diversification efforts. It is hoped this article will stimulate further analysis of the complex interactions between risk aversion, price volatility and household investment decisions.

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