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The role of risk in shaping production decisions: an empirical analysis

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Abstract

This paper uses data on risk preferences and perceptions of risk collected through hypothetical questions in combination with more traditional measures of a households' ability to deal with risk to identify the impact of risk on production decisions. Contextualized hypothetical questions on risk preferences and risk perceptions were collected along with standard socioeconomic survey for 300 coffee-farming households in Uganda. This data is used here to show both that data collected from hypothetical questions can be usefully utilised to understand a household's behaviour under risk in real settings, and that risk has a significant impact on the production decisions of poor coffee farmers in Uganda.

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1 Introduction

The importance of risk in determining individual behaviour and welfare is often acknowledged. Eswaran and Kotwal have shown that for a given degree of risk aversion, under-investment in risky production activities will be greater for households who are more constrained in their consumption smoothing activities (Eswaran and Kotwal 1986); and this theoretical finding is the basis for studies in which involvement in risky production activities is compared across households with different abilities to smooth consumption (Morduch 1991; Rosenzweig and Binswanger 1993; Dercon 1996).

Whilst it is the role of constraints that is ultimately of concern and of policy interest (Zimmerman and Carter 2003), the reliance on measures of wealth to identify the impact of risk in many contexts is problematic as it is not fully possible to deal with the endogeneity issues entailed in identifying the causal relationship between a measure of wealth and production decisions. An unobserved preference for risk will affect not only current production choices, but also past production choices and thus the asset-wealth of a household (given the higher return expected from high risk activities), causing a household's ability to deal with risk to be endogenous to production choices. Only if an innate measure of risk preferences is also included can this endogeneity problem be solved.

Data on risk preferences, however, are usually collected using university students in laboratory settings with little reference to real world behaviour. Risk experiments have been successfully used in the field to determine risk preferences (Binswanger 1980; Wik and Holden 1998; Humphrey and Verschoor 2004) but the focus of these studies has in general been examining the outcome of the experiment rather than using this data to understand behaviour. An example of an exception to this are studies by Barr and Packard on risk aversion and pension behaviour in Peru and Chile (Barr and Packard 2002; Bar and Packard 2005).

This paper uses data on stated risk preferences and perceptions of risk to identify the impact of risk on production decisions made by poor households. Stated preferences on loss aversion, trust and time preferences collected through hypothetical questions have been used to explain real world behaviour in Fehr and Gotte (2002), Karlan (2005) and Ashraf et al (2006) respectively. Additionally Nyarko and Schotter have shown that stated beliefs can be a good predictor of actual behaviour (Nyarko and Schotter 2002). Data on the risk preferences and perceptions of Ugandan coffee farmers was collected through hypothetical questions in addition to a standard socioeconomic survey. This paper shows these questions yield data that behave as the theory would predict in explaining farmers' production choices, and that these measures are strongly significant in explaining the share of labour allocated to risky crops.

Questions concerning the validity of data collected on risk preferences using hypothetical questions have been raised in the past. If risk taking is socially desirable respondents have a non-financial goal to appear risk-loving which can be countered by the introduction of real incentives. In their literature review Camerer and Hogarth (1999) found three studies (Camerer 1989; Cox and Grether 1996; Loomes and Taylor 1992) in which there was no significant difference between choices of lotteries when monetary incentives were introduced; five similar studies in which respondents were more risk averse with payoffs (Beattie and Loomes 1997; Battalio, Kagel, and Jiranyakul 1990; Cubitt, Starmer, and Sugden 1998; Slovic 1969; Schoemaker 1990), and two in which respondents were actually more risk seeking when monetary payoffs were introduced (Edwards 1953; Grether and Plott 1979). However, they concluded that if there was an effect to offering incentives it was to increase the level of risk aversion reported.

Looking at studies which have offered both real and hypothetical payoffs to farmers in developing countries, it is not clear that the resulting estimates of risk aversion are biased. Binswanger found measures of risk aversion calculated from hypothetical choices were more dispersed than measures of risk aversion calculated from the experimental game (Binswanger 1980, p.398). This suggests measurement error is indeed reduced when real payoffs are used. However, interestingly, Binswanger finds no bias from posturing in the hypothetical responses: respondents believed they would act more or less aversely to risk than they actually did in the real game.

Binswanger's most critical statements on the use of hypothetical questions came from comparison of a different type of hypothetical questions asked to the respondents (a more complex questioning first used in Brazil by Scandizzo and Dillon (1979)). This debate highlights care has to be taken in the careful contexrtualisation and implementation of hypothetical questions on risk, but it does not rule out its use altogether.

There is already some empirical evidence that hypothetical questions on risk correlate as expected with risk taking behaviour (Barsky, Juster, Kimball, and Shapiro 1997; Feinerman and Finkelshtain 1996; Knight, Weir, and Woldehanna 2003). These studies determine whether there is a correlation between risk preferences and behaviour, but the focus is not to present an empirical model of risk-taking behaviour under uncertainty. In particular, a household's ability to deal with risk is not controlled for (Morduch 1991; Dercon 1996) nor a household's perception of risk in a given activity. This paper uses data on risk preference and risk perceptions to determine whether they influence individual behaviour as a model of labour allocation under risk would predict, in particular recognising that the ability of a household to deal with risk is crucially important in determining how preferences affects behaviour.

The paper proceeds as follows. A simple model of production under uninsurable risk is considered and its application to the context of this paper – the share of labour households allocated to risky coffee production – is presented in the next section. In the third section the data to be used in analysis is described. In the fourth section the basic results of this paper are discussed. The penultimate section discusses some robustness checks and the final section concludes.

2 Modelling crop choice under uncertainty

Bardhan and Udry show that in the absence of fully functioning credit and insurance markets the preferences and wealth of a household, as exemplified in the concavity of the value function, and the liquidity constraint a household faces becomes important in determining production decisions (Bardhan and Udry 1999). In this model consumption expenditure is allocated from current cash in hand which is given by the real value of assets the household holds, A_t, and the crop income accruing to the household as a result of the production decisions made in the previous period, Π_t. The amount from total resources that is withheld for future consumption is denoted by w_t. The return to w_t is certain and given by $w_{t+1} = (1 + \tau)w_t$. The household is assumed to be credit constrained such that w_t cannot fall below 0.[1]

Crop income is determined by the realization of a zero mean independent and identically distributed shock, θ_t, the share of labour allocated to a risky crop, r_t, and the total level of labour allocated to crop production, L_t. The average rate of return to labour allocated to the risky crop is higher than the average rate of return to labour allocated to other crops, but the variance is also higher as it is affected by the shock, θ_t, to a greater extent. When a positive shock is realised, allocating a higher share of labour to the risky crop increases crop income, whilst when a negative shock is realised allocating a higher share of labour to the risky crop decreases crop income. The production function can thus be written as $\Pi_{t+1} = \pi(r_t, \theta_{t+1})$ where $\pi'_\theta > 0$ and $\pi'_r > 0$ if $\theta > 0$ and $\pi'_r < 0$ if $\theta < 0$.

The value function for the household is thus given by

$$V_t(A_t+\Pi_t) = \max_{w_t, r_t} u(A_t+\Pi_t-w_t, L_t)+\beta E_t V_{t+1}[(1+\tau)w_t+\pi(r_t, L_t, \theta_{t+1})]+\lambda_t^w w_t+\lambda_t^{r0} r_t+\lambda_t^{r1}(1-r_t) \tag{1}$$

where λ_t^w is the Lagrange multiplier corresponding to the liquidity constraint in period t. Consumption in period t will be chosen to satisfy:

$$-u' + \beta(1 + \tau)E_t[V'_{t+1}] + \lambda_t^w = 0 \tag{2}$$

[1] Access to a limited amount of credit can also be allowed for in this model by assuming that w_t cannot fall below an amount B determined by how much the household can borrow. The question of importance here is whether or not the credit constraint is binding.

with complementary slackness between w_t and k_t. By the envelope property r_{t-1} will satisfy

$$E_{t-1}[V_t'] = E_{t-1}[u'\frac{\partial \pi}{\partial r_{t-1}}] + \lambda_t^{r0} - \lambda_t^{r1} = 0 \tag{3}$$

which substituting for $u\prime$ from Equation 2 gives

$$E_{t-1}[[\beta(1+\tau)V_{t+1}' + \lambda_t^w]\frac{\partial \pi}{\partial r_{t-1}}] + \lambda_t^{r0} - \lambda_t^{r1} = 0 \tag{4}$$

This contrasts with a pure profit maximising outcome which would be given as $E_{t-1}[\frac{\partial \pi}{\partial r_{t-1}}] + \lambda_t^{r0} - \lambda_t^{r1} = 0$ in two ways: the presence of the curvature of the value function (V_{t-1}') and the presence of the parameter that reflects when liquidity constraints bind (λ_t^w).

First let us assume there is no binding credit constraint and consider how the curvature of the value function affects labour allocation. If there was no uncertainty Equation 4 would simplify to $\frac{\partial \pi}{\partial r_{t-1}} + \lambda_t^{r0} - \lambda_t^{r1} = 0$ and r_t would be chosen so as to maximise crop income as per the pure profit maximising outcome.[2] Sandmo has shown that when uncertainty is present, a source of uninsurable risk in production will cause the producer to spend less effort on risky production (Sandmo 1971). Production decisions depart from the profit maximising allocation as the concavity of the value function increases. The concavity of the value function is in part dependent on the concavity of the household's utility function. As exemplified by the Arrow-Pratt measures of absolute and relative risk aversion, the greater the household's risk aversion the higher will be the concavity of the utility function. However, the value function of a household will in general be less concave than its utility function. If the household does not hold any assets nor has access to a market for assets, such that it cannot transfer income from one period to the next, the concavity of the value function is equal to the concavity of the utility function, but the more a household can disassociate consumption from income earned in one period

[2] As we have assumed there are no decreasing returns to scale in the production of the risky crop this would imply the corner solution of $r_t = 1$ would be the chosen given the average return to labour allocated to risky crop production is higher than the average rate of return to safer crop production.

through intertemporal transfer of resources the flatter the value function becomes with respect to current income (Deaton 1991). When households can transfer resources from period to period without limit, the value function becomes flat and households make production decisions without reference to consumption preferences i.e. Equation 4 simplifies to $E_{t-1}[\frac{\partial \pi}{\partial r_{t-1}}] + \lambda_t^{r0} - \lambda_t^{r1} = 0$ (still assuming there are no credit constraints) which is the profit maximising outcome when uncertainty is present.[3] Thus Zeldes shows that even for households with utility functions that display constant relative risk aversion, the curvature of the value function will depend on wealth (Zeldes 1989).

Binding liquidity constraints have an additional effect on the choice of r_t. Bardhan and Udry show that households who believe their liquidity constraint may bind in period t take fewer risks - i.e. choose a lower r_t - than households who believe their credit constraint will not bind in period t, at the cost of lower average return (Bardhan and Udry 1999, chapter 8).

This discussion suggests that the choice of how much labour to expend on coffee production will be a function of risk preferences, wealth, access to credit and expectations about the risk of crop production (in particular the risk that crop production will cause a household to go below its credit constraint). This gives rise to the following reduced form:

$$r_t = \alpha W_t + \gamma(W_t * P) + \eta\theta_t + \varepsilon_t \tag{5}$$

W_t denotes the wealth of the household. Entered linearly it reflects the degree of the credit constraint experienced by households. When interacted with risk preferences, P_t, it reflects the concavity of the value function. θ_t refers to expectations about uncertainty surrounding risky production activities.

We have assumed that in any given period the rate of return to labour allocated to the risky crop is independent of the decision of how much of the risky crop to grow in a given period.

[3] Risk neutral households will also have a flat value function and will thus also choose r_t solely on the basis of $\frac{\partial \pi}{\partial r_{t-1}}$.

Whilst this seems like a reasonable assumption for an annual crop this may not necessarily be the case when the risky crop is a perennial such as coffee. For a perennial crop the long lag between planting perennial crops and realising yields causes the return to labour allocated to a perennial crop in period t to be set by production decisions made in prior periods. This dependence creates a diminishing return to both time allocated to perennial crop production (as new trees have to be planted and are unproductive in the current period) and time allocated to non-perennial crop production (as existing trees have to be removed before non-perennials can be planted in the current period). The correct reduced form when the risky crop is a perennial is thus given by

$$r_t = \alpha W_t + \gamma(W_t * P) + \eta\theta_t + K_t + \varepsilon_t \tag{6}$$

where K_t is the vintage stock vector (the number of trees of each vintage: the return to labour depends on both the number and age of the trees[4]) at time t. For now we assume the choice of K_t is an exogenous decision to the decision to the choice of r_t, however this assumption is relaxed in Section 5. Including K_t also has the advantage of controlling for any unobserved preference for producing coffee which in impacting both r_t and W_t (given the high return to coffee production) would render W_t endogenous.

The next section describes the context and data for the analysis. It first suggests why coffee in Uganda is a suitable context to test the above relationship. It then describes the data used to test the relationship in Equation 6.

3 Coffee production in Uganda: the context and data

For coffee-producing households in rural Uganda, coffee is a relatively risky yet high return production option in the standard portfolio of crops. Coffee production is characterised by a

[4] In Uganda coffee trees become productive three years after they are planted and stay productive for up to seventy or eighty years, although a tree's yield potential falls after thirty to forty years (UCTF 2002 and Magambo 2000).

very low technological level, with a low use of purchased inputs, and limited use of modern farming methods such as irrigation. The costs of production, amounting mainly to labour and land costs, are estimated to be around $0.10 per kilo.[5] The average price for a kilo of unmilled coffee post coffee market liberalisation in 1991 is $0.30 (in 2001 prices), which suggests an average return of $200 per hectare. The return to matooke production, a banana-like staple produced by the majority of households in Uganda, is calculated as $150 per hectare using information in Bibagambah (1996). However, although the average price of coffee since coffee market liberalisation is $0.30, there is a large degree of variation in this price as Figure 1 shows - much more so than for other crops. During the period in which data was collected the median price recorded for a kilo of unmilled coffee was $0.16 which implies a per hectare return of about $60.

Although coffee production was always somewhat risky (both in the return received and the fact that producing coffee subjected farmers to the food crop market), there has been an increase in price variation as a result of market liberalisation in 1991. The coefficient of variation of the farm-gate price increased from 0.38 pre 1991 to 0.62 after, compared with the coefficient of variation of matooke price of 0.25 and the coefficient of variation of the sweet potato price of 0.28 during this time. Additionally yield risk has increased in the last decade as a result of the spread of coffee wilt disease. A survey carried out by the Ugandan government in 2003 revealed coffee wilt had affected almost half of the area planted to Robusta coffee (Munyambonera 2004). Once a tree is infected with coffee wilt disease it withers and dies, so the threat of infection poses a considerable source of uncertainty in yields. Whilst the threat of disease is substantial, data on diseases which affect other crops is not available making it impossible to say definitively

[5] The Uganda Coffee Development Authority provides some estimates of the costs of growing coffee, which allows us to calculate the return to coffee production for an average farmer. The data used comes from sensitivity studies conducted by UCDA throughout 2001 in which farmers in Masaka, Bushenyi and Kiboga regions of Uganda were interviewed. The UCDA estimates the cost of man labour to be 1,500 Ugandan shilling per day and the cost of inputs (unspecified) to be 30,000 shillings. Estimates suggest 100 days of man labour are needed to produce 1,000 kilos of kiboko (unmilled coffee) from one hectare of land. The cost of land was not factored into the UCDA analyses, but Deininger and Mpuga (Deininger and Mpuga 2002) state the rental price per hectare to range between 3,500 and 11,000 shillings for the regions of Uganda sampled in the UCDA survey. The calculations here use the UCDA estimates and estimates of the rental price of land per hectare from Deininger and Mpuga (2002)

that coffee yields are more subject to uncertainty than yields of other crops. On the basis of price risk and in the presence of substantial yield risk there is a case for assuming the return to coffee is more volatile than that of other crops. This makes it suitable for consideration as a risky and high return crop in comparison to other crops grown by Ugandan farmers.

Data on production decisions, risk preferences, perceptions of risk and wealth was collected for 300 Ugandan coffee farmers at the beginning of 2003 . This data is used to determine how well hypothetical preference and perception data can explain real production behaviour of farmers under risk. Data was collected in four districts in Uganda (Mukono, Luwero, Masaka and Bushenyi) that combined are responsible for about 50 percent of Robusta coffee produced in Uganda. The sample of coffee producers was drawn randomly from a sampling frame constructed from coffee farmers identified in the 1999/2000 National Household Survey. As the period between the baseline and the follow up survey was relatively short, there was little attrition resulting from death or migration. Most households were still in existence within the village and it was relatively easy to trace them.[6]

Summary statistics of the data used in this analysis are presented in Table 1. The majority of coffee grown in Uganda is grown by small holders, and this was true for this sample also, with more than two-thirds of the households owning land less than or equal to five acres. Heads of coffee-producing households tend to be older than the national average, at 50 years. The mean level of education of household heads is 5 years. Most households have had a problem with coffee wilt disease in the last few years and on average a quarter of trees have been lost.

The share of labour going to coffee production was calculated using questions that asked households to report the time allocated to crop production in total (in days) by household members and paid labourers; and the time allocated to coffee crop production (in days) by household members and paid labourers.[7] Although the data analysis focuses on explaining the

[6] The data were collected by a team from the Uganda Bureau of Statistics in collaboration with the Centre for the Study of African Economies at Oxford University. Funding was provided by the World Bank.

[7] Given the allocation of labour to coffee production is to some extent seasonal, it is possible that the household's response to this question depends on when the interview was conducted. Although all interviews were conducted at the same time of year, the timing of the coffee season varies across the regions. To test for this labour share

share of labour allocated to coffee production, regressions using the share of revenue coming from coffee as dependent variables are also conducted. The share of revenue from coffee production was calculated by the share of crop income (from produce sold at market and consumed at home) coming from coffee. To the extent revenue from coffee in a given period is dependent on labour share, a similar pattern should be observed, although the dependence of revenue share on realised price and yield might weaken the hypothesised relationship.

A measure of wealth is used to proxy for a household's ability to smooth income shocks. If credit and insurance markets are incomplete, as we expect in rural Uganda, a household's ability to deal with fluctuations in income will depend on its wealth - both as a means to insure itself and to facilitate access to the limited credit market that does exist. A measure of liquid and land wealth per household member is used; and the log of it is taken to minimise the impact of outliers on the results. Land wealth is included as studies have shown land markets to be active in rural Uganda (Deininger and Okidi 2001; Baland, Gaspart, Place, and Platteau 2001).[8] The number of people that can be asked for financial help in a time of need is also included as a regressor to capture access to informal borrowing not picked up by this per capita measure of wealth.

To measure the vintage stock vector, K_t, the number of trees of each vintage is needed. Whilst the number of trees of each specific vintage was not recorded in the survey, the total number of trees, number of trees too young to produce, and number of trees at the end of their productive life were recorded, which allows an approximation to be made. The number of trees held was weighted by whether they were too young to produce (weight of zero), productive (weight of one), or at the end of their productive life (weight of 0.5).

was regressed on length of time since last sale. If proximity to harvest time inflates the time household's report allocating to coffee production this should be significant and negative, however it was not found to be significant. The sample was also split into two groups reflecting the two seasonal patterns of the regions sampled, and tests of significant difference in mean labour allocated across the two groups computed. A significant difference was found. This could be attributed to many factors that vary between regions in addition to season as indicated in the discussion below, but is controlled for in the analysis by the inclusion of regional dummies.

[8] Regressions were also run using a measure of wealth that did not include land wealth but this did not alter the qualitative results (although wealth became less significant).

3.1 A measure of risk preference

To provide a measure of risk aversion for the analysis farmers were asked to choose among five lotteries offered to them. Data from the choice of lottery was used to classify farmers as more or less risk averse. The choice of lotteries method was used as it was simple for the respondent to understand and the use of a constant probability of 0.5 avoids some of the problems associated with heterogeneity in the application of decision weights. The lotteries offered increased in mean and spread such that each successive lottery represented an increase in risk. The lotteries offered were given contextual specification to encourage the farmer, as much as possible, to reveal his preference for crop income risk relevant to the production choices being considered. The lotteries offered to the farmer increased in mean and spread in the same manner for each contextual specification. Preference data was collected for coffee yield and price risk and also for matooke yield risk. The questions asked which of the following the farmer would prefer (using the example of coffee prices):

> a coffee price that gave 6, 000 shillings per 20 kilos of kiboko (unprocessed coffee) every year; 5,400 shillings with probability 0.5 and 9,600 shillings with probability 0.5; 4,800 shillings with probability 0.5 and 12,000 shillings with probability 0.5; 2,400 shillings with probability 0.5 and 18,000 shillings with probability 0.5; or 0 shillings with probability 0.5 and 24,000 shillings with probability 0.5.

The current farm-gate price for twenty kilos of kiboko at the time of the survey was 6,000 shillings ($0.16 per kilo). Visual aids were used depicting the different options offered to the farmer, to make it easier to understand the options offered and easier for a choice to be made.

Table 2 indicates the mean and variance of each lottery, and the risk preference parameters associated with each choice[9]. The option chosen by the median coffee farmer was option 3 for

[9] Following Binswanger, a constant partial risk aversion utility function of the form $U(Y) = (1 - S)Y^{(1-S)}$ was used to calculate a range of relative risk aversion compatible with each choice. To compute a unique value of S for each alternative, the geometric mean of the two endpoints was used (because as the interval length decreases the alternatives get more risky) except for the most risky alternative which has an endpoint of 0 (assuming no

the lottery specified in terms of coffee price risk and option 2 for the lottery specified in terms of coffee and matooke yield risk. This suggests an average risk aversion parameter similar to that in other studies coming from the coffee price risk question, but higher than other studies for the response to the yield questions. The option chosen by the median farmer in the Binswanger (1980, 1981) study is comparable to option 3. An analysis of the covariates of the measured risk aversion suggests the measure covaries as the literature would suggest with wealth, measures of social capital and past shocks to the household, although the significance of its covariance with wealth is weak (Hill 2005).

The data on risk preferences enters the analysis both as a calculated parameter and as a categorical variable. When it is entered as a categorical variable, a test of joint significance across all categories is performed. The questions remained hypothetical given survey budget considerations. There may thus be some concern that the data collected suffer from a high degree of measurement error. This issue is discussed in more detail in Section 5 and some robustness checks performed. Perhaps a greater cause for concern is the extent to which data collected on risk preferences, whether from questions with real or hypothetical payoffs, capture a household's innate preference for risk or some combination of innate preference and ability to deal with risk. It is unclear whether data from questions on risk preferences provide a measure of the concavity of a household's utility function or the concavity of a household's value function. As a first cut at analysis we assume that the data collected is a measure of the concavity of a household's value function, and include them in the regressions linearly, rather than interacted with wealth as is necessary if they measure innate risk preference. This assumption is relaxed in Section 5.

farmer was risk loving) and so the arithmetic mean was used. For the no risk option, the value of the lowest endpoint was used as the unique value of S.

3.2 A measure of risk perception

Farmer perceptions of relative returns and their variability are also important in determining input allocation decisions. To capture heterogeneity in households' beliefs about the distribution of the future coffee price, data was collected on household's expectations about the future price. Respondents gave an idea of their expected distribution of the price of coffee in six months (July 2003) and in three years through the following exercise. The respondents were given twenty beans and a handout marked with three squares of different price categories (less than \$0.10 (200 shillings), between \$0.10 and \$0.20 (between 200 and 400 shillings), and more than \$0.20 (400 shillings)). They were asked to place beans on the squares in accordance with what they thought was the chance of that outcome. If the respondent thought one option was very likely they were instructed to put many beans on the corresponding square, if the respondent thought the option was unlikely they were instructed to place few beans there. So for example if the respondent was sure the price was going to rise in the next six months and felt sure that she would receive at least \$0.20 per kilo for her coffee in July she would place all her beans on the square marked more than \$0.20. If the respondent could not predict at all what the price would do, she would place the beans evenly among the squares. Once the exercise had been explained to the respondents, they found it easy to place the beans.

Estimates of the mean and variance of the farmer's beliefs about the future price distribution were calculated from the response to these questions.[10] The average expected price in 6 months was (standard deviations in brackets) \$0.22 (\$0.06) and the average expected standard deviation of the price was \$0.08 (\$0.06). An analysis of this measure suggests the estimates of future return and variance vary as a result of past experience of the coffee price and access to price information (Hill 2005).

[10] For each farmer the beans were split into seven 100 shilling intervals from 100 to 800. A common lower and upper limit was placed on the data. The class mark for each of these 100 shilling classes was taken as the midpoint of the class. The mean was calculated as $\sum_{i=1}^{7} f_i x_i$ where x_i is the given class mark for class i and f_i is the probability the price would fall into this class, and the variance as $\sum_{i=1}^{7} (x_i - \overline{x})^2 f_i$.

If perceptions about the future price of coffee are not stationary or are stationary but distributed such that the higher moments of the distribution are non-negligible, moments of the distribution other than the mean and variance will be important in explaining risk behaviour. In addition, a number of studies (Kahneman and Tversky 1979; Shahabuddin, Mestelman, and Feeny 1986) have suggested that downside risk is particularly important in affecting behaviour under uncertainty. As an alternative measure of perceived risk we calculate the perceived probability that risk falls below $0.10 per kilo and use this in explaining crop choice. As $0.10 is approximately the average cost of producing one kilo of coffee, this approximates the perceived probability of a negative return to coffee production.

Coffee wilt disease has significantly affected expected coffee yields in the last few years. Areas that have recently experienced disease are more likely to be infected again, and certainly households in those areas are more likely to perceive a future risk, so we might expect past experience with the disease to impact expectations about its future prevalence and future expected yields. The number of trees cut down or abandoned as a result of disease in the last three years is included as a measure of exposure to coffee wilt disease under the assumption that the higher a household's exposure to disease in the past, the lower expected future yields will be. However only when K_t is included in the regression can the impact of coffee wilt disease on beliefs about coffee yield be separated from the impact of coffee wilt disease on tree stocks.

3.3 Controls and Specification

Various controls are included in all regressions. Although technology is assumed constant across households, if coffee production is more or less labour intensive than other crop production and markets are not perfect for either labour or land, technological considerations will be of importance in determining portfolio choice. To allow for this a land to labour ratio is included in the regression (measured by a ratio of total cultivatable land owned to available household labour[11]). Regional dummies are used to account for agro-climatic differences in regions and for considerable geographic variability in the crops grown with coffee (Pender, Jagger, Nkonya, and Sserunkuuma 2004). Distance from the nearest market is also included to control for differences in crop prices resulting from differential market access. Traditional cash crop production in some countries is favoured by men rather than women and some research suggests gender may also be correlated with risk preference (Barsky, Juster, Kimball, and Shapiro 1997; Wik and Holden 1998). As such it is important to account for gender of the household head in the analysis. Age has been shown to be correlated with risk taking behaviour and in Uganda there may be a higher perceived return to coffee production among older household heads for whom the traditional status of coffee is still important. Age of household head is also included in all regressions.

Section 4 presents results from the empirical analysis. Because the sample contained only coffee farmers, the results are only representative of coffee farmers in Uganda. Also because of this few corner observations (where the share of coffee produced equals zero) were observed, and a Tobit specification is not needed. In all regressions standard errors are controlled for clustering at the village level. Clustering is observed in the data at the village level as households from the same village are likely to be more similar each other than households from different villages. Also, enumerators varied across villages causing cluster specific measurement error to occur.

4 Empirical results

Before turning to multivariate regression analysis non-parametric results examining the relationship between the portfolio decision and two of the variables of interest - wealth and risk preference - are presented. First, the log of per capita liquid wealth was regressed non-parametrically on the share of labour allocated to coffee production and the share of crop revenue coming from coffee production. Results for the two relationships are shown in Figure 2. Both show an in-

[11] Taken as 312 days multiplied by the number of household members older than 14 and able to work.

creasing relationship between wealth and portfolio allocation to coffee. For the share of labour allocated to coffee the relationship is constant across all levels of wealth, for revenue share some non-linearity seems to be present.

Second, Table 3 shows how the mean share of labour and revenue allocated to coffee production varies across different risk preference categories. Results are presented for two of the three risk preference measures coming from questions on coffee price and coffee yield respectively. For both labour and revenue share it appears that both risk averse and risk loving households are less likely to hold a high share of coffee in their portfolio. This might be a result of not controlling for other explanatory factors, but it may also be an indication that whilst coffee production is risky, it is not the most risky production activity available to farmers. Examining the other crops grown we see that farmers who responded as most risk-loving are more likely to grow pineapples, tomatoes and other garden vegetables. A nonparametric test for the existence of a trend across ordered groups was performed using a nonparametric test developed by Cuzick(1985). The average P compatible with the option chosen was used as the score. The null hypothesis of no trend was rejected at 5% for labour share and revenue share using data from coffee price lotteries and at 1% using data from coffee yield lotteries. The sign on the z-value of Cuzick's test of trend suggests overall a negative trend between risk aversion and coffee production.

Turning now to multivariate analysis, results from cross-sectional reduced form regressions are run using labour share as the dependent variable and are shown in Table 4. Dummies reflecting the household's choice of lottery (column 1) are positive and jointly significant, however the coefficients do not increase linearly as the model would suggest - a similar pattern to that observed in Table 3 is present in that both risk neutral and risk averse farmers devote a lower share of labour to coffee production. From columns 1 we also see the impact of options 2 to 4 are not significantly different from each other. This remains true for the regressions that follow, so in the following regressions these categories are collapsed and three categories of farmer are considered: those who are most risk averse (the omitted category), those with moderate risk aversion, and those who are minimally risk averse or even risk loving. When entered like this (columns 2 and 3) we still observe less risk averse farmers producing more coffee, but again this is only significant for farmers with moderate risk aversion. In column 4 risk preferences are entered as the calculated coefficient of risk aversion. This is significant and negative as expected.

Wealth in these regression reflects the household's ability to access credit and also controls for the household's ability to deal with risk. Wealth is also positive and significant which indicates that households that are more able to smooth consumption through intertemporal transfer of resources and households that are more able to access credit devote a higher share of labour to coffee production. The measure of access to informal borrowing (number of people that can be asked for financial help if a serious problem arises) is not significant in any of the regressions.

The data on expectations about the future variability of the price allow us to look specifically at the effect of a household's beliefs about the riskiness of coffee income on its portfolio decisions. The future expected price was found to be insignificant in all regressions (perhaps indicating that a measure of the expected relative return to coffee production would be more appropriate) and whilst the coefficient on variance is negative as expected, it is insignificant. The results in columns 1 and 2 of Table 4 are typical of results in other specifications using these measures. However when the perceived probability of the price falling below $0.10 is used instead (columns 3 and 4) a significant relationship between perceptions and behaviour is observed. This is a consistent result across different model specifications. Downside risk appears to be very important in explaining labour allocation and regression results using this measure of perceived risk are presented from now on.

A household's experience of coffee wilt disease in the last three years negatively affects its allocation of labour to coffee production. Given the household's reduced capacity to produce coffee as a result of wilt is controlled for by the inclusion of K_t this may be because it captures household beliefs about future yield risk.

Results using revenue share as a dependent variable are also estimated (Table 5) as a robustness check and are similar to the results for labour share, with one exception. Expectations about the riskiness of the future price are not significant in any model specifications using either perceived variance or perceived probability of a negative return. Barring this exception the results tell a consistent story. The concavity of a household's utility function does affect a household's decision of how much coffee to produce. Additionally, perceptions of risk seem to be important in determining labour allocation. Two robustness checks are considered in the next section.

5 Robustness checks

5.1 Endogeneity of K_t

The dependence of current output on past inputs is a central characteristic of perennial crop production. K_t is the cumulative outcome of previous periods' investment of land and labour in coffee production through uprooting, cutting down and planting new trees. As a result production can be described by the following structural model where I_t represents investment and disinvestment decisions made in period t, x_t is the shock to the number of coffee trees in period t as a result of coffee wilt disease, and K_0 is the initial stock of trees inherited by the household:

$$r_t = f(W_t, P, \theta_t, K_t) \tag{7}$$

$$K_t = g(I_{t-1}, x_{t-1}, ..., I_{t-N}, x_{t-N}, K_0) \tag{8}$$

N is a finite number of years beyond which point investments made in the stock of coffee trees has no bearing on the status of the stock in a given period.

Thus far we have assumed that decisions made in previous periods are exogenous to the decision made in the current period - i.e. that N is sufficiently long to ensure that the factors affecting K_t are separate to those affecting r_t. For Ugandan coffee farmers many trees are very old - up to 40 or 50 years - and anecdotally households do not cut down trees when the price falls, but keep them in case the price rises. Over the past few years there has been little new planting observed and changes in stocks of coffee trees have been driven more by wilt disease shocks than investment. These empirical observations indicate that perhaps production capacity is set much earlier for these households, at a very different time. If this is the case, the assumption that K_t is exogenous may be a valid one.

However, if we assume N is sufficiently short so levels of wealth do not change much between $t-N$ and t; that there is little impact to the stock of trees held from coffee wilt shocks, and that perceptions about the future price distribution do not change much over time then the factors that affect K_t and r_t will be the same (assuming also that P does not change over time). In this case the correct reduced form regression of r_t will be given by Equation 5.[12]

A third scenario lies between these two extremes. While some production capacity may be dependent on shocks to wilt disease and K_0, there may be some investment in K_t made as a result of risk preferences, wealth and price perceptions still relevant to the choice of r_t. As a result there may be some degree of simultaneity between K_t and r_t. In this case we need to include K_t and instrument for it - i.e. estimate the structural model described in Equations 7 and 8.

Ideal instruments for K_t would be the stock of coffee trees inherited or held in 1992, before the price structure of coffee changed due to liberalization, and values of θ_t and W_t since then (still assuming P is constant across time). In the absence of this data, the year of acquisition of the plot of land on which coffee is grown is used. The year of acquisition is used as households who had this land before 1992 may have been more likely to plant coffee on it before 1992 (and thus hold pre-1992 coffee stocks) than households who acquired land after 1992.

Table 4 presented results for the first scenario only, an exogenous K_t. Table 6 presents

[12] Running this regression has the disadvantage that we cannot control for any unobserved preference for producing coffee which in impacting both r_t and W_t (given the high return to coffee production) would render wealth endogenous.

results for the second and third scenario: excluding K_t (columns 1 and 2) and including K_t and instrumenting for it (columns 3 and 4). From the first two columns we see that when K_t is not included, the results are largely identical to those when it is included. The coefficient on wealth increases in magnitude perhaps indicating that there is some feedback from growing coffee onto wealth. Additionally, the coefficient on the number of trees lost to wilt disease becomes more negative than when K_t is included, most probably because without K_t some of the coefficient on this variable reflects the impact of wilt on the household's coffee production capacity.

Instrumenting K_t with the year of plot acquisition causes K_t to be insignificant (columns 3 and 4). The first stage regressions are shown in the appendix. The year land was acquired has the expected sign and is significant in explaining the weighted number of trees per unit of labour. The predictive power of the instrument (R-squared due to the instrument) is 0.02. It appears that the instrument is quite good. Although instrumenting causes K_t to be insignificant, the Hausman test shows we cannot reject the null of no significant difference in coefficients. This indicates there is not a problem of endogeneity which suggests the decision of how many coffee trees to hold is a different one to that of how much labour to allocate to coffee production in a given year.

These regressions were also run using revenue share as the dependent variable. The results are not shown to conserve space. The results on the variables of interest when K_t was omitted remained unchanged. Including K_t and instrumenting again caused K_t to become insignificant but the other results remained unchanged. The Hausman test again shows that we cannot reject the null of no significant difference in coefficients (Hausman $\chi^2(1) = 0.29$ and Davidson-McKinnon test indicates the null of exogeneity cannot be rejected, t-test=0.54).

5.2 Innate risk preferences

Contextualising the risk preference questions in terms of familiar situations of coffee price and yield risk, allowed the farmer to give a response to a situation he or she knows well, hopefully encouraging a meaningful response. However, as some studies have encountered, it may be the case that farmers who are less dependent on coffee income are less concerned about coffee revenue risk, and as a result will respond in a less risk averse fashion that their true preferences when questions are framed in this way (Moscardi and DeJanvry 1977; Feinerman and Finkelshtain 1996). This would result in a negative reverse causality observed between the share of coffee in production and the measure of risk aversion coming from a response to a question on coffee price or coffee yield risk. It is thus important to repeat the regressions using the measure of risk from the hybrid matooke yield risk question. As can be seen by comparing Table 4 and Table 7 results are very similar across measures of risk preferences, suggesting the way the question was framed (as coffee or matooke income risk) did not impact the response.

As the earlier discussion highlighted, there may be some concerns that because the questions were hypothetical they measure risk preferences with a large error. Whilst it may be the case that measurement error is not a problem for this analysis[13] in the worst case scenario measurement error in reported risk aversion will bias all coefficient estimates. To control for any question specific measurement error an instrumental variables specification was used in which one measure of risk aversion is instrumented with the other two using the estimated risk aversion parameters. This does not change the results significantly and so the results are not reported. This is perhaps not surprising, as whilst instrumenting will allow question specific measurement error in the risk aversion measures to be controlled for, it does not control for any systematic measurement error that might be present.

Perhaps a cause for greater concern is the extent to which questions on risk preferences, hypothetical or real, capture a measure of innate risk aversion or a combination of this and a household's ability to deal with risk. It is questionable as to whether households abstract from their current economic circumstances, and ability to deal with risk when answering questions about the level of risk they are happy to accept. As a result it is not clear whether a measure of

[13] If measurement error (e) is purely white noise its only effect is to increase the variance of the error term, and bias the estimate of the intercept if e has a non-zero mean (Wooldridge 2002).

the curvature of a household's utility function or the curvature of a household's value function is captured. This has to be borne in mind when interpreting observed empirical relationships between measured risk preference and other variables.

So far the analysis has assumed that questions on risk capture a measure of the concavity of a household's value function (i.e. $P * W$). If this is not the case and instead these questions measure P directly then P needs to be interacted with W in the analysis, as the sensitivity of production decisions to risk preferences will be higher for households that are less able to insure their consumption. In Table 8 risk preferences are interacted with wealth in a number of ways. First risk preferences are simply interacted with a dummy reflecting whether the household is in the top quarter of the wealth distribution, then risk preferences are allowed to vary at different wealth levels more fully. In columns 1 and 2 results when risk preferences are allowed to vary between the top 25% and bottom 75% of the wealth distribution are presented.[14] Dummies reflecting the household's choice of lottery are positive and jointly significant for the bottom 75% of the wealth distribution, but are insignificant in explaining labour share for the top 25%. This is as the model predicts: the curvature of the value function diverges more from the curvature of the utility function at higher wealth levels.

In columns 3 and 4 wealth is interacted with the calculated coefficient of risk aversion. In column 3 the coefficient of risk aversion is interacted with a measure of wealth calculated as the distance between the household's wealth and the maximum reported wealth level (this is thus higher for poorer households) and as can be seen the interacted term has a negative significant coefficient as expected. As an increase in wealth might have a greater impact in reducing the concavity of the value function at lower levels of wealth, the risk preference parameter is interacted with the exponential of the difference between maximum wealth and wealth. This does not change the results significantly (column 4). Finally this relationship is measured non-

[14] Regressions were repeated using a dummy taking the value 1 if the household was in the top half of the distribution and also using the number of people that can be asked for help in time of need as the differentiating variable (those households with no-one to ask for help or one person to ask for help, were separated from those households who could ask two or more people for help in time of need), and the results were very similar.

parametrically using a Robinson partial kernel regression.

The relationship we want to estimate is the following:

$$y_i = x_i\beta + P_i\phi(W^{\max} - W_i) + \varepsilon_i \tag{9}$$

which differs from the usual partial linear regression in that P_i appears interacted with $\phi(.)$. To revert back to the usual partial linear regression model we divide through by P_i which gives

$$\frac{y_i}{P_i} = \frac{x_i\beta}{P_i} + \phi(W^{\max} - W_i) + \frac{\varepsilon_i}{P_i} \tag{10}$$

allowing $\phi(W^{\max} - W_i)$ to be estimated in the usual way. However, as Equation 10 shows the error term in this specification is clearly heteroscedastic. As with parametric estimation heteroscedasticity will not bias the estimation of $\phi(.)$, but it will be inefficient and make inference problematic (Dette and Munke 1998). However, for the purpose of gaining a better understanding of the shape of the relationship between P_i and $\phi(.)$ this procedure will suffice. Figure 3 shows the estimated relationship between $\frac{y_i}{P_i}$ and $\phi(.)$. As can be seen it is very linear indicating the specification used in column 3 of Table 8 is adequate for this data.

The results are thus consistent with both P as measure of innate risk aversion and P as a measure of the concavity of a household's value function. The remainder of the results on the other variables of interest remain unchanged. Although we cannot draw firm conclusions about what P is measuring, a household's ability to deal with risk, its risk perceptions and risk preferences are all important factors in determining allocation of its time to a risky production activity.

6 Conclusion

This study has hoped to go someway into looking at how risk affects production of coffee for households in Uganda and to indicate the merit of simultaneously considering the effect of a household's ability to deal with risk, risk preferences and perceptions of risk to identify the impact of risk on production decisions. By using data on households' risk preferences and perception of risk in combination with more traditional measures of a households' ability to deal with risk this paper identifies the impact of risk on production in a way previous empirical studies have not.

Risk averse households were found to be less likely to allocate labour to coffee production, but the effect of risk preference on labour allocation was minimal for households in the top quarter of the wealth distribution. This suggests risk preferences are only important to the extent households cannot insure against income fluctuations. In addition, the effect of risk on coffee production was found to taper off for households that are risk neutral, suggesting that coffee production is perhaps not the most risky production activity available to these households. By examining the other crops these households grow it seems growing pineapples, tomatoes, and other garden vegetables may be riskier production activities, but this hypothesis requires further research. The perceived probability of a negative return was also found to have a strong negative impact on labour allocation. This was not the case for the variance of the coffee price which suggests that perceived downside risk is more important in explaining such decisions.

Whilst the analysis has shown the utility of collecting information on risk preferences and perceptions in identifying the impact of risk on production behaviour of poor households, it also highlights the burden of risk on small-holder farmers. Using the results in Table 8 (which assumes innate risk preferences were measured) we see that if a risk averse farmer (with median values of all other characteristics) were to move from the 10th to the 50th wealth percentile he would increase his share of labour allocated to coffee by 34 days. This is a shift that would allow him to add 3% to his yearly crop income. In the face of these numbers the welfare benefits of schemes that help provide some form of insurance to these farmers (perhaps coffee price insurance schemes or disease resistant trees) become clear.

This study has only considered the impact of risk on short-run labour allocation decisions.

The results on the exogeneity of coffee tree stocks suggest that long term production decisions cannot be analysed within the same model. However, given the dependence of many small-holder farmers on risky perennial crop production this issue merits further research.

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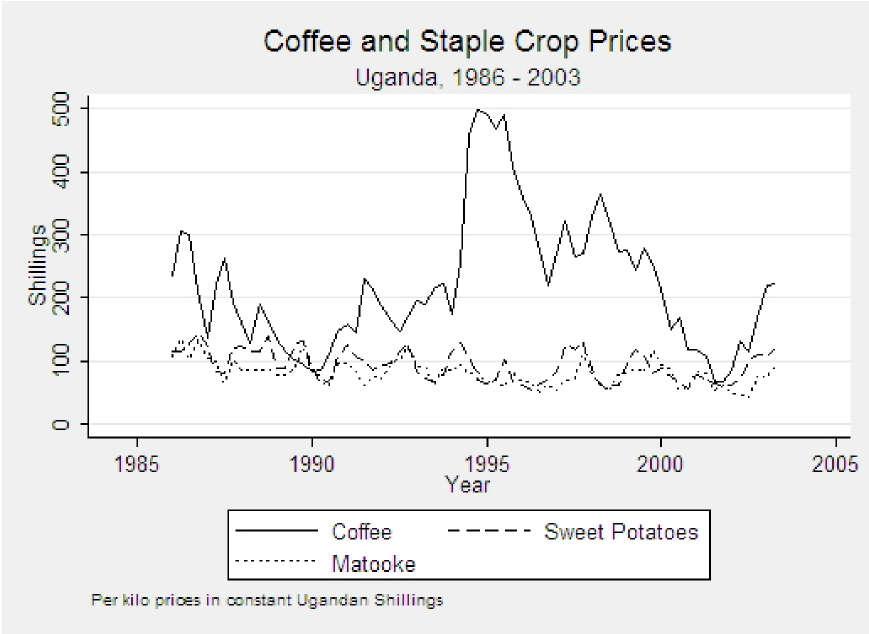

Figure 1: Coffee and staple crop prices 1986 - 2003 (Source: Henstridge 1997, UCDA and UBOS data)

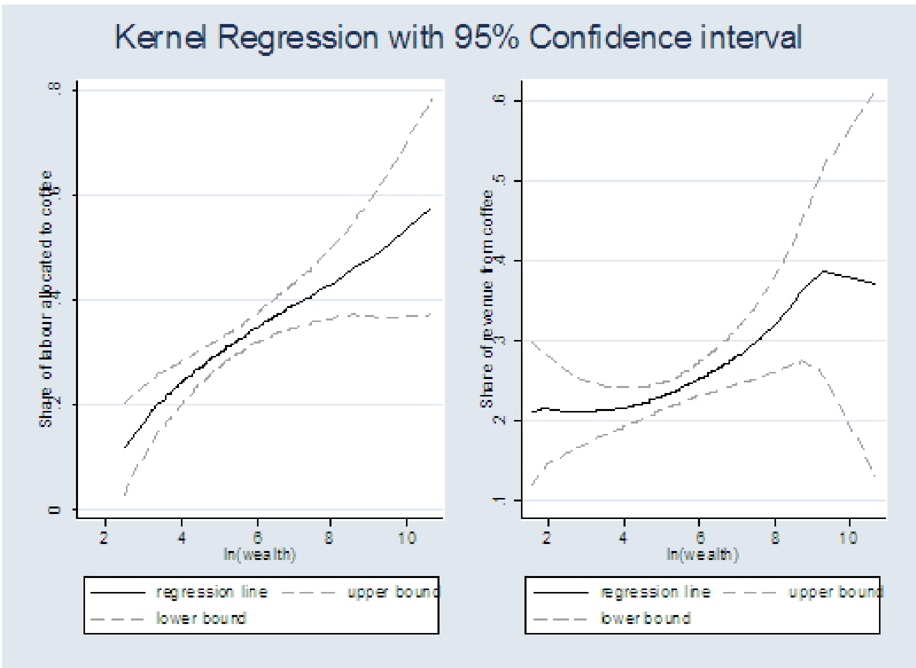

Figure 2: Non-parametric estimates of the effect of wealth on labour share and revenue share

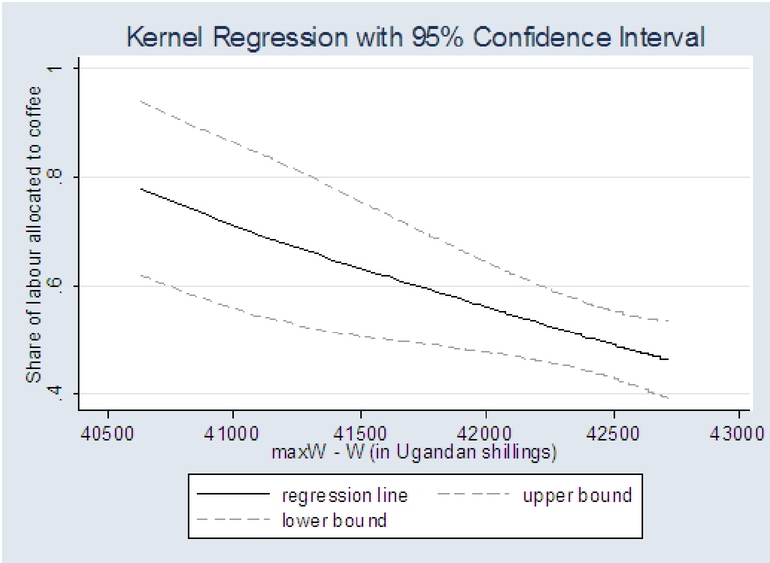

Figure 3: Non-parametric estimation of $(\ln W^{\max} - \ln W)$ on share of labour allocated to coffee / risk aversion parameter

Table 1: Descriptive statistics

	2003		2000	
	Median	Mean	Median	Mean
Share of labour on coffee	0.27		-	
Share of farm revenue from coffee	0.24		0.13	
Share of land on coffee	0.07		0.04	
Wealth (2003 constant US $)	248		230	
No. of people you can ask for help	2		2	
No. of household members	6		6	
Land owned (acres)	3		4	
Education of farmer (completed yrs)	5		5	
Share of trees lost to wilt in last 3 yrs	0.24		-	
Age of farmer (yrs)	50		48	
Gender of farmer (1=female)		0.24		0.22
Year in which coffee plot acquired	1982		-	
Masaka		0.20		-
Mukono /Kayunga		0.21		-
Bushenyi		0.29		-
Luwero		0.30		-

Table 2: Description of lotteries offered

	Mean payoff	Stnd. dev. of payoff	Range of P compatible with this choice
Option 1: 6000 shillings, 6000 shillings	6000	0	7.33 - ∞
Option 2: 5400 shillings, 9600 shillings	7500	2100	1.86 – 7.33
Option 3: 4800 shillings, 12000 shillings	8400	3600	0.63 – 1.86
Option 4: 2400 shillings, 18000 shillings	10200	7800	0.275 – 0.63
Option 5: 0 shillings, 24000 shillings	12000	12000	0 – 0.275

Table 3: Labour, revenue and land share by risk preference category

	Score (average P)	Labour share mean (st. dev.)	Revenue share mean (st. dev.)	No. of obs.
From hypothetical questions about coffee prices:				
Option 1	7.33	0.272 (0.202)	0.182 (0.157)	67
Option 2	3.69	0.312 (0.237)	0.231 (0.213)	49
Option 3	1.08	0.371 (0.240)	0.270 (0.216)	54
Option 4	0.416	0.343 (0.236)	0.256 (0.230)	79
Option 5	0.138	0.296 (0.184)	0.255 (0.210)	45
Test of trend (z-value)		-2.09**	-2.02**	
From hypothetical questions about coffee yields:				
Option 1	7.33	0.264 (0.200)	0.183 (0.164)	107
Option 2	3.69	0.323 (0.231)	0.234 (0.200)	51
Option 3	1.08	0.400 (0.224)	0.318 (0.250)	55
Option 4	0.416	0.385 (0.227)	0.221 (0.166)	35
Option 5	0.138	0.297 (0.233)	0.278 (0.243)	46
Test of trend (z-value)		-3.24***	-2.57***	

Table 4: Results for labour share as the dependent variable

	Labour share			
ln (wealth)	0.035 (0.010***)	0.035 (0.010***)	0.032 (0.010***)	0.033 (0.010***)
People to help	0.005 (0.010)	0.005 (0.010)	0.006 (0.010)	-0.005 (0.010)
Risk option 2	0.079 (0.049)			
Risk option 3	0.104 (0.043**)			
Risk option 4	0.090 (0.038**)			
Risk option 5	0.058 (0.039)			
Risk options 2-4		0.092 (0.035***)	0.094 (0.035***)	
Risk option 5		0.058 (0.039)	0.066 (0.039*)	
Estimated risk aversion coefficient				-0.012 (0.005**)
Trees lost to wilt	-0.069 (0.039)	-0.071 (0.040*)	-0.077 (0.042*)	-0.077 (0.040**)
Expected mean	0.055 (0.227)	0.058 (0.224)		
Expected variance	-6.46 (4.51)	-6.67 (4.40)		
Prob. of negative return			-0.228 (0.087***)	-0.231 (0.084***)
K_t/ Labour	0.037 (0.008***)	0.036 (0.008***)	0.038 (0.008***)	0.038 (0.008***)
Land-labour ratio	-1.79 (0.728**)	-1.71 (0.739**)	-1.77 (0.741**)	-1.92 (0.696***)
Gender of head	0.018 (0.029)	0.017 (0.030)	0.019 (0.029)	0.021 (0.029)
Age of head	-0.0003 (0.001)	-0.0002 (0.001)	-0.0002 (0.001)	-0.0002 (0.001)
Distance to Kampala	0.00002 (0.00005)	0.00003 (0.00004)	0.00003 (0.00004)	0.00001 (0.00005)
Distance to market	-0.005 (0.004)	-0.005 (0.004)	-0.006 (0.004)	-0.006 (0.005)
Intercept	0.218 (0.105**)	0.219 (0.105**)	0.227 (0.082***)	0.322 (0.084***)
No. of observations	293	293	293	293
F-test	6.27***	7.33***	8.97***	9.46***
R-squared	0.2849	0.2838	0.2952	0.2895

Standard errors (corrected for clustering at the village level) are in brackets. *** denotes significant at 0.01, ** at 0.05, * at 0.1. Regional dummies are included but not shown.

Table 5: Results for revenue share as the dependent variable

	Revenue share	
ln (wealth)	0.020 (0.012*)	0.022 (0.011*)
People to help	0.004 (0.008)	0.005 (0.008)
Risk options 2-4	0.063 (0.023***)	
Risk option 5	0.068 (0.036*)	
Estimated risk aversion coefficient		-0.013 (0.004***)
Trees lost to wilt	-0.097 (0.038**)	-0.093 (0.037**)
Prob. of negative return	0.022 (0.067)	-0.004 (0.073)
K / labour	0.025 (0.012**)	0.027 (0.012**)
Land-labour ratio	-1.563 (0.516***)	-1.75 (0.519***)
Gender of head	-0.038 (0.022*)	-0.038 (0.022*)
Age of head	0.001 (0.001)	0.001 (0.001)
Distance to Kampala	-0.0001 (0.00003***)	-0.0001 (0.00003***)
Distance to market	-0.009 (0.003***)	-0.008 (0.003***)
Intercept	0.104 (0.070)	0.166 (0.076**)
No. of observations	299	299
F-test	6.43***	8.20***
R-squared	0.1646	0.1740

Standard errors (corrected for clustering at the village level) are in brackets. *** denotes significant at 0.01, ** at 0.05, * at 0.1. Regional dummies are included but not shown.

Table 6: Results allowing for the endoegeneity of the stock of coffee trees

	Second scenario		Third scenario	
	(1)	(2)	(3)	(4)
ln (wealth)	0.041 (0.011***)	0.039 (0.010***)	0.041 (0.018**)	0.041 (0.018**)
People to help	0.004 (0.010)	-0.0001 (0.010)	0.004 (0.018)	0.001 (0.10)
Risk options 2-4	0.102 (0.036***)		0.095 (0.033***)	
Risk option 5	0.061 (0.040)		-0.011 (0.037)	
Estimated risk aversion coeff.		-0.011 (0.004**)		-0.011 (0.004**)
Trees lost to wilt	-0.102 (0.041**)	-0.096 (0.041**)	-0.114 (0.060*)	-0.109 (0.058*)
Prob of negative return	-0.240 (0.085***)	-0.310 (0.109***)	-0.168 (0.085**)	-0.213 (0.086**)
K / labour			0.006 (0.055)	0.010 (0.057)
Land-labour ratio	-0.291 (0.614)	-0.318 (0.539)	-0.624 (2.322)	-0.814 (2.41)
Gender of head	0.019 (0.030)	0.017 (0.030)	0.028 (0.029)	0.026 (0.029)
Age of head	-0.0002 (0.001)	-0.0002 (0.001)	-0.0004 (0.001)	-0.0001 (0.001)
Distance to Kampala	0.00004 (0.00005)	0.00004 (0.00005)	0.0001 (0.0001)	0.0001 (0.0001)
Distance to market	-0.006 (0.004)	-0.008 (0.004)	-0.007 (0.004)	-0.006 (0.004)
Intercept	0.207 (0.085**)	0.421 (0.128***)	0.225 (0.089**)	0.284 (0.090***)
Number of observations	275	275	275	275
F-test	5.98***	8.96***	6.30***	6.03***
R-squared	0.2540	0.2488	0.2760	0.2618
Hausman test, $\chi^2(1)$			0.29	0.26
Davidson-Mackinnon t-test			0.53	0.51

Standard errors (corrected for clustering at the village level) are in brackets. *** denotes significant at 0.01, ** at 0.05, * at 0.1. Regional dummies are included but not shown.

Table 7: Results using measures of risk from questions on coffee and matooke yeid risk

Using a measure of risk preference from a question on	coffee yields	coffee yields	matooke yields	matooke yields
ln (wealth)	0.031 (0.010***)	0.030 (0.010***)	0.031 (0.011***)	0.031 (0.010***)
People to ask for help	0.005 (0.010)	0.003 (0.010)	0.007 (0.010)	0.005 (0.010)
Risk options 2-4	0.097 (0.029***)		0.088 (0.031***)	
Risk option 5	0.016 (0.034)		0.020 (0.050)	
Estimated risk aversion coeff.		-0.011 (0.004**)		-0.012 (0.005**)
Trees lost to wilt	-0.086 (0.042**)	-0.076 (0.042*)	-0.069 (0.041**)	-0.071 (0.041*)
Prob. of negative return	-0.183 (0.077**)	-0.213 (0.082**)	-0.235 (0.087***)	-0.238 (0.085***)
K / labour	0.034 (0.008***)	0.038 (0.007***)	0.037 (0.007***)	0.038 (0.008***)
Land to labour ratio	-1.74 (0.753**)	-1.86 (0.722**)	-1.81 (0.695**)	-1.80 (0.761**)
Gender of head	0.024 (0.028)	0.20 (0.029)	0.011 (0.029)	0.016 (0.029)
Age of head	-0.0005 (0.001)	-0.0002 (0.001)	-0.0004 (0.001)	-0.0003 (0.001)
Distance to Kampala	0.00003 (0.00005)	-0.00001 (0.00005)	0.00003 (0.00005)	-0.00001 (0.00005)
Distance to market	-0.0007 (0.005)	-0.0007 (0.004)	-0.0006 (0.004)	-0.0008 (0.005)
Intercept	0.266 (0.079***)	0.339 (0.088***)	0.262 (0.079***)	0.348 (0.090***)
No. of observations	293	293	293	293
F-test	12.67***	11.73***	9.75***	10.78***
R-squared	0.3077	0.2888	0.2994	0.2886

Standard errors (corrected for clustering at the village level) are in brackets. *** denotes significant at 0.01, ** at 0.05, * at 0.1. Regional dummies are included but not shown.

Table 8: Results when allowing measurement of innate risk preferences

	Labour share		
ln (wealth)	0.038 (0.015**)	0.027 (0.011**)	0.030 (0.010***)
People to ask for help	0.005 (0.010)	0.005 (0.010)	0.003 (0.010)
Dummy for 76^{th}-100^{th}	0.040 (0.073)		
Option 2-$4^{(1st-75th)}$	0.110 (0.036***)		
Option $5^{(1st-75th)}$	0.079 (0.042*)		
Option 2-$4^{(76th-100th)}$	0.033 (0.068)		
Option $5^{(76th-100th)}$	0.019 (0.077)		
$P * (\ln W^{\max} - \ln W)$		-0.002 (0.001**)	
$P * (\exp(W^{\max} - \ln W))$			-0.007 (0.003**)
Trees lost to wilt	-0.077 (0.041**)	-0.075 (0.040*)	-0.076 (0.042*)
Prob. of negative return	-0.223 (0.086**)	-0.224 (0.084***)	-0.0214 (0.082**)
K / labour	0.036 (0.007**)	0.038 (0.008***)	0.038 (0.008***)
Land to labour ratio	-1.688 (0.748***)	-1.85 (0.0704***)	-1.85 (0.722**)
Gender of head	0.020 (0.029)	0.020 (0.029)	0.020 (0.029)
Age of head	-0.0003 (0.001)	-0.0002 (0.001)	-0.0002 (0.001)
Distance to Kampala	-0.00002 (0.00005)	-0.00002 (0.00004)	0.000003 (0.00005)
Distance to market	-0.006 (0.004)	-0.006 (0.005)	-0.007 (0.004)
Intercept	0.190 (0.098)	0.350 (0.088***)	0.34 (0.088***)
No. of observations	293	293	293
F-test	8.21***	9.24***	11.70
R-squared	0.2989	0.2885	0.2888

Standard errors (corrected for clustering at the village level) are in brackets. *** denotes significant at 0.01, ** at 0.05, * at 0.1. Regional dummies are included but not shown.

Appendix: Results of first stage of IV regression

	K_t / Labour	
ln (wealth)	0.261 (0.079***)	0.237 (0.078***)
People to ask for help	-0.081 (0.061)	-0.088 (0.060)
Risk options 2-4	0.362 (0.185*)	
Risk option 5	-0.051 (0.253)	
Estimated risk aversion coefficient		-0.006 (0.030)
Trees lost to wilt	-0.624 (0.298**)	-0.687 (0.296**)
Prob. of negative return	-0.291 (0.551)	-0.377 (0.565)
Land to labour ratio	41.6 (5.12***)	42.5 (5.07***)
Gender of head	0.008 (0.195)	0.031 (0.194)
Age of head	-0.0134 (0.007*)	-0.011 (0.007*)
Distance to Kampala	0.0003 (0.001)	0.0001 (0.001)
Distance to market	-0.012 (0.029)	-0.009 (0.029)
Year in which coffee plot acquired	-0.020 (0.007***)	-0.018 (0.007***)
constant	39.9 (14.1***)	36.3 (14.1***)
No. of observations	275	275
R-squared	0.3404	0.3384
F-test of signif. of instrument	8.28***	6.90***

Standard errors in brackets (*** denotes significant at 0.01, ** at 0.05, * at 0.1)
Regional dummies included but not shown.