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Coffee Price Risk in the Market: Exporter, Trader and Producer Data from Uganda

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Abstract

Coffee is Uganda's most important export good. Post-liberalisation, increased competitiveness has increased the extent to which the coffee price fluctuates throughout the marketing chain. Using original survey data collected at all levels of the value chain this paper examines which actors are most affected by coffee price risk. Coffee farmers are found to be most affected by coffee price risk and willingness to pay for price insurance among farmers is calculated using data on farmers' risk preferences and risk perceptions. Substantial demand for price insurance was found, as was wide variation in willingness to pay. Variation in perceptions of price risk among farmers is examined as a means to understanding this varying demand for insurance.

1 Introduction

The transfer of marketing responsibilities from the state to private agents in developing country commodity markets has enhanced competitiveness in these markets, often allowing producers to receive a larger share of the export price. However increased competitiveness has also increased the extent to which fluctuations in international commodity prices are passed from exporters to domestic traders to producers. The greater price fluctuations at all levels of the marketing chain is suggestive of an increase in price risk faced by all market participants, but the question of who is most exposed to the price risk now felt in the system is a real one that needs to be considered if the full effects of market liberalisation are to be understood.

Using original survey data collected in Uganda at all levels of the coffee value chain, this paper examines the price risk present in the post-liberalised Ugandan coffee market. Fafchamps, Hill et al (2003) have shown that liberalisation of the marketing of coffee in Uganda has increased the exposure of all actors in the coffee market to international price changes. Fluctuations in international prices are passed through the marketing chain as evidenced by the coefficient of variation of the farm-gate price rising from 0.38 to 0.62 after liberalisation without any change in the coefficient of variation of the world coffee price. This paper tries to answer the question for whom this increased price volatility translates into price risk.

Data collected on coffee exporters, domestic coffee traders and coffee farmers allows a description of the price risk in the sector. The description suggests exporters and producers find themselves most at risk from price fluctuations and as a result have a need for hedging instruments. However, in contrast to farmers, exporters are able to manage their price risk, either through hedging on the international market or structuring their buying and selling contracts in a way that mitigates their risk. Estimates of the demand schedule for coffee price insurance among coffee farmers are constructed using data collected on farmer's risk preferences and perceptions of price risk. These estimates show that the majority of farmers would demand insurance at actuarially fair premiums.

The estimates also show that there is wide variation among farmers in willingness to pay as a result of varying perceptions of the future price distribution, and the latter part of the paper considers potential causes for this variation: in particular whether differences in perceived risk arise because price risk varies across farmers or whether perceptions of price risk vary as a result of a diversity of access to market information, or heterogeneity in the way agents use information to update their beliefs about the future price.

The paper proceeds as follows. The following section briefly describes the data used throughout this paper. Section 3 describes the price risk each market participant faces. Section 4 sets out a model to calculate the demand for price insurance among farmers, and Section 5 presents and discusses the results. Section 6 examines the causes of heterogeneity in the farmer's perception of risk and willingness to pay data and section 7 concludes.

2 The Data

Detailed data on exporters, traders and producers comes from surveys conducted in Uganda in early 2003[1]. The general purpose of the surveys was to look at the effect of commodity price fluctuations on producers and to assess the potential for risk management schemes. Data was collected on all Robusta coffee exporters, and from 100 traders and 300 producers in four districts that were identified as among the districts that produced the most Robusta coffee in Uganda –Mukono, Luwero, Masaka and Bushenyi.

Exporter and trader surveys asked for information on price hedging behaviour as well as questions on the structure of their trading business; operating costs; access to information and trading networks; financial and credit resources; and general characteristics.

All coffee exporters in Uganda have to be registered with UCDA.[2] and, with the exception of three who refused to respond, all exporters of Robusta coffee were interviewed. A considerable degree of heterogeneity exists among domestic coffee traders in Uganda. During field testing of

[1] 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.

[2] It is believed that small quantities of Robusta coffee are exported by unregistered exporters towards neighboring countries (Tanzania, Sudan) for domestic consumption. It is also thought that some Robusta coffee crosses the border from DR Congo to be exported by Uganda. These informal border movements are ignored here as they represent a very small proportion of exports.

the trader questionnaire, two broad classes of traders clearly emerged: ddebe boys, that is, small itinerant traders who operate largely by bicycle, do not possess a store front, and buy directly from farmers to sell to large traders; and large traders who own a store or a mill, buy from small traders, and sell to exporters in Kampala. Given the greater heterogeneity that exists among large traders it was decided to over sample the lager traders.[3] The trader sample was stratified on the basis of these two types: ddebe boys and those who own a store or a mill (this stratification also corresponds to their two different roles in the value chain). In each of the four survey districts a list of large traders was constructed a few days prior to interviewing with the aid of a local guide knowledgeable of the coffee industry of a region. Large traders were then randomly selected from this list. Given the difficulty of locating ddebe boys operating in an area – and the impossibility of conducting a listing exercise – it was decided to interview small traders at their point of sale, that is, when they visit large traders. Ddebe boys were thus randomly selected among small traders delivering coffee to an interviewed large trader. A sample of just over 100 traders was randomly selected in the four selected coffee growing districts, divided equally between large and small traders.

The sample of coffee producers was drawn randomly from a sampling frame constructed from a national household survey conducted in 1999/2000 which was used to identify coffee farmers. 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. The data collected includes information on the farmers' production decisions and coffee sales for the previous calendar year in addition to household characteristics and risk preferences and expectations about the future coffee price.

[3] Small traders all tend to operate in a similar way, aggregating coffee with the small working capital they have, selling it immediately, and then buying and aggregating coffee again.

3 Price risk in the coffee sector in Uganda

Since liberalisation of the internal coffee market in 1992 farmers have been free to decide how and to whom to sell their coffee. Transactions at the farm level are quite small and farmers most times sell as individuals, only in a few cases selling as a group (through a cooperative society or private farmers' association). Most coffee sales are made at the farm-gate to small traders who tour the countryside on bicycles or motorcycles (called ddebe boys after the ddebe container they use to measure the coffee). These small-scale traders act as aggregators either for bigger independent traders or for exporters and their agents. The majority of Ugandan producers sell their coffee in the form of dry cherries locally known as kiboko which are then milled (the cherry is separated from the husk) by the traders who buy the coffee. Milled coffee of average quality is referred to as fair average quality (FAQ) coffee[4]. After the coffee has been milled, transported to Kampala and sold to exporters it is sorted – broken cherries, withered cherries, stones and husks that may have entered the mix are discarded and the coffee is graded for export (export grade).

As exporters deal directly with the international coffee market they are exposed to all the price variability entailed therein. The greatest source of risk they face is the price of coffee rising once they are locked into a contract to deliver a specified quantity of coffee at a given date and price. In such a context one would expect the number of exporters using hedging instruments (such as coffee futures and coffee call and put options) to be quite large. Interestingly, however, only 35% of the Robusta coffee exporters in Uganda reported using hedging instruments. Internationally owned exporting firms are more inclined to use these instruments: none of the Ugandan owned firms were using hedging instruments whilst 88% of the foreign owned exporters were. Instead, to cover their risk many of the local exporters engage in short 'back to back' contracts. As an indication of this

[4] Well looked-after, healthy trees produce a ratio of 0.6 Kg of Fair Average Quality (FAQ) coffee cherries for 1 Kg of kiboko, while old and diseased trees produce kiboko with a lower ratio that can reach as low as 1:0.4.

82% of Ugandan exporters said 100% of their contracts were of duration 45 days or less, compared with 33% of the international exporters. Although not many exporters may be engaged in futures and options trading all exporters undertake action to manage the price risk they face.[5]

Most domestic traders interviewed operate on a small scale owning few if any vehicles and equipment and have been in the coffee trading business for some time. Although most traders interviewed operate for only half of the year, coffee comprises on average about 80% of their trading business. Traders potentially face two types of price risk. Traders who enter contracts with exporters to deliver a given amount of coffee at a given price fear downside risk in the same way exporters do. Very few of these traders seem to take measures to hedge against the risk entailed. Insurance instruments are not available and only 35% of traders cover the price risk from entering into a selling contract by contracting some of their buying activities. However, these contracts traders enter are of short duration: the median contract length is four days and 90% of such contracts are for a week or less. The price risk entailed in such a contract is thus minimal compared to exporters who contract deliveries of coffee months in advance.

Only a small proportion of trader's sales are made in this way (76% of traders reported 10% or less of sales made in this way and 48% never sell in this way) and for the majority of traders their fear is of the price of coffee falling after they have bought coffee and are waiting to sell it. This price risk, whilst present, is minimal as the turnover of coffee purchased is very quick. The median duration of a completed purchase and sale is two days. For 88% of traders their latest completed purchase and sale transaction lasted less than a week and for nearly all traders less than two weeks (98%). Sometimes traders are more exposed to downside price risk by operating on a contract basis

[5] The falling number of local exporters may indicate that using 'back to back' contracts for price risk management is not as effective as using hedging instruments. A reason often cited for this decline in local capacity in the export market is that indigenous exporters have not been able to compete with international firms who can access credit at lower interest rates than found domestically through financing from abroad (Bonger, Ddumba-Sentamu, and Nabumba 1999; Kawuma and Byarugaba 1996; Buchanayandi and Kiwanuka 1996). It may also be a result of indigenous companies' lack of access to risk management resources.

with suppliers. On average 13.3% of purchases were made with payment of an advance. Again the average contract is short (median contract is one week in duration), but does increase the trader's exposure to price risk.

Traders were asked whether they would be interested in a contract that offered them price protection, and what they would be willing to pay for such a contract. If traders are subject to little price risk, one would expect them to have minimal demand for price insurance. Traders were asked the following question for milled (FAQ) coffee:

> Suppose the price at which you could sell FAQ coffee was 600 Shillings per kilo today. Further suppose a reputable organization proposes the following contract. The contract guarantees that you would receive at least this price for the following 30 days. If the price falls below 600, they will buy from you an agreed upon quantity of (standard quality) FAQ coffee at 600 Shillings per kilo. If the price rises, you can sell to someone else at the higher price. Would you be interested in such a contract?

This question was repeated for a price of 1000 shillings per kilo. Figure 1 shows where these two prices lie in the prices experienced by traders over the last three years (indicated by domestic FAQ price). At 600 shillings per kilo 34% of the traders were willing to pay for such a contract and at 1000 shillings per kilo 40% of traders would pay something[6]. When further questioned about how much traders would be willing to pay (for a 30 day contract and a 6 month contract) it emerged that only 3% of traders would be willing to pay the actuarially fair premium for price insurance as would be offered through a hedging instrument purchased on the international market (50 - 100

[6] Traders who were not interested in the contract were asked why this was so. Much of the disinterest at both price levels was as a result of expectations the price would rise (this was responsible for 77% of the disinterest at 600 shillings and 59% of the disinterest at 1000 shillings). It also emerged that disinterest at the higher price of 1000 shillings was a result of a feeling among a number of the traders that this was not the kind of scheme that interested them given they were middlemen and could be competitive without this kind of hedging instrument (30% responded this was the case).

Shillings per kilo of milled coffee of a fair average quality)[7]. Results concur with the hypothesis that price risk is of little concern to traders.

The majority of coffee grown in Uganda is grown by smallholders. It is nearly always intercropped with staples and comprises on average 23% of farm revenue[8]. The price risk the farmer faces is the risk of investing land and labour in coffee production, when the returns are uncertain. Land is invested in coffee production three years in advance of realising returns as coffee trees become productive three years after planting and in a given season labour is committed to coffee production up to six months before harvesting and returns are realised. For the majority of farmers the price is negotiated at the time of sale and payment is not made until then[9]. To the extent traders report purchasing in advance from farmers, the advance purchase contract is about a week in duration and as such may reduce uncertainty in the application of labour to picking and drying the cherries but not the uncertainty surrounding the return to land and other labour inputs. Farmers are thus exposed to a significant degree of price risk.

Farmers do not have hedging instruments at their disposal, and have little access to any credit and insurance markets, so the means they have to deal with income shocks of any kind are limited and often costly. As a result, 90% of farmers said that over the three years prior to the survey they had found themselves unable to buy something they needed because of a low coffee price. Likewise, over a third of farmers that had taken loans in the three years prior to the survey reported being prevented from paying back their loans because of low coffee prices.

If it is the case that much of the price risk in the internal marketing chain is experienced by coffee farmers, we would expect them to have a high demand for price protection instruments. The

[7] The cost of price insurance at the given prices provided by a Robusta coffee put option was calculated by looking at the cost of Robusta coffee put options on the Liffe

[8] 211 of the 300 farmers interviewed owned land less than or equal to 5 acres. All coffee farmers interviewed grew coffee in conjunction with a number of other crops, mostly with Matooke (a banana plant).

[9] In only one out of the five hundred transactions recorded was payment made before the sale, although in nearly ten percent of the transactions recorded a sale price was agreed with traders in advance of the sale.

following question was asked to the farmers in two of the four survey districts:

> Price risk management refers to buying a financial product that allows you to insure a price for your coffee before you sell it based on the international market. You pay a fee to insure a price for your coffee for a specific number of days or months. If the global price rises during that period you sell your coffee for the market price and receive no payout. If price falls during that time you sell your coffee for the market price and receive a payout from the global market. Would you recommend a product like this to other farmers in your village?

Of the farmers asked 88% responded they would recommend a product like this to other farmers in their village which is indicative of their interest in such a product and willingness to pay for it. Although this is a more general question than that asked to the traders it suggests a much greater demand for insurance among farmers than traders. The demand for price protection among farmers is considered more comprehensively in the next section.

4 A model to determine demand for price insurance

There are three ways of determining an individual's willingness to pay for insurance: directly ask the individual what they would be willing to pay for an insurance scheme described in detail to them (a stated preference technique, called the contingent valuation method because a realistic contingent scenario is presented to the individual which they are asked to value); observe their production and consumption practices to determine what they already 'pay' through informal methods to avoid income risk (a revealed preference technique, for an example see (Gautam, Hazell, and Alderman 1994) and (Sakurai and Reardon 1997)); and calculate willingness to pay by comparing their utility in a world with and without insurance and determining what they would be willing to pay to be indifferent between moving from one world to another (for an example see Fraser 1992).

There are benefits and pitfalls to all methods (for a comprehensive review see Sarris 2002). The contingent valuation method is very sensitive to the description of the contingent scenario (Hanemann 1994; Diamond and Hausman 1994) and subject to bias in that respondents may over or under state their willingness to pay for a service dependent on what they perceive the purpose of the survey to be. More accurate responses are elicited when the contingent scenario is well defined and is a scenario with which the respondent is familiar. The revealed preference method relies on the researcher being able to understand and model the full set of decisions and actions the household takes to insure its consumption, which makes the data requirements for such estimation very stringent and the results subject to model specifications.

In the with-without comparison method a specific functional form must be assumed for an individual's expected utility. Parameterisation of the utility function requires data on risk preferences, and calculation of expected utility with and without insurance requires data on estimates of volatility of prices and yields. In the absence of individual data on risk preferences and perceptions of the volatility of return, accepted values of risk preferences and estimates of the volatility of yields and prices calculated from national data is used. As risk preferences vary across the population and heterogeneity of beliefs about probability of future events is often observed (Sherrick, Barry, Ellinger, and Schnitkey 2004), this is less than satisfactory when wanting to determine individual willingness to pay. If data on individual preferences and perceptions is available, it could be used to generate more individual specific measures of willingness to pay.

The contingent valuation method was used (above) to determine willingness to pay amongst traders, and the latter approach is used to determine willingness to pay among farmers. A simple model comparing the expected utility of income with and without price insurance is used to calculate how much a farmer would be willing to pay for price protection at a given price. Data on risk preferences and perceived volatility of the coffee price was collected for farmers allowing estimates of willingness to pay based on both individual perceptions of price risk and national estimates. As data on farmers' preferences and perceptions was collected using stated methods there is a possibility that, as in the contingent valuation method, estimates using this data may also suffer from bias. As described below great care was taken to ensure as much as possible accurate data was collected, and it is hoped potential bias will be smaller than that from using a contingent valuation method given there is less of a perceived incentive to deviate from revealing one's true preferences and the data does not rely on the specification of a contingent scenario unfamiliar to these farmers.

The model is laid out for the case of price insurance offered within one year and after the decision of how much coffee to produce has been made. As such the model calculates the benefit of insurance when it is assumed production decisions are not affected by the ability to insure. A wealth of literature suggests that when households are unable to insure they are likely to try and reduce variability in their income ex-ante which they may do by taking up low risk activities at the cost of low return (Morduch 1995; Dercon 2002). It may be that by affording some minimum price guarantee price insurance would encourage coffee farmers to invest more household resources in coffee production - a high risk but high return activity. This assumption of fixed shares of income may allow estimation of a "short term" benefit to insurance. Focusing on the short term benefits of price insurance also allows us to makes simplifying assumptions of stationarity of the price distribution. Were the long term effects of offering insurance considered, the benefit from the provision of insurance could be higher than the analysis suggests.

A household's income, y, can be characterised as coming from two components – income from coffee production and income from other sources of production:

$$y = Y_0 + pq \tag{1}$$

where Y_0 is the income from sources other than coffee, p is the price of coffee and q the quantity harvested and sold such that pq represents the income resulting from coffee. Y_0 is assumed known at time t but there is uncertainty surrounding p and q. Whilst all crop production is subject to uncertainty in prices, coffee faces greater price risk as a result of a highly fluctuating producer price: the coefficient of variation of the coffee price is 0.62 compared to a coefficient of variation of 0.25 for staple crops (such as banana and potato) grown by coffee farmers. Coffee yields have also been subject to uncertainty as a result of the increased incidence of disease faced by farmers in the last ten years. The simplifying assumption that coffee is the one risky income source farmers face is made because of this extreme uncertainty surrounding the income from coffee production compared to that from other crops.

In the absence of any savings or credit market to transfer income from one period to another the household's consumption in a given period is determined by the income it receives. If a constant relative risk aversion utility function is assumed the household's utility in a given period is:

$$EU(Y) = \frac{(Y_0 + pq)^{1-R}}{1-R} \tag{2}$$

(with $EU(Y) = ln(Y)$ when $R = 1$). Approximating using a second order Taylorian expansion gives:

$$EU(Y) \approx \frac{(Y_0 + \overline{p})^{1-R}}{1-R} - \frac{R}{2} var(pq)\,(Y_0 + \overline{p})^{R-1} \tag{3}$$

where $var(pq) = varpvarq + \overline{q}^2 varp + \overline{p}^2 varq + 2\overline{pq}covar(pq)$.[10] Other specifications of the utility function can be similarly approximated using the expected mean and variance of the income. A

[10] Under the assumption of stationarity of the return to coffee production in the short run (and the assumption that the return to coffee is normally distributed) this approximation becomes exact. However in the presence of non-stationarity or non-normality of returns to coffee production, this second order approximation may become a poor one. Given we are estimating demand for short run insurance non-stationarity is unlikely and this approximation seems a valid one.

constant relative risk aversion (CRRA) utility function has been used here as it has the desirable property of decreasing absolute risk aversion.

By assuming the household has no means of disassociating current consumption from income, Equation 2 calculates the utility of the household when it is completely uninsured, denote the utility in this situation as $EU(Y_{without})$. Consider now the case of the household when it can purchase insurance that guarantees a minimum per kilo price for coffee. Under insurance the distribution of the price is truncated from below. When the price falls below the protected price, a, a payout is made on each kilo of coffee protected to bring the per kilo price back to a. The truncated price distribution has a higher mean and a lower variance. There is a per kilo cost to price protection and this is denoted as b. To simplify the following analysis it is assumed that protection is bought for the expected quantity of coffee produced, although in reality a household could decide to insure only part of its production. It is also assumed that the per kilo premium b is not a function of the amount of coffee insured. Expected utility under price protection is thus given as:

$$EU(Y_{with}) = \frac{(Y_0 + \overline{p^*}\overline{q} - b\overline{q})^{1-R}}{1-R} - \frac{R}{2}var(p^*q)\left(Y_0 + \overline{p^*}\overline{q} - b\overline{q}\right)^{R-1} \tag{4}$$

where $p^*$is the truncated price distribution. The value of b that equates $EU(Y_{without})$ and $EU(Y_{with})$ is the maximum per kilo premium a household is willing to pay to insure coffee at a given price.[11]

Before moving on to the discussion of the results, it is worth noting that although imperfect credit and insurance markets exist in rural Uganda, households do have means of insuring themselves against shocks to their income. Households smooth their consumption from one period to the next by consuming only part of their income and saving the rest when the realisation of their income is high and consuming more than their income by running down their assets or borrowing

[11] The need for cash-constrained farmers to pay for price protection before harvesting is not considered here. This may hinder farmers' ability to insure against price risk, and may result in latent demand for the scheme not being realised.

(if they are able) when the realisation of their income is low (Rosenzweig and Wolpin 1993; Lim and Townsend 1998; Fafchamps, Udry, and Czukas 1998). In this way households are able to have some insurance against fluctuations in their income even if they do not have access to formal insurance markets. By comparing a situation of no insurance to a situation of price insurance we are estimating how much farmers are willing to pay for insurance. That they are willing to pay does not mean they do not insure, in fact use of existing insurance instruments will be observed when households have insurance options available to them that provides insurance at the price they are willing to pay.

5 Demand for price insurance

5.1 Data

To estimate the model data on income shares from coffee and other production activities, risk preferences, and farmer's expectations of average coffee return and its variability is needed. To provide a measure of risk aversion for the analysis, a series of questions about crop yields and coffee prices were posed to farmers as part of the farmer survey to get an idea of the level of yield, and income risk each farmer was happy to accept. 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 20 kilos of kiboko at the time of the survey was 6,000 shillings. A similar method of collecting data on preferences has been used in a developing country context before (Scandizzo and Dillon 1979; Binswanger 1981). The choice of lotteries method was used as it was simple for the respondent to understand and the use of a constant probability avoiding extreme probabilities avoided some of the problems associated with heterogeneity in the application of decision weights. The lotteries offered increased in both mean and variance. Data from the choice of lottery was used to classify farmers as more or less risk averse. Given the specification of a CRRA utility function above, it is useful (for consistency) to define an individual specific range of relative risk aversion, R, compatible with each choice of lottery by using $U(Y) = \frac{Y^{(1-R)}}{1-R}$. However, as it seems the assumption of a constant partial risk aversion utility function of the form $U(M) = (1-S)M^{(1-S)}$ (where M denotes the certainty equivalent of a given lottery) is a more appropriate one when data is collected in this way (Binswanger 1981; Wik and Holden 1998), a constant partial risk aversion specification was also used to calculate the range of relative partial risk aversion compatible with each choice (and to calculate willingness to pay). The coefficient of partial risk aversion, S, is defined over gains and losses in a given lottery and is independent of initial wealth. As a result the range of S for a given lottery is the same for all households. Table 1 shows the response to this question for coffee prices and indicates the range of risk preference compatible with each choice.[12,13] In many of the willingness to pay estimates S is used, but the impact of using S as opposed to R is considered by also presenting estimates using R and testing the difference.

[12] 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 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).

[13] Computing S also allows us to compare the response of Ugandan households to that recorded for Indian households by Binswanger. We find that the average risk aversion paremeter is similar. The option chosen by the median farmer in the Binswanger study is comparable to option 3, which is also the median for these farmers.

Non-coffee income is known for each household, and income from coffee production is estimated using data on the mean and variance of coffee yields and prices. Two sets of estimates of the first two moments of the probability distribution for prices and yields were used - national estimates based on national price and production series and individual estimates based on the cross-sectional data collected.

Many studies have shown that the movement of the international coffee price exhibits a considerable degree of autocorrelation (Gersovitz and Paxson 1990; Deaton and Laroque 1992). Using annual international coffee price data Deaton and Laroque (Deaton and Laroque 1996) have shown the international coffee price can be characterised parsimoniously as an AR(1) distribution, with a first order auto-correlation coefficient of 0.8. The expected value of the price in the next period for an AR(1) distribution is given as $E[y_{t+1}] = \mu + \alpha_1(y_t - \mu)$ and the variance of the expectation as σ_ε^2. Assuming a Gaussian i.i.d. error, ε, the future price, y_{t+1}, is fully described as $y_{t+1} \sim N\left(\mu + \alpha_1(y_t - \mu), \sigma_\varepsilon^2\right)$. From this it is possible to generate estimates based on national data for the expected value of the price and its variance in 6 months.[14] Under price insurance the price distribution is effectively truncated from the left hand side with the probability of the price falling below the point of truncation located at the point of truncation. Standard equations for the calculation of the first two moments of a truncated normal distribution can be used to determine the mean and variance of the truncated distribution at varying points of truncation (levels of price insurance).[15]

Households' subjective perceptions of price risk may differ markedly from those based on objective probabilities. In order to get a measure of subjective perceptions respondents gave an idea

[14] Data used was the monthly farmgate price recorded by the Uganda Coffee Development Authority.

[15] These equations are: $mean_a = \mu\left(1 - \Phi\left(\frac{a-\mu}{\sigma}\right)\right) + \sigma\phi\left(\frac{a-\mu}{\sigma}\right) + a\left(\Phi\left(\frac{a-\mu}{\sigma}\right)\right)$ and $variance_a = \mu^2\left(1 - \Phi\left(\frac{a-\mu}{\sigma}\right)\right) + 2\mu\sigma\phi\left(\frac{a-\mu}{\sigma}\right) + \sigma^2\left(\frac{a-\mu}{\sigma}\right)\phi\left(\frac{a-\mu}{\sigma}\right) + \sigma^2\left(1 - \Phi\left(\frac{a-\mu}{\sigma}\right)\right) + a^2\Phi\left(\frac{a-\mu}{\sigma}\right) - \overline{x}_a^2$ where a is the point of truncation, μ is the mean of the untruncated distribution and σ^2 is the variance of the untruncated distribution.

of their expected distribution of the price they would receive for coffee in six months time (July 2003) through the following exercise. The respondents were given twenty beans and a handout marked with three squares of different price categories (less than 200 shillings, between 200 and 400 shillings, and more than 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. Estimates of the mean and variance of farmer's expected price distribution were calculated from the response to these questions as were estimates of mean and variance for the truncated price distribution present under insurance.[16] Table 3 shows these estimates and expected mean and variance based on historical data. It is clear from the table that on average the expected price and its variance are much lower than they would be based on historical data. We may thus expect some differences in demand for insurance based on the two sets of expectations.

Similarly two sets of estimates of the mean and variance of the coffee yield distribution were used in the calculations. For the first set of estimates, national data on annual quantities of coffee exported was used to calculate a national estimate of average coffee yield and coefficient of variation of coffee yields.[17] Household production levels were used to calibrate these national estimates for each household.

[16] 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 $\sum_{i=1}^{5} (x_i - \overline{x})^2 f_i$ .To calculate the mean and variance of the price under the hedging instrument the probability of the price falling below the minimum price was given to the value of the minimum price. So for 300 Shillings this gives a mean and variance of (and similarly for 400 shillings): $E(p+r) = \overline{x}_{300} = 300 \sum_{i=1}^{2} f_i + \sum_{i=3}^{7} x_i f_i$ and $var(p+r) = (300 - \overline{x}_{300})^2 \sum_{i=1}^{2} f_i + \sum_{i=3}^{7} (x_i - \overline{x}_{300})^2 f_i$

[17] This data is published by the Uganda Coffee Trade Federation in their annual publication: *The Coffee Yearbook.*

Ideally we would have collected data on households' perceptions of coffee yield risk in addition to households' perceptions of coffee price risk. Unfortunately such data was not collected and an alternative strategy is needed to derive individually based estimates of coffee yield risk. As cross-sectional data was collected at two points in time - 2000 and 2003 - two observations of total coffee yield exist for the surveyed households. The difference in yield between the two years gives some indication of variation of yields, but it is likely that estimates based on this alone would be dominated by measurement error rather than provide a true estimate of yield variation. Unexpected variations in yield come primarily from two sources - weather and disease - and we would expect variations in yield per tree as a result of varying weather conditions would be common for a given geographic area. By pooling observations within a given geographic area we can arrive at a cleaner estimate of weather induced yield variation. A measure of yield per tree for household i in locale v, y_{vi}, is given by dividing the total coffee yield (q_{vi}) by the number of coffee trees the household owns (T_{vi}). The following regression was run on the difference in yield per tree between the two years (Δy_{vi}) to estimate the variation in y_{vi} coming from different sources - variation in labour and land allocation per tree (measured by the number of working age members in the household divided by the number of trees and the cultivatable land divided by the number of trees), variation in yield per tree common to households within a given geographic area (w_v) and variation in yield per tree specific to each household (which might largely reflect measurement error, ε_{vi}). The following was estimated by using a fixed effects specification, where the geographic area over which the fixed effect was defined was a county.[18]

$$\Delta y_{vi} = \Delta labour/tree_{vi} + \Delta land/tree_{vi} + w_v + \varepsilon_{vi} \tag{5}$$

[18] A county is one level below a district. Each county had, on average, fifteen sampled households.

Results are shown in Table 2.[19] Estimates of the fixed effect, w_v, were taken to be the difference in yield arising from varying rainfall and climatic conditions.

The variation of total yield of a household will depend not only on variations in the weather, but also on variations in the incidence of disease. In the case of Uganda the major disease that affects coffee yields is coffee wilt disease.[20] The number of trees lost to coffee wilt disease between 2000 and 2003 is recorded for each household. This was used in combination with a measure of the average yield of each tree for that household to estimate the impact of disease on coffee output. The estimate of total difference in quantity as a result of variations in the weather and incidence of disease is thus given as:

$$\widehat{\Delta q_i} = \widehat{w_v} * \overline{T_{vi}} + \Delta_{wilt} T_{vi} * \overline{y_{vi}} \tag{6}$$

where $\Delta_{wilt} T_{vi}$ is the number of trees lost to coffee wilt between 2000 and 2003. The square of $\widehat{\Delta q_{vi}}$ is taken as an estimate of $var q_{vi}$. An estimate of $\overline{q}_i$ is given by $\overline{q_i} = \overline{T_{vi}} * \overline{y_{vi}}$.

Quantitative and qualitative data suggests there is an increase in harvesting effort and thus yield when the price is high, and an estimate of covariance between price and quantity from national figures on quantity of coffee exported and price is found to be positive. However the use of national level data to calculate the covariance may overestimate an individual farmer's covariance between price and quantity (quantity is measured by the amount of coffee exported and there is some evidence that exporters hold stocks of coffee to sell when the price is high) and so results are presented for both the case of zero covariance, and the positive covariance estimated from national data.

[19] Accurate estimates of yield per tree were not available for some households, perhaps because the period coffee output was recorded for and the period the number of trees in production were recalled for are different. Because of this estimates of yield greater than 10 kilos per tree were omitted, which is why the number of observations recorded is only 258.

[20] Coffee wilt disease has been found to be in existence in all coffee producing regions of Uganda. In the worst hit regions as many as 75% of coffee trees have been estimated to have been affected. In the sample of farmers surveyed as part of this work, 85% had experienced coffee disease to some extent.

5.2 Willingness to pay estimates

Expected utility with and without insurance was calculated using this data. Demand for insurance was calculated by determining the number of households for which $EU(Y_{with}) - EU(Y_{without}) > 0$ at different levels of b. Using individual estimates of moments of the yield and price distributions it was estimated that 85% of farmers were willing to pay something to insure their price (at both 300 and 400 Shillings per kilo). Willingness to pay results are presented in summary in Figure 2. The figure indicates the proportion of farmers willing to pay a per kilo premium denoted in Shillings for price protection at 300 Shillings and 400 Shillings respectively. The level of demand is graphed for the lower and upper bounds of the estimated coefficient of partial risk aversion. There is significant demand for insurance among farmers, even at quite substantial per kilo costs of insurance. 75% of farmers are willing to pay 20 Shillings per kilo for price protection at 300 Shillings (6% of the price) and 75% are willing to pay 40 Shillings per kilo at 400 Shillings (10% of the price). There is still significant demand for insurance at much higher premiums, for example half of farmers are willing to pay 20% of the price to insure at 400 Shillings (and a quarter willing to pay 25% of the price).

The conclusion that a substantial proportion of farmers are willing to pay for price insurance at reasonable prices concurs with the findings from the direct question on interest in price protection reported at the end of Section 3 and is in stark contrast to the trader estimates of willingness to pay (to the extent we can compare the two estimates). The results for trader demand at 1000 Shillings per kilo of FAQ (milled coffee) and farmer demand at 400 Shillings of kiboko (unmilled coffee) are most comparable and willingness to pay for a contract offering such protection for 6 months is depicted for traders and farmers in Figure 3. Figure 3 shows that whilst perhaps 80% of farmers would pay enough for price protection as offered through a hedging instrument purchased on the international market (20 - 50 Shillings per kilo), only 3% of traders would. Whilst the trader and farmer results may not be directly comparable, methodological differences are unlikely to explain the substantial difference in demand across a large range of premiums.

The sensitivity of results to changing the specification of the utility function and assumptions of covariance between price and quantity was considered and estimates under different specifications are presented in Figure 4. The top panel of Figure 4 shows that assuming a positive covariance between the price and the quantity of coffee produced increased the estimated willingness to pay for insurance (as would be expected), although only at lower premium levels as the effect tapers of as the premium increases. Overall the difference is not substantial with at most a ten percent difference between the proportion of farmers estimated to be willing to pay at a given premium. The bottom panel of Figure 4 suggests that there is very little difference in estimates of price insurance based on a constant relative risk aversion or a constant partial risk aversion specification. For both graphs two-sample Kolmogorov-Smirnov tests for equality of distribution functions were performed and in both cases the null hypothesis of no difference in the distribution could not be rejected for estimates of willingness to pay at 300 shillings and at 400 shillings.

The estimates of willingness to pay for price insurance show substantial variation in demand among farmers. To examine where this variation is coming from, assumptions of common risk preferences and common price expectations are imposed alternately on the data to determine how this affects estimated demand. The results are depicted in Figure 5. Assuming a constant risk aversion parameter across the population results in little change in the estimates and does not reduce variation, and the Kolmogorov-Smirnov test shows we cannot reject the hypothesis that the distribution functions are equal (the test yields a p-value of 0.947 for willingness to pay at 300 shillings, and a p-value of 0.672 for willingness to pay at 400 shillings). Using a measure of yield variance based on national statistics also appears to do little to alter the variation observed in estimates of willingness to pay, although it appears the premium farmers are willing to pay increases slightly. This is indeed confirmed by a Kolmogorov-Smirnov test, the hypothesis of equality of distributions is rejected in favour of the hypothesis that the values in the distribution function under national estimates are larger than the values in the distribution function under individual estimates (a p-value of 0.037 and 0.000 is reported).

However, when no heterogeneity in price expectations is assumed and expectations are based on national estimates of the future price distribution, the demand schedule is effectively compacted to premiums between 12.5% and 21% of the insured price: all farmers will be willing to pay a 12.5% premium to insure the price, even at the low price of 300 shillings per kilo, but no farmer would pay more than 21%. Using national price expectations data greatly reduces the variation observed in demand for price protection. This is confirmed by the Kolmogorov-Smirnov test. The hypothesis of equality of distributions is strongly rejected (the test yields a p-value of 0.000 for both willingness to pay schedules), and the hypotheses that the distributions based on individual estimates are bigger and smaller than the distributions based on national estimates are found to be true.

It would thus appear that understanding the variation in farmer's perception of the price risk they face is key to understanding variation in the cost of price risk to farmers. The next section examines potential explanations for observed variation in subjective price expectations.

6 Understanding differences in perceptions of risk

The question this section seeks to answer is why perceptions of price risk vary so much across households. In particular, whether price risk does vary across farmers or whether perceptions of price risk vary perhaps as a result of differential access to market information or heterogeneity in the way individuals update their beliefs.

Economic theory would have us believe that individuals base beliefs on a rational weighting of the information available to them, updating their beliefs with new information in a Bayesian manner. Variation in beliefs across individuals in this framework arises as a result of varying experiences of price risk and variation in access to price information. Some empirical studies have shown perceptions of risk held by individuals are broadly consistent with a Bayesian framework (Viscusi 1985; McCluskey and Rausser 2001; Smith and Johnson 1988). However, the behavioural economics literature tells us that the formation of beliefs is much more complex than a theory based on Bayesian updating alone would suggest (Mullainathan and Thaler 2000). Tversky and Kahneman (1974) show that people rely on a number of heuristic principles to simplify the complex task of assessing probabilities of uncertain events . These heuristic tools, whilst useful, can lead to systematic errors in the subjective assessment of probability. Some examples of the impact of these heuristic tools on forming perceptions are: overconfidence (good outcomes are attributed to personal skill and bad outcomes to bad luck, Miller and Ross 1975), extrapolation, making judgements based on salience (the availability heuristic, Kahneman and Tversky 1973) and making judgements based on similarity (the representativeness heuristic, Tversky and Kahneman 1974). An observed dependence of judgements and confidence on moods offers another point of departure from a Bayesian model. People in good moods have been found to hold more optimistic beliefs than people in bad moods (Kavanagh and Bower 1985; Wright and Bower 1992), and Kramer, Newton, and Pommerenke (1993) find that positive moods not only cause more optimism, they also encourage increased confidence about the optimistic expectations held.

Evidence of an impact of mood in forming beliefs, evidence of excessive overweighting of recent and salient experiences, or the use of irrelevant information in forming beliefs about the coffee price would indicate perceptions of risk are not formed in a Bayesian manner. Much of the empirical work on the formation of beliefs has been based in developed countries (often using tests conducted in university laboratories). By examining the causes of variation in perceptions of risk among coffee farmers in Uganda we can gain some understanding of the formation of beliefs in a developing country context for a source of income risk of great significance to the individuals involved. The extent to which these factors can be identified with the available data is somewhat limited, but by examining variables that reflect variation in coffee price received (R), access to market information (I) and non-Bayesian behaviour in updating beliefs (E) through the following regressions:

$$variance(p) = \beta_0 + \beta_R R + \beta_I I + \beta_E E + \varepsilon \quad (7)$$

$$mean(p) = \beta_0 + \beta_R R + \beta_I I + \beta_E E + \varepsilon \quad (8)$$

we can arrive at a first understanding of the relative importance of these factors in influencing beliefs about the mean and variance of the future price. The next section describes how we try to identify variables that reflect R, I and E with the data available.

6.1 Testing causes of variation in risk perceptions

Diversity of private information is a cause of heterogeneity in price perceptions across farmers that is consistent with a Bayesian framework. We would expect farmers with access to more information to have more accurate beliefs. Given nearly all farmers underestimated the variance of the future price, greater access to market information may lead to a higher perceived variance of the price distribution and a positive coefficient can be expected on any variable which represents increased access to market information. The impact of access to information variables on the expected price may be less clear given some farmers overestimated and some underestimated the expected price. Farmers that are members of farmer's groups or live closer to markets might have greater access to price information, and variables reflecting these are included. Conversation has been shown to be critical in the formation of beliefs (Shilier 1995) and whilst there is no detailed data on social interactions in the data set that would be ideal for examining this, a dummy taking the value 1 if the household received price information from a source other than the person who purchased their coffee and 0 otherwise is used, as is a dummy taking the value of 1 if the farmer is a member of a farmers group.

Given there is one integrated market for coffee in Uganda and price fluctuations at the border are passed on to farmers one would expect farmers' experience of price to be quite uniform, and thus farmers' price expectations quite similar. However, there is substantial price fluctuation within the crop year and farmers vary as to what time of year they sell coffee as a result of regional variations in harvesting times.[21] The impact of these agroclimatic differences on timing of coffee sales is a priori unclear but is captured through the use of a season dummy which takes the value of 1 if the household is located in the west of the country and 0 if the household is located in the centre of the country. Variation in the timing of coffee sales also depends on whether a farmer can store coffee and mitigate the effects of low prices by waiting to sell coffee when the price rises. A dummy taking the value 1 if the household reported storing coffee and 0 otherwise is included. The ability to store coffee suggests coffee can be sold when it is more beneficial to a farmer, thus we expect farmers who can store coffee perceive a distribution with a higher mean and lower variance than those who cannot.

Farmers also receive a different price for coffee depending on the type of coffee they sell, and whether they sell at the market or farm-gate. There are three main types of coffee that are sold: wet cherries, dry unmilled cherries (kiboko) or milled cherries (FAQ). Sales of wet coffee are often made as an emergency sale for immediate cash - the coffee is sold when it has not been dried, leaving the trader to dry the coffee. The quality of the coffee is jeopardised through making sales of this type and when farmers sell in this way they receive a lower price. Farmers who mill coffee

[21] For central regions in Uganda, the main harvest season is from November to January. For western regions the main harvest season is from May to August.

and sell it as FAQ receive a higher price as do farmers who travel to the market to sell kiboko (Fafchamps and Hill 2005). A dummy for sales of wet coffee, taking the value 1 if coffee was sold wet in the last year, is included as is a dummy that takes the value of 1 if the household sells at the market (but not a dummy for FAQ sales as only 2% of farmers recorded as having sold FAQ in the year prior to the survey). Given wet sales reduce the price received for coffee we may expect farmer who engage in them to have lower expectations about the future price. By lowering the price received they also increase the variance of the price experienced by farmers who sometimes make sales of wet coffee and thus these farmers may also anticipate a higher variance of the future price. Given selling at the market increases the price received for coffee, we may expect farmer who sell there will expect a higher price, however, selling coffee at the market may also be indicative of greater access to market information.

The most recent price the farmer received is perhaps the best indication of a household's experience of the coffee price, and given the permanence observed in the coffee price, the higher this is the higher will be the expected price. However, despite the permanence observed in the coffee price, excessive adaptation of beliefs to recent prices may indicate the use of the availability heuristic in which information recently received is overweighted. However, it is not possible for us to test whether this is the case using only information on the recent price. If the most recent price received also indicates, in some way, the ability of the household to avoid receiving a low price for coffee we might expect a negative relationship between the last price received and the perceived variation of the price. Otherwise, a significant relationship between the last price received and beliefs about the variance of the future price is not expected within a Bayesian framework. However, the observation that individuals in better moods tend to be more optimistic and confident in their beliefs might lead us to expect a negative relationship between the last price received and expected variation of the future price.

To test the presence of non-Bayesian updating we turn to the concepts of salience and illusory correlation. Past experiences of the coffee price that are particularly salient, such as prices so low as to leave farmers with less income than they need, may affect both expected return and the expected variability of the return. Empirically distinguishing whether or not households give excessive weight to past experiences is quite difficult. To try and capture the impact of salient information in forming beliefs, a dummy that records whether the farmer recalled experiencing a low coffee price such that the household was prevented from buying what it needed was included. It is assumed this is a more salient memory than a low coffee price that did not impact the household in this way. If this is the case a household that has experienced a negative price shock would be more likely to expect a lower price level and perhaps a higher variance in the price. More generally, we can expect coffee price shocks to have a greater impact on households with low levels of income and a higher share of income from coffee, and so a measure of liquid wealth (liquid wealth per capita) and the importance of coffee as a source of income (number of trees per hectare) are included.

Shocks to coffee income that arise from sudden falls in yield (as a result of disease or bad weather) but are associated with a higher probability of sudden falls in the price could indicate the presence of illusory correlation in forming beliefs. A dummy taking the value 1 if the household has experienced coffee wilt disease in the last three years is also included as a measure of coffee yield risk. If illusory correlation is present, coffee wilt shocks will lower the price level and perhaps raise the variance of the expected price.

The gender of the household head is included as some literature suggests women perceive risks to be higher than men (Lundeberg et al. 1994), and the number of years of education of the household head is also included in case this has an impact on the way beliefs are updated. Age of household head is also included for this reason and in case it indicates a different history of experience of the coffee price.

Descriptive statistics for the variables used are presented in Table 4. The most recent price received by coffee farmers is on average 29 cents per kilo of FAQ equivalent, but the standard deviation of this price is 8 cents which suggest variation in the experience of coffee prices is significant among these farmers. 16% of farmers were recorded as having sold coffee wet at some point in the year prior to the survey and 74% of farmers replied that they sometimes stored coffee after it was harvested. The descriptive statistics also suggest there is variation in access to price information across farmers. Slightly less than half (45%) received price information from someone other than who they sold coffee to, 15% belong to a farmer's group, 18% of coffee farmers had sold coffee at the market and the distance of farmers from the nearest market varies widely with a median of 6.25 miles. Recent shocks to coffee price and coffee yield have not varied much across farmers with 90% of farmers recorded as not having enough income for what they need as a result of a low coffee price and 85% experiencing an incidence of coffee wilt disease in the last three years.

6.2 Results

Non-parametric estimates of the relationship between the most recent price received and the future price distribution are displayed in Figures 6 and 7. The higher the most recent price received the higher the expected price as predicted (Figure 6), and also the lower is expected variance (Figure 7). Regression analysis is conducted to examine the significance of these relationships and other possible covariates. Regressions using expected price and expected coefficient of variation of the price as dependent variables were run and results are presented in Table 5. Reported standard errors have been corrected for clustering at the village level.

Turning first to the results for expected price (column 1) we find that, in concurrence with the non-parametric results, the most recent price received is strongly and significantly positive in predicting the expected price of coffee in 6 months time. This is consistent with a Bayesian understanding of the formation of beliefs but could also be consistent with the use of the availability heuristic. Farmers that reported sometimes selling coffee wet have lower expectations of the future price which seems to confirm that farmers receive a lower price for coffee when they sell in this way. Farmers who received information about the coffee price from someone other than the person they sold to also have lower expectations of the coffee price, which is at odds with the anticipated sign. All other possible covariates were found to be insignificant.

The model was more successful in explaining some of the heterogeneity in beliefs about the variance of the future price. Variables that characterise a household's coffee trading pattern appear to correlate strongly with perceptions of price risk (although the season dummy was insignificant, perhaps as expected). Households that are able to store coffee have a significantly lower perception of risk. This could indicate that storing coffee is a means by which households can mitigate some of the price risk they face reducing their experience of price risk and perception. However, the causality could also run the other way: households that store only do so because they do not perceive a large risk in storing coffee whilst those that believe the price of coffee is highly variable will not undertake the risk of storing this commodity. Although the regression analysis conducted highlights a correlation, it is not able to determine the causal relationship underlying it. Some information on whether the household has access to storage facilities which it uses for other crops would enable us to examine this relationship further, but unfortunately such information is not available. Higher price risk is also perceived if coffee is sometimes sold wet. As sales of wet coffee are often made at times of emergency when the household's need for money forces them to sell for a low price, it may be that households who do not have to sell coffee wet are subject to less price variability. However it may be that households who perceive the coffee price to be very volatile are more likely to sell coffee wet, as they fear the price of coffee will fall whilst it dries. Long run data on the timing of wet coffee sales is needed to determine the causality of this observed relationship.

Increased access to price information appears to increase the accuracy of risk perceptions. Receiving price information from someone other than the trader to whom coffee is sold, being a member of a farmers group, selling coffee at the market and proximity to a coffee market all increase the amount of market information a farmer has access to and all increase the expected variance of the coffee price, making perceived variation a truer reflection of actual variation of the price of coffee. Although none of these variables are strongly significant, an F-test on the joint significance of these market information variables is $F(4, 78) = 3.80$ for the coefficient of variation in July, which means we can reject the null of zero coefficients with 99% confidence.

Again we find the regression results concur with the non-parametric results, and the last price received has a negative impact on expectations about the price. Farmers who recently received a higher price for coffee may be those that are able to avoid low coffee prices, although given we have controlled for the ability of the household to store coffee and other characteristics of the sale it is not clear what the mechanisms used to do this would be. It may be that a model based on Bayesian updating alone cannot explain the negative relationship observed. Recent good performance tends to make individuals more optimistic and confident, and it is possible that this is what is being observed here. If receiving a low coffee price induces pessimism about the price these results also confer with work which perceptions formed in negative moods are actually more accurate (Au, Chan, Wang, and Vertinsky 2003), as individuals that received a lower price had truer beliefs about the future variance of the coffee price.

Also in support of the idea that individuals are not perfectly Bayesian in the way they update their beliefs is the significance of the coffee wilt shock dummy in explaining beliefs about the variation of the coffee price. The presence of coffee wilt disease increases yield, but not price uncertainty and the fact that farmers that have experienced coffee wilt shocks in the last three years view the coffee price as more variable is perhaps indicative of the importance of illusory correlation in forming beliefs. However the three variables included to try and identify the impact of salient experiences in forming beliefs - negative price shock dummy, per capita wealth and the number of coffee trees per acre - were all found to be insignificant. A test of the joint significance of the last price received, coffee wilt shock, negative price shock, per capita liquid wealth and share of land planted to coffee is $F(5, 78) = 5.86^{***}$ which means we cannot reject the presence of non-Bayesian behaviour in the formation of beliefs. However the extent to which this can been properly explored with the available data is limited, and this result indicates the need for more research more than anything else.

Given the difference between the data available and the data really needed to test the importance of the three factors - R, I and E - in forming beliefs, the conclusions we can make based on this analysis are limited. Much of what this analysis has been able to do is to highlight correlations observed in the data, rather than to arrive at any causal understanding of the processes at work. Greater information on past prices received, memories of past prices, timing of sales and ability to store is needed to further understand the formation of beliefs. It is clear that the most recent price received is important in forming beliefs about the expected value and volatility about the future price, and that access to information on prices influences perceived risk. We have also been able to determine that there is some evidence in the data consistent with the hypothesis that farmers face varying degrees of price risk based on how they sell and with the hypothesis that non-Bayesian methods of updating are used in the formation of perceptions of risk.

7 Conclusion

This paper has considered who is vulnerable to price risk in the post liberalisation market structure. Exporters are exposed to price risk but appear able to mitigate its effects through the structure of contracts and the use of hedging instruments. Domestic traders seem to be subject to very little price risk on account of high turnover and their ability to pass price changes quickly on to producers. As producers have no-one to pass price changes onto and do not partake in forward contracting they are very exposed to price risk. Substantial demand among farmers for price insurance confirms the hypothesis that farmers face substantial price risk. High demand for price insurance was in evidence whether or not we allow for variation in farmer's perception of price risk, but when data on individual perceptions of risk was used to estimate demand for insurance, wide variation in willingness to pay for insurance was found. This varying cost of price risk was analysed by considering how perceptions of price risk were found to vary across farmers. Access to price information was found to influence the degree of risk perceived. Evidence consistent with heterogeneity in price risk faced by farmers and with the presence of non-Bayesian updating was also observed, but further research is required to confirm these hypotheses.

In rural Uganda, only 8% of households have access to bank savings instruments and as a result households often save in the form of assets such as land and livestock (Kiiza and Pederson 2001; Mpuga 2004). The sale of these assets could allow the farmer to insure income when the coffee price is low, but the cost of selling productive assets such as these can be high as it means the loss of future returns from these assets. The cost per kilo of using livestock to insure the coffee price at \$0.16 per kilo was crudely estimated as between \$0.04 and \$0.09 whereas, in comparison, the cost of price insurance provided by a Robusta coffee put option at the time of the survey was \$0.002 - \$0.006 per kilo. The analysis put forward here suggests the provision of insurance options such as these would increase the welfare gains to farmers from coffee market liberalisation. Although more research is needed into why storing coffee, and sales of wet coffee are correlated with perceived price volatility, initial results indicate that in the absence of insurance access to storage and the prevention of wet sales may help to moderate farmer's price risk.

References

Au, K., F. Chan, D. Wang, and I. Vertinsky (2003). Mood in foreign exchange trading: Cognitive processes and performance. *Organizational Behavior and Human Decision Processes 91*, 322–338.

Binswanger, H. (1981). Attitudes toward risk: Theoretical implications of an experiment in rural India. *The Economic Journal 91*, 867–890.

Bonger, T., J. Ddumba-Sentamu, and R. Nabumba (1999). The structure, conduct and performance of the post-reformed coffee marketing system in Uganda. Kampala, Uganda.

Buchanayandi, T. and D. Kiwanuka (1996). The dynamics in coffee trade in Uganda (a possible move from monopoly to a cartel). Kampala, Uganda.

Deaton, A. and G. Laroque (1992). On the behaviour of commodity prices. *Review of Economic Studies 59*(1), 154 – 192.

Deaton, A. and G. Laroque (1996). Competitive storage and commodity price dynamics. *Journal of Political Economy 104*(5), 896 – 915.

Dercon, S. (2002). Income risk, coping strategies and safety nets. *The World Bank Research Observer 17*(2), 141 – 166.

Diamond, P. and J. Hausman (1994). Contingent valuation: Is some number better than no number? *Journal of Economic Perspectives 8*(4), 45 – 64.

Fafchamps, M. and R. V. Hill (2005). Selling at the farm-gate or travelling to market. *American Journal of Agricultural Economics*, forthcoming.

Fafchamps, M., R. V. Hill, R. W. Nsibirwa, and A. Kaudha (2003). The transmission of international commodity prices to domestic producers. Centre for the Study of African Economies

Working Papers WPS/2003-14.

Fafchamps, M., C. Udry, and K. Czukas (1998). Drought and saving in west Africa: Are livestock a buffer stock? *Journal of Development Economics 55*(2), 273–305.

Fraser, R. W. (1992). An analysis of willingness to pay for crop insurance. *The Australian Journal of Agricultural Economics 36*(1), 83–95.

Gautam, M., P. B. R. Hazell, and H. Alderman (1994). *Rural demand for drought insurance.* Policy Research Working Paper No. 1383. Washington, D.C: World Bank Policy Research Department: Washington DC.

Gersovitz, M. and C. Paxson (1990). The economies of Africa and the prices of their exports. Princeton University, Studies in International Finance, No. 68.

Hanemann, W. M. (1994). Valuing the environment through contingent valuation. *Journal of Economic Perspectives 8*(4), 19–43.

Kahneman, D. and A. Tversky (1973). On the psychology of prediction. *Psychological Review 80*, 237–251.

Kavanagh, D. J. and G. H. Bower (1985). Mood and self-efficacy: Impact of joy and madness on perceived capabilities. *Cognitive Therapy and Research 9*, 507–525.

Kawuma, F. S. M. and J. N. Byarugaba (1996). Prognosis of the coffee trade in Uganda: A review of liberalisation and its impact on the coffee trader in Uganda and the role of the Uganda Coffee Trade Federation. Uganda Coffee Trade Federation, Kampala, Uganda.

Kiiza, B. and G. Pederson (2001). Household financial savings mobilisation: Empirical evidence from Uganda. *Journal of African Economies 10*(4), 390–409.

Kramer, R. M., E. Newton, and P. L. Pommerenke (1993). Self-enhancement biases and negotiator judgment: Effects of self-esteem and mood. *Organizational Behavior and Human Decision*

Processes 56(1), 110–133.

Lim, Y. and R. M. Townsend (1998). General equilibrium models of financial systems: Theory and measurement in village economies. *Review of Economic Dynamics 1*(1), 59–118.

Lundeberg, M. A., P. Fox, and J. Puncochar (1994). Highly confident but wrong: Gender differences and similarities in confidence judgements. *Journal of Educational Psychology 86*, 114 – 121.

McCluskey, J. J. and G. C. Rausser (2001). Estimation of perceived risk and its effect on property values. *Land Economics 77*(1), 42 – 56.

Miller, D. T. and M. Ross (1975). Self-serving bias in attribution of causality: Fact or fiction? *Psychological Bulletin 82*, 213–225.

Morduch, J. (1995). Income smoothing and consumption smoothing. *Journal of Economic Perspectives 9*(3), 103–114.

Mpuga, P. (2004). Demand for credit in rural Uganda: Who cares for the peasants? A paper presented at the Conference on Growth, Poverty Reduction and Human Development in Africa Centre for the Study of African Economies, March 21-22 2004.

Mullainathan, S. and R. H. Thaler (2000). Behavioral economics. NBER Working Paper Series, No. 7948.

Rosenzweig, M. and K. Wolpin (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investment in bullocks in India. *Journal of Political Economy 101*(2), 223–244.

Sakurai, T. and T. Reardon (1997). Potential demand for drought insurance in Burkina Faso and its determinants. *American Journal of Agricultural Economics 79*, 1193–1207.

Sarris, A. (2002). The demand for commodity insurance by developing country agricultural producers: Theory and an application to cocoa in Ghana. World Bank Policy Research Working Paper Series No. 2887, Washington DC.

Scandizzo, P. L. and J. L. Dillon (1979). Peasant agriculture and risk preferences in northeast Brazil: A statistical sampling approach. In J. A. Roumasset, J.-M. Boussard, and I. Singh (Eds.), *Risk, Uncertainty and Agricultural Development*, pp. 133–160. New York, New York: Agricultural Development Centre.

Sherrick, B., P. J. Barry, P. N. Ellinger, and G. Schnitkey (2004). Factors influencing farmers' crop insurance decisions. *American Journal of Agricultural Economics 86*(1), 103–114.

Shilier, R. J. (1995). Conversation, information and herd behavior. *American Economic Review 85*(2), 181–185.

Smith, K. and F. R. Johnson (1988). How do risk perceptions respond to information? the case of Radon. *The Review of Economics and Statistics 70*(1), 1–8.

Tversky, A. and D. Kahneman (1974). Judgement under uncertainty: Heuristics and biases. *Science 185*(2), 1124 – 1131.

Viscusi, W. K. (1985). Are individuals Bayesian decision makers? *American Economic Association Papers and Proceedings 75*(2), 381–385.

Wik, M. and S. Holden (1998). Experimental studies of peasants' attitudes toward risk in northern Zambia. Discussion Paper D -14, Department of Economics and Social Sciences, Agricultural University of Norway.

Wright, W. F. and G. H. Bower (1992). Mood effects on subjective probability assessment. *Organizational Behavior and Human Decision Processes 52*(2), 276–291.

Option	Mean payoff	Stnd. dev. of payoff	Range of S compatible with this choice	No. of respondents
6000 shillings, 6000 shillings	6000	0	7.33 - ∞	67
5400 shillings, 9600 shillings	7500	2100	1.86 – 7.33	52
4800 shillings, 12000 shillings	8400	3600	0.63 – 1.86	54
2400 shillings, 18000 shillings	10200	7800	0.275 – 0.63	81
0 shillings, 24000 shillings	12000	12000	0 – 0.275	46

Table 1: Description of lotteries offered

	Expected Price		Expected Variance	
	Historical	Subjective	Historical	Subjective
6 months	0.245	0.219 (0.055)	0.013	0.007 (0.003)
truncated at 300 sh	0.249	0.235 (0.046)	0.008	0.006 (0.003)
truncated at 400 sh	0.267	0.258 (0.033)	0.006	0.005 (0.002)

Table 2: Expectations of the future price of coffee (standard deviation shown, where appropriate, in brackets)

Dependent variable is change in yield per tree		
Change in labour per tree	2.93	(2.12)
Change in land per tree	1.76	(2.05)
Constant	0.09	(0.14)
Number of observations	258	
Number of groups	16	
F(2, 240)	F(2,240) = 10.29***	
F-test that all fixed effects=0	F(15, 240) = 2.22***	
Fraction of variance due to the fixed effects	0.175	

Table 3: Determinants of changes in yield

	Mean	**Median**
Most recent price received	0.287	0.292
Coffee sold wet	0.159	-
Stores coffee	0.743	-
Price information from other than trader	0.454	-
Member of farmer's group	0.152	-
Coffee sold at market	0.179	-
Distance from nearest coffee market (miles)	10.935	6.25
Age of coffee farmer	51.322	50
Education of coffee farmer	5.566	5
Gender of coffee farmer	0.235	-
Liquid wealth per capita (US$ per capita)	695.49	228.07
Trees planted per acre	118.784	50
Season (1= western season)	0.502	-
Negative price shock	0.894	-
Coffee wilt disease shock	0.848	-

Table 4: Descriptive statistics

	Expected Price (July)	Coefficient of Variation (July)
Last price received	0.124 (0.043***)	-0.447 (0.101***)
Negative price shock	-0.006 (0.010)	0.037 (0.027)
Coffee wilt disease shock	-0.018 (0.013)	0.061(0.026**)
Stores coffee	0.011 (0.008)	-0.060 (0.020***)
Coffee sold wet	-0.0159 (0.009**)	0.042 (0.024*)
Coffee sold at market	-0.010 (0.010)	0.034 (0.024)
Received price information from someone other than buyer of coffee	-0.017 (0.007**)	0.033 (0018*)
Member of farmer's group	-0.003 (0.009)	0.039 (0.023*)
ln(distance to coffee market)	0.001 (0.004)	-0.013 (0.009)
Age of coffee farmer	-0.0002 (0.002)	0.0002 (0.0005)
Education of coffee farmer	0.001 (0.001)	-0.002 (0.002)
Gender of coffee farmer	-0.004 (0.007)	-0.024 (0.020)
ln (liquid wealth per capita)	0.0003 (0.003)	-0.007 (0.007)
Coffee trees per acre	$6.28\ 10^8$ ($9.92\ 10^6$)	0.00003 (0.00003)
Western season dummy	-0.004 (0.009)	0.019 (0.020)
Intercept	0.211 (0.031***)	0.503 (0.070***)
Number of observations	282	282
$F(15, 68)$	2.57***	4.49***
R-squared	0.104	0.193

Table 5: Determinants of price expectations, standard errors are corrected for clustering at the village level in columns 1 to 4 (*** denotes significant at 0.01, ** at 0.05, * at 0.1 and ' at 0.15)

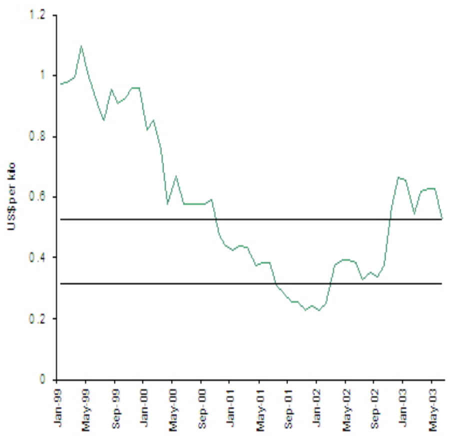

Figure 1: Domestic FAQ price of coffee during the last three years

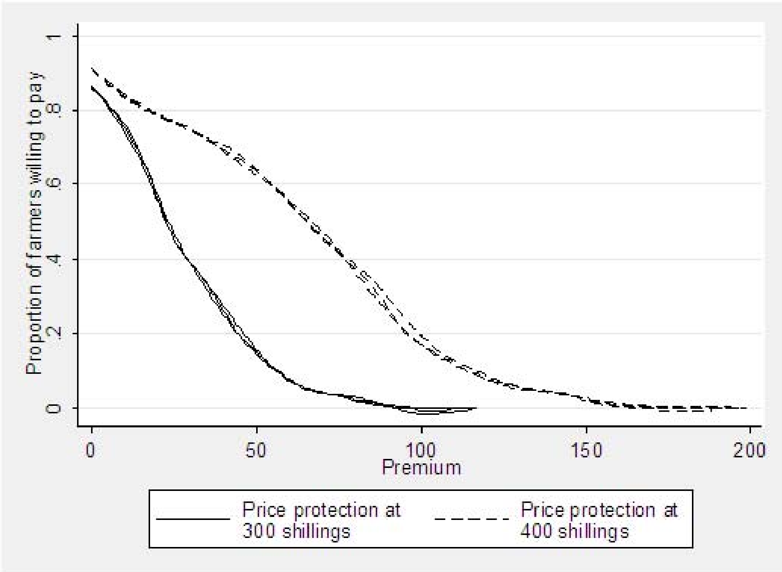

Figure 2: Proportion of farmers willing to pay for insurance at a given premium per kilo of kiboko

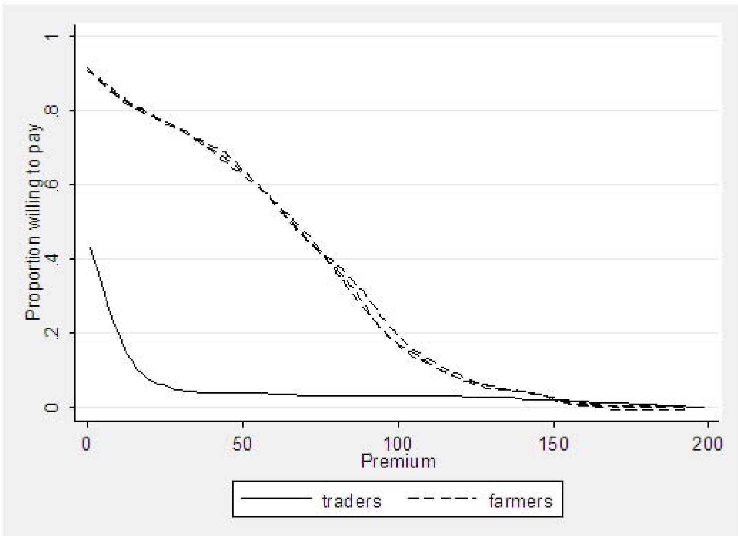

Figure 3: Proportion of farmers and traders willing to pay for an insurance contract offering protection at 400 shillings per kilo of kiboko (1000 shillings per kilo FAQ) at a given premium per kilo of kiboko

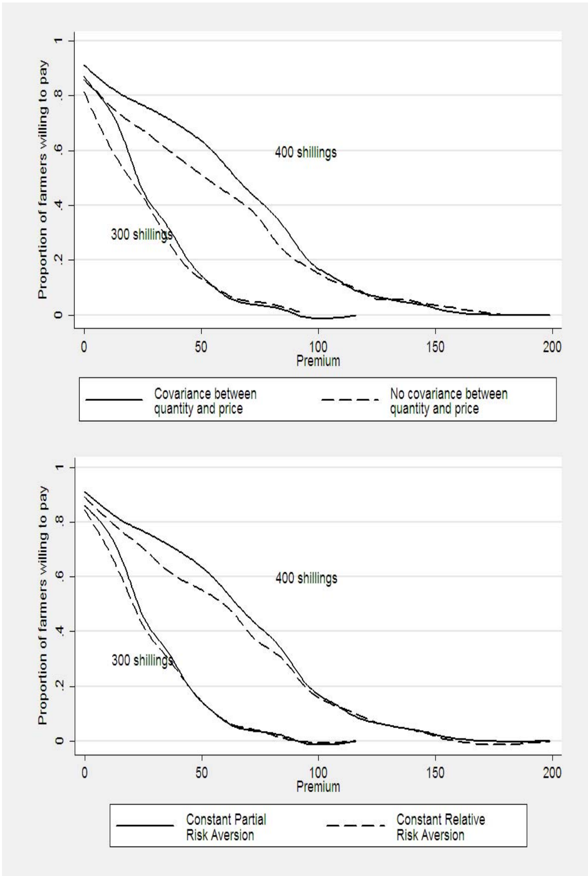

Figure 4: Proportion of farmers willing to pay for price insurance at a given premium per kilo of kiboko. The top panel shows estimates with and without covariance between price and quantity. The bottom panel shows estimates of risk aversion using alternately a CRRA and CPRA utility function.

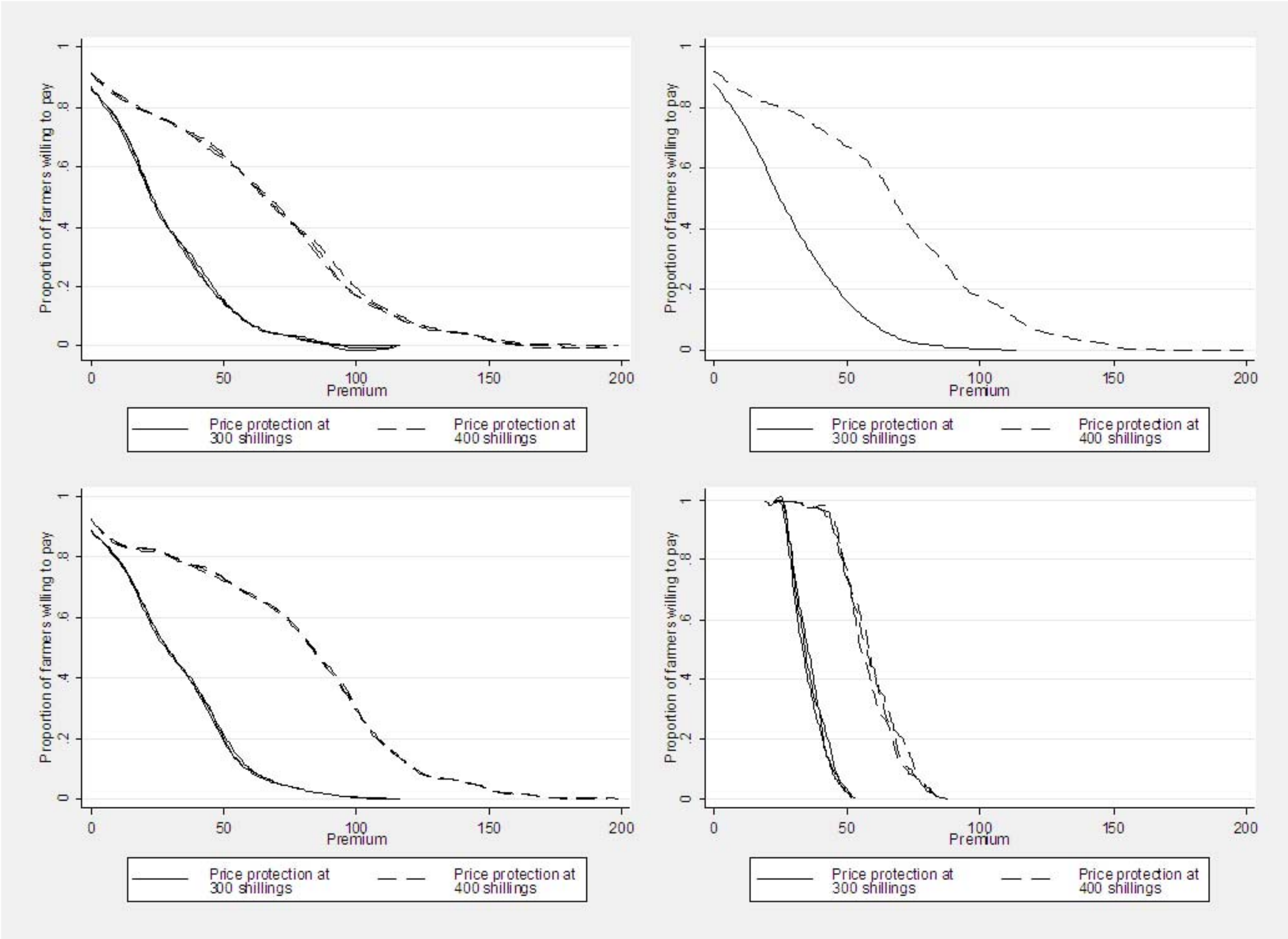

Figure 5: Proportion of farmers willing to pay for price insurance at a given premium per kilo of kiboko. The top left graph uses individual estimates of risk aversion and price expectations. The top right graph uses a common estimate of CPRA=3. The bottom left graph uses a common estimate of variations in yield based on national data. The bottom right graph uses a common estimate of variations in price based on national data.

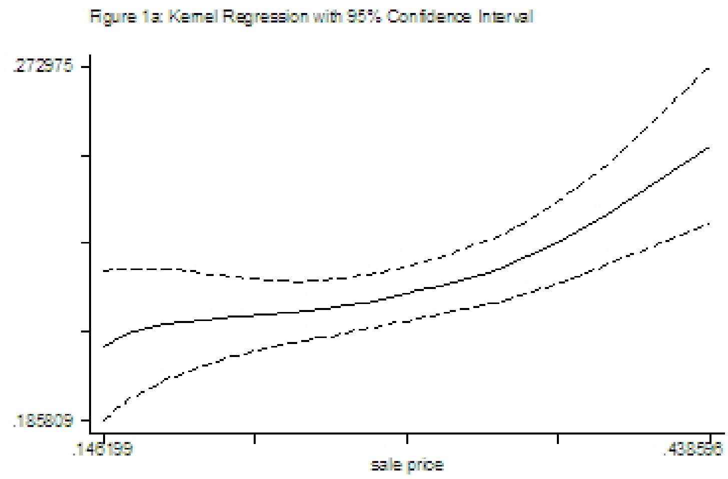

Figure 6: Non-parametric estimation of the relationship between expected price in 6 months and most recent price received

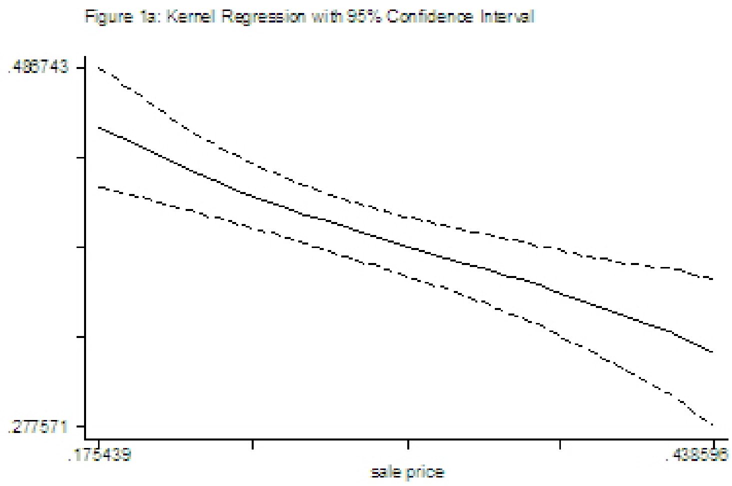

Figure 7: Non-parametric estimation of the relationship between coefficient of variation in 6 months and most recent price received