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The welfare effects of coffee price volatility for Ethiopian coffee producers*

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Abstract

This paper estimates the welfare effects for Ethiopian coffee producers from eliminating coffee price volatility. To estimate volatility the GARCH technique is applied to monthly coffee prices in Ethiopia for the period 1976-2012. To distinguish between the unpredictable and predictable components of volatility we obtain separate estimates of the conditional and unconditional variance of the residual. This is combined with estimates of the coefficient of relative risk aversion to measure the welfare effects from eliminating the unpredictable component of price volatility. A key finding is that the welfare gain from eliminating coffee price volatility is small; the gain per producer comes to a meagre US$ 0.76 in a year. This has important policy implications for the efficacy of price stabilisation mechanisms for coffee producers, i.e. any attempt to eliminate coffee price volatility at a cost may not be a preferred outcome for Ethiopian producers. The contribution of the paper lies in using the unconditional variance as it more truly reflects price risk faced by coffee producers without overestimating it.

Keywords: Ethiopia, coffee producers, coffee price volatility, welfare effects, GARCH

JEL classifications: D13, D80, D81, O13, Q12, Q13

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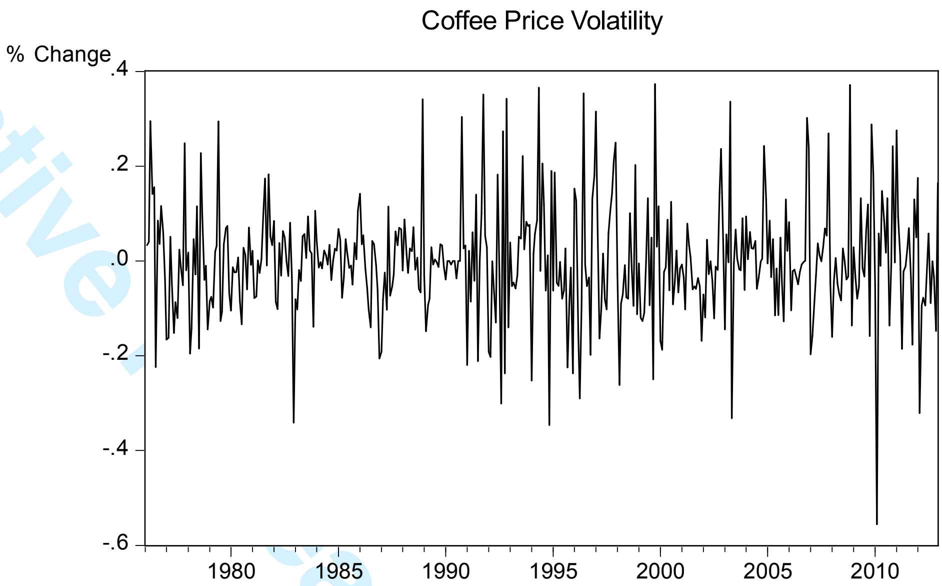
1. Introduction

The impact of market reform programmes on coffee price volatility in Ethiopia was discussed in a paper by Gemech and Struthers (2007).[1] That study covered the period 1982 to the end of 2001 using monthly data and compared the degree of volatility pre- and post-market reforms. Using the generalised autoregressive conditional heteroskedasticity (GARCH) technique, the evidence was clear that the degree of volatility increased dramatically in the post-reform period. In the current paper the extent of price volatility and its increased amplitude after 1992 is evident from a visual inspection of Figure 1, which reveals striking differences between real coffee price behaviour before the reform period (1976-91) and that after the reform period (1992-2012). It appears that prices were relatively tranquil before the reforms and became much more volatile after the market reforms were adopted, clearly displaying the phenomenon of volatility clustering.

[1] Unless specified otherwise, 'coffee' means green (raw or un-roasted) beans and coffee prices imply prices of green beans. There is no exact definition of price volatility, in general it is an estimate of the range within which prices might vary at a future time. Prices are said to be volatile when the range in which they might fall (rise) at a future date widens. An increase in price volatility therefore implies greater uncertainty about future prices.

Fig. 1: Changes in the log of monthly (real) coffee price, 1976 –2012 (ICO, 2014)



One of the issues raised but not addressed in the paper by Gemech and Struthers (2007) relates to the welfare implications of the increase in coffee price volatility for Ethiopian coffee producers (hereafter referred to as producers). In this paper we ask the following question: to what extent would a producer prefer the relative stability of prices of the pre-reform period, albeit with lower average prices, to the higher average prices of the post-reform period, but if those higher average prices are accompanied by greater volatility? This question is of interest for a number of reasons. Firstly, from a theoretical perspective, the issue is essentially an exercise in estimating the welfare effects of commodity price volatility. In the context of this paper, welfare effects refer to the potential cost or benefit from reducing or eliminating uncertainty arising from price volatility.[2] To estimate the welfare effects this paper applies concepts from expected utility theory of relative risk premia and specific risk aversion

[2] Price volatility indicates the range within which prices might vary in the future. An increase in price volatility will affect coffee producers as it reduces the accuracy of their forecasts of future prices exposing them to higher levels of price risk. It is difficult to define exactly the price risk exposure of a producer. The most accepted interpretation is the difference in the expected sale price, on the basis of which a producer makes production and marketing decisions, and the actual sale price. How price risk affects producers will vary according to their individual circumstances. In general, it affects their ability to optimise output because the exposure to risk and inability to insure against it may induce them to adopt sub-optimal input usage and engage in low risk activities that result in more stable but lower income.

parameters such as the constant relative risk aversion. Constant relative risk aversion (CRRA) means that the proportion of wealth that economic agents are willing to expose to risk does not change as the level of wealth changes. At one level, this is an exercise in asking what the *certainty equivalent* is to the average farmer from contrasting the two possibilities outlined above.

Secondly, the issue is of great importance to the long-standing policy debate as to whether or not stabilisation policies for primary commodity prices are worthwhile. If the welfare gain from eliminating price volatility is negligible, then this begs the question as to whether the benefits derived from price stabilisation interventions are worth the costs of setting up such interventions (such as buffer stocks, marketing boards, production and marketing regulations).

The welfare gains for producers from eliminating coffee price volatility using a framework developed by Lucas (1987; 2003) are estimated. The paper also extends the literature on commodity price volatility that typically applies the GARCH econometric technique to measures of coffee price volatility. This is achieved by decomposing the standard measure of volatility, the variance, into two separate measures, the conditional and unconditional variance - where these reflect producers' probabilistic assessments of their predictable and unpredictable price volatilities. It is the unpredictable price volatilities that more truly reflect price risk faced by coffee producers. The results suggest that the welfare gains for producers from eliminating the unpredictable coffee price volatilities are negligible. This has important implications in the policy arena in terms of the efficacy of traditional commodity price stabilisation schemes. Since the welfare gains for producers are very small, any multilateral or unilateral market interventions to reduce price volatility or stabilise coffee prices may not be in the interests of coffee producers.

The paper is organised as follows. Section 2 discusses the importance of coffee for the Ethiopian economy and the evolution of coffee marketing policies. Section 3 identifies the methodology for estimating the welfare effects for producers from eliminating coffee price volatility. Section 4 estimates the price risk (uncertainty) faced by producers from coffee price volatility. Section 5 estimates the welfare gains for producers from eliminating coffee price volatility; and Section 6 concludes.

2. Coffee and the Ethiopian economy

Coffee is at the heart of the Ethiopian economy. It is the country's most important export product, accounting for around 32 percent of the value of all merchandise exports and around 16 to 20 percent of the country's total foreign exchange earnings over the years 2011 to 2013 (ICO, 2013).The land area under coffee cultivation is difficult to determine because plots are fragmented and interspersed with other crops. It is estimated, however, that over the period 2011-13, the area under coffee trees ranged from 450,000 to 500,000 hectares, with annual production ranging from 400,000 to 480,000 tonnes (CSA, 2014; ICO, 2014; FAO, 2014). Coffee is cultivated by over 4 million, primarily smallholder, farming households. However, with those employed in ancillary activities to coffee production, even more households depend on coffee for part of their livelihoods. It is estimated that the livelihoods of as many as 15 million (approximately 20 percent of the population) directly or indirectly depend on income from coffee production. (LMC, 2003; Minten et al., 2014).

Smallholder farmers, most of whom work on less than two hectares of land, grow 95 percent of the coffee while the remaining 5 percent is grown on large coffee farms; the average yield per hectare is estimated to be around 0.72 tonnes (or 720 kg), one of the lowest in Africa (STCP, 2011; Tefera and Tefera, 2013). Since these farmers are highly dependent on income from coffee production they are vulnerable to negative price shocks arising from domestic economic policy and international coffee and commodity markets.

Over the past four decades, coffee marketing in Ethiopia has passed through three phases:

- Until 1974, coffee production and marketing was mostly left to the free market. Although there was a National Coffee Board its role was mainly to oversee the general development of the coffee sector. This was concurrent with the period of the imperial government, which came to an end in 1974.
- From 1974, the military regime (1974-91) nationalised large coffee farms and converted them to state farms. During this period the state-owned Ethiopian Coffee Marketing Corporation (ECMC) exerted considerable control over the production and marketing of coffee. Producers had to sell all coffee at a fixed price and there was little choice as to when they sold. The broad objective of these regulations was price support and price stabilisation for the specific welfare of producers as well as macroeconomic stabilisation for the general welfare of the population. Some of the regulations were necessary for compliance with the International Coffee Agreement (ICA) that was signed in 1962 by the major coffee producing and consuming countries.[3] The ICA was finally suspended in 1989. This, coupled with the general switch in economic policy in the late 1980s and early 1990s away from intervention in markets, led to the progressive replacement in coffee producing countries of state-controlled marketing systems by markets run by private agents.
- During the post-military regime (after 1991) a free market economic policy was reintroduced by the transitional government. This was facilitated by the suspension of the ICA and general support in favour of economic liberalisation. Private traders were allowed to compete with the ECMC and they soon started handling more than 75 percent

[3] According to the regulatory provisions of the ICA, basic export quotas were allocated to each of the exporting countries and they were adjusted according to changes in prices. Export quotas were tightened if international coffee prices fell below a particular level and loosened when they rose above that level.

of coffee exports.[4] The ECMC was abolished in 1995 and replaced by the Coffee and Tea Authority (CTA). Over the years the CTA has also seen its power reduced as coffee marketing services have been decentralised and amalgamated with general agricultural marketing services covering food crops and livestock farming.

There have been significant domestic policy interventions in the last decade relating to coffee marketing. From December 2008 it has become mandatory for private traders to sell their coffee through the Ethiopian Commodity Exchange (ECX), a modern commodity exchange.[5] However, farmers cooperatives and producers who are exporters can bypass the ECX and sell directly to international buyers. The government on several occasions intervened in the coffee market in an effort to reduce hoarding by exporters.[6] In May 2011 the amount of coffee an exporter could store was limited to 500 tonnes. In the intervening period, the government has been promoting cooperatives and encouraging private investment in the coffee industry to improve quality and productivity. Since 2009, the state-owned coffee farms have been privatised, the last of them in 2014. The share of exports of cooperatives steadily increased from around 3 percent in 2006 to around 6 percent in 2013.[7] The majority of coffee exports however remains in the hands of the private sector, estimated at around 90 percent in 2012/13 (Minten et al., 2014).

3. Measuring welfare effects of price volatility

[4] See Gemech and Struthers (2007) for a full discussion of the nature and types of reforms carried out from 1992; the reforms included abolition of the coffee marketing board, and devaluation of the Ethiopian currency (the birr)

[5] The ECX trades standard coffee contracts, based on a warehouse receipt system, with standard parameters for coffee grades, transaction size, payment, and delivery.

[6] The interventions included revoking traders licenses, seizing their coffee stocks and selling them on their behalf.

[7] The most important cooperative involved in coffee exports is the Oromia Coffee Cooperative Union, which over this period accounted for 57 percent of the export transactions made by cooperatives. Other important cooperatives include the Yirgacheffe, Sidama, and Kafa Forest Coffee Cooperatives (Minten et al., 2014).

In attempting to explain choice under uncertainty, the two main models competing for dominance are expected utility theory and prospect theory. Both models have been used to explain behaviour in a variety of settings in developed and developing countries. Two recent papers find no strong evidence in two very different settings to suggest that one or the other model is superior. Harrison, Humphrey and Verschoor's (2010), study of 531 subjects in poor areas of Ethiopia, India and Uganda use both expected utility theory and prospect theory in a 'mixture model' to explain the data (behaviour of subjects). They find that in the face of uncertainty, some subjects' behaviour is best explained by the former and others by the latter. They conclude that there is support for each model and 'there is no single, correct model that explains all of the data' (Harrison, Humphrey and Verschoor, 2010: 2). Harrison and Rutström (2009) produce a similar finding in a laboratory experiment using lottery choices.

Other papers that have tried to measure the welfare effects of commodity price volatility are Vargas Hill (2010), for the Ugandan coffee market, and Bellemare, Barrrett and Just (2013), using evidence on general price volatility from rural Ethiopia. Using an experimental approach, Vargas Hill (2010) analyses data on farmers' subjective perceptions of price risk after Uganda's coffee market was liberalised in the 1990s. Though perceived price risk in general was found to be significant, it also tended to vary greatly across different households. Such variation in perceived price risk was found to be caused by previous prices received as well as the level to which these prices could go (high or low). Together, these influences had a significant impact on perceptions of price risk.

The welfare implications of these perceptions were calibrated in terms of stylised price insurance contracts, where significant differences in household willingness to pay for such contracts clearly reflected differences in perceived risk between different households. In a similar vein, but this time adopting an expected utility approach, Bellemare, Barrett and Just (2013) set out an analytical framework to develop a willingness to pay index for achieving price stability. This is determined by households' income levels and takes account not only of the variances of single commodities but also the co-variances across several commodtities. Depending on the percentage of income that households are willing to forego to stabilise prices (in this study of seven key food commodities), almost all of the sampled rural Ethiopian households would benefit to some extent. However, the study finds that the richest housohlds tend to benefit most.

In this paper expected utility theory is used as it generates a parameter (CRRA) that can be used in a welfare equation.[8]There is now an extensive literature that applies the concept of CRRA to a number of related scenarios that examine risky behaviour. For example, papers by Moledina, Roe, and Shane (2003), Cardenas and Carpenter (2005), Hansen (2007), Schechter (2007) and Harrison, Humphrey and Verschoor (2010) apply the concept to; inter alia, betting games with modest and large stakes, lotteries, and a variety of different scenarios related to commodity price volatility. At the heart of these and other similar studies, is the assumption that poor people in developing countries have very high discount rates and are more risk averse than poor people in developed countries. This leads to lower savings rates and low accumulation of capital. An important early study on this aspect is by Binswanger (1980) in which the author carried out experimental estimates of risk aversion through field work in rural India. Attitudes to risk were measured in 240 households using two methods: an interview approach which elicited certainty equivalents and an experimental gambling approach with real substantial payoffs. The findings were that interviewees were subject to interviewer bias and the results were completely different from the experimental measure of risk aversion. The experimental method showed that at high payoff levels, most individuals were moderately risk averse and addtional wealth did not significantly reduce risk aversion.

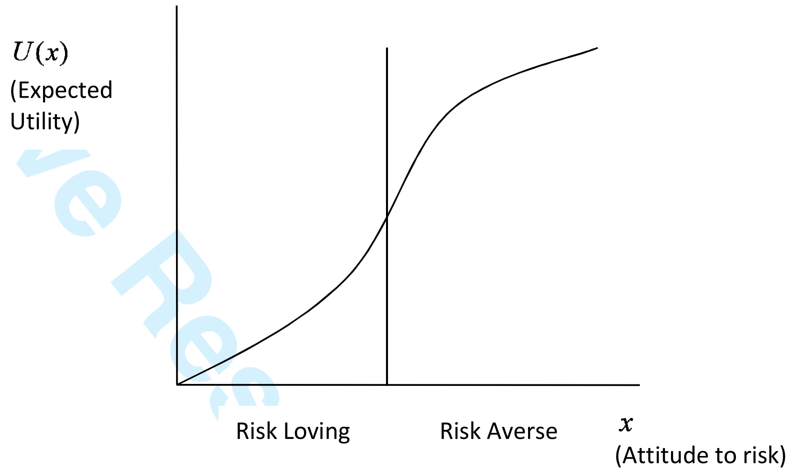
[8] Prospect theory, in contrast to expected utility theory, is concerned with gains and losses rather than absolute wealth. An important result of prospect theory is that people's attitudes toward risks concerning gains may be quite different from their attitudes toward risks concerning losses.

More broadly, whether agents are risk averse, risk neutral or risk loving depends on their attitudes to risky outcomes. Analysis of the welfare effects from volatility in commodity prices can be traced to the seminal work of Newbery and Stiglitz (1981). Economists have long assumed that the diminishing marginal utility applied to income, wealth or consumption causes each additional unit to give less utility than the previous unit. When expressed on a graph of utility against some variable like consumption, income or wealth this generates a concave utility function. This rises at a decreasing rate consistent with the notion of diminishing marginal utility and describes the risk-averse agent. If, on the other hand, the function rises at an increasing rate, suggesting increasing, not decreasing marginal utility, the agent is said to be risk loving. The risk-averse agent will choose the certain outcome over an uncertain one with the same expected income; while the risk-loving agent will do the opposite.

A version that combines both types of behaviour is Friedman and Savage's (1948) logistic or sigmoidal curve shown in Fig. 2. At very low levels of x (for the sake of argument, wealth) agents display risk-loving behaviour (in the convex segment of utility curve) and after a particular level they tend to be risk averse (in the concave segment of utility curve). However, it is possible that after reaching a certain higher level of wealth their behaviour may again change to risk-loving (this can be shown by extending the concave segment of the utility curve in Fig. 2 with a convex segment). This form has been tested in some anthropological studies attempting to gauge the risk attitudes of groups of people in developing countries (Henrich and McElreath, 2002). In this vein, Kuznar and Frederick (2003) have represented the curve by the following function, which when $\alpha > \beta > 0$, is monotonically increasing with respect to x:

$$U(x) = \alpha x - \sin \beta x \qquad (1)$$

Fig. 2: The Risk Loving and Risk Averse Agent: The Sigmoidal Curve



Whatever the shape of the curve, how is it possible to produce a single measure of the degree of risk aversion or risk proneness of agents? The shapes of the curves, the degree of concavity or convexity are clearly of moment in this regard. For example, the more concave the curve, the more quickly it flattens out and thus the more risk averse the agent; and the faster it rises the more risk loving the agent. The problem is that utility functions are not unique. Arrow (1965) and Pratt (1964) addressed this problem by devising what came to be known as the Arrow-Pratt measure of absolute risk aversion (ARA):

$$r_u(x) = -U''(x)/U'(x) \qquad (2)$$

where $U''(x)$ and $U'(x)$ are respectively the second and first derivatives of the utility function, $r_u(x) > 0$ if $U(x)$ is monotonically increasing and strictly concave (the case of the risk averse agent), $r_u(x) = 0$ for the risk neutral agent and $r_u(x) < 0$ for the risk loving agent.

But, the Arrow-Pratt measure is unable to explain sigmoid type curves when agents change between risk averse and risk loving as x increases.

A modification to the ARA measure is the relative risk aversion (RRA) equation:

$$R_u(x) = -xU''(x)/U'(x) \qquad (3)$$

The only difference is that the RRA measure is scaled by the factor x. To illustrate, consider the function

$$U(x) = x^{\alpha} \text{ , where } \alpha \in (0,1) \qquad (4)$$

This displays both ARA and constant relative risk aversion (CRRA), shown as follows

$$R_u(x) = -x\alpha(\alpha-1)x^{\alpha-2} / \alpha x^{\alpha-1} \qquad (5)$$

$$R_u(x) = 1 - \alpha \qquad (6)$$

So there is absolute risk aversion (ARA) and because dR_u / dx = 0, there is also constant relative risk aversion (CRRA). An intuitive explanation for this is that the higher the CRRA the more risk averse is the agent and therefore the more concave the utility curve. The more concave the curve, the higher is the value of $U''(x)$ relative to $U'(x)$ hence the higher the values of $r_u(x)$ and $R_u(x)$. For a concave curve $r_u(x)$ > 0 as the rate of change of the slope of the curve, $U''(x)$ < 0; for a convex curve $r_u(x)$ < 0 as $U''(x)$ > 0.

In the literature on attitudes towards risk of people in developing countries (Shechter 2007; Cardenas and Carpenter, 2005), the standard measure used for risk is the CRRA measure. This measure assumes that the functional form of the utility functions underlying the attitudes to risk for such people satisfy the condition dR_u / dx = 0 and gives the CRRA function as

$$U(x) = x^{1-\gamma} / 1 - \gamma \qquad (7)$$

where $\gamma \in (0,1)$ (Lucas, 1987) and $\gamma = R_u(x)$.

Lucas (2003) asks what the welfare gains from stabilisation would be if all consumption variability could be eliminated. His approach is essentially to measure the welfare effect of eliminating overall consumption variability by considering a single consumer who has an *'endowed' stochastic consumption stream* represented by the series of equations set out below.

By using a single consumer with a stochastic consumption stream with risk aversion, Lucas derives the so-called compensation parameter - the welfare gain from eliminating consumption risk. The consumption stream is given by:

$$c_t = Ae^{\mu t} e^{-1/2\sigma^2} \varepsilon_t \qquad (8)$$

where $\log \varepsilon_t$ is N (0, $\sigma_y{}^2$).

Given these assumptions:

$$E\left(e^{-1/2\sigma^2} \varepsilon_t\right) = 1 \qquad (9)$$

Mean consumption at t is therefore $Ae^{\mu t}$ and it is assumed that preferences over these consumption paths are given by:

$$E\left\{\sum_{t=0}^{\infty}(1/1+\rho)^t c_t^{1-\gamma}/1-\gamma\right\} \qquad (10)$$

ρ is a subjective discount rate, γ is the coefficient of risk aversion, and the expectation is shown in relation to the common distribution of the shocks ε_0, ε_1 etc.

Lucas (2003) postulates that a risk-averse consumer prefers a deterministic (or certain) consumption path to a risky path with the same mean. This utility difference is then quantified by multiplying the risky (or uncertain) path by the constant factor 1+λ (in all dates and states); where λ is chosen in order that the representative household is indifferent between the deterministic path and the compensated, risky path.

In essence, λ is chosen to solve the following equation:

$$E\left\{\sum_{t=0}^{\infty}\beta_t((1+\lambda)c_t)^{1-\gamma}/1-\gamma\right\} = \sum_{t=0}^{\infty}\beta_t(Ae^{\mu t})^{1-\gamma}/1-\gamma \qquad (11)$$

where c_t is given by equation (8). Cancelling, rearranging, taking logs and collecting terms gives:

$$\lambda \approx 1/2\gamma\sigma^2 \qquad (12)$$

λ is the welfare gain from eliminating consumption risk and it depends on two parameters: the risk aversion parameter γ and the amount of risk σ^2.

For our purposes, we substitute the single consumer by the single producer and we use revenue from coffee sales (income) rather than consumption. It is assumed that producers have zero or negligible savings, therefore consumption is equal to income.[9] The welfare gain λ therefore is the amount by which the producer would have to be compensated to be indifferent between the risky and deterministic (certain) income streams from coffee sales. Moledina, Roe and Shane (2003) suggest that the welfare effects of price volatility can be modelled using Lucas's (2003) approach. A risk averse agent (producer in our case) is endowed with a stochastic income stream (from coffee sales), from which consumption takes place. Because he/she is risk averse, the agent prefers the certain income (consumption) stream to the risky stream with the same mean. The more risk averse the agent, the higher the value of γ. In this paper we use λ as the measure of welfare gain from eliminationg coffee price volatility. This is calculated using Equation 12, which requires knowledge of the values of γ and σ^2.

Empirical estimates of γ have been produced by a number of researchers. Harrison, Humphrey and Verschoor (2010) find a value of 0.536 for rural households in Ethiopia, India and Uganda. Schechter (2007) estimates values of γ in a gambling exercise for rural Paraguayan households in which the assumption is made that households do not save. She arrives at an average value of 1.92. She also incorporates the concept of background risk. This relates to the notion that rural households in Paraguay face a number of daily risks and the possible loss from losing the bet in the gamble exercise is only one of many risks to consider. When such background risk is included, and saving is impossible, the value of γ

[9] We noted in Section 2 that most coffee producers in Ethiopia are smallholders with low levels of income. They are therefore highly dependent on this income for their living and are not in a position to use the income to build up savings.

falls to 1.22. The household also takes into account its normal daily income in addition to the possible winnings from the gamble. If the normal daily income of the household is ignored, a lower bound value of γ = 0.81 is obtained.

Cardenas and Carpenter (2005), summarise possible values of γ arrived at by various studies for a range of different scenarios such as bets and outcomes of lotteries. In a variety of experiments in a number of developing countries, studies by Binswanger (1980), Nielson (2001), Holt and Laury (2002) and Barr (2003) yield estimates of γ that tend to be less than one. For example, Barr's (2003) study of villagers in Zimbabwe estimates γ in a two-staged experiment that involved pooling their group risk aversion along with their individual risk aversion, and arrived at values of γ around 0.65. Such estimates corresponded rather well to those found by Binswanger (1980) for rural India. What is also of interest from the Cardenas and Carpenter paper is that measures of γ from studies of developing countries do not necessarily support the commonly held view that the degree of risk aversion is much higher in developing countries than in developed countries.This tends to contradict the *a priori* and somewhat intuitive perception that poor people in less developed countries are necessarily and in all circumstances more risk averse than people in developed countries across all income levels and stakes (e.g. in gambles and bets). In terms of the sigmoidal utility function (Figure 2), we can see that agents 'crossover' at the point of inflection; therefore it is essential to refer to the stake size before reaching any general predictions about risk preferences.[10] To estimate the welfare gain for producers from eliminating coffee price volatility we can use a value of γ in the range of 0.6 to 1, a value close to the findings of most of the empirical studies.

With respect to the σ^2, and following Moledina, Roe and Shane (2003), we decompose the variance (σ^2) into two components: the *conditional variance* and the *unconditional variance,*

[10] See Rabin (2000); Henrich and McElreath (2002);Kuznar and Frederick (2003).

where they refer respectively to, the *predictable* and the *unpredictable components of volatility*. When measuring price volatility and calculating its welfare effects, we use the unconditional variance as it reflects better the risk to the income stream from price volatility and does not overstate the producers' price risk exposure. This is discussed in the next section.

4. Measuring price volatility

Previous studies have typically measured commodity price volatility or uncertainty over time using the variance which does not distinguish between conditional and unconditional variances.[11] Implicit in this measurement is the idea that past realisations of prices and volatility have no bearing on current or future realisations. However, it seems reasonable to expect that producers have an implicit knowledge of the conditional distribution of commodity prices and can distinguish regular features in price processes such as seasonal fluctuations and government policy interventions. On the basis of this information, producers generate probabilistic assessments of the predictable and unpredictable price volatilities.

Since the overall variance does not distinguish between these components of the variance of the price series, it can overstate the degree of uncertainty or risk. Following Ramey and Ramey (1995), Dehn (2000) and Moledina, Roe and Shane (2003), the variance of the residuals is decomposed into conditional (predictable) and unconditional (unpredictable) to measure coffee price volatility more accurately. The conditional variance has relatively less relevance for measuring price risk as it is predictable by economic agents using past information. On the other hand, the unconditional variance is unpredictable and therefore is

[11] The term conditional implies explicit dependence on a past sequence of observations while the term unconditional applies more to long-term behaviour of a time series and assumes no explicit knowledge of past information.

a better measure of the price risk faced by producers. We use this measure of uncertainty to assess the welfare gains obtained from eliminating coffee price volatility.[12]

To capture coffee price volatility in Ethiopia, the generalized autoregressive conditional heteroskedasticity (GARCH) model proposed by Bollerslev (1986) as an extension of Engle's (1982) ARCH model is used. The proxy for the true measure of coffee price volatility then becomes the unconditional variance obtained from the GARCH (p,q) model for the changes in the spot price of coffee. The GARCH methodology is described by the following set of equations.

$$r_t = \mu_t + \varepsilon_t \quad (13)$$

$$y_t = f(\Omega_{t-1}, X) \quad (14)$$

The conditional variance, h_t is given by

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \, h_{t-i} + \sum_{j=1}^{q} \beta_j \, \epsilon_{t-j}^2 \quad (15)$$

Where r_t in equation (13) is the rate of return (percentage change) in prices, μ_t is the mean of r_t conditional on past information, $f(\Omega_{t-1}, X)$ in equation (14) which represents the forecast or deterministic component, of the current return as a function of the information known at time (t – 1). This forecast includes: past innovations $\{\varepsilon_{t-1}, \varepsilon_{t-2}, ...\}$,past observations $\{y_{t-1}, y_{t-2}, ...\}$ and any other relevant information captured by the explanatory variables X. The information set (Ω_{t-1}) is complete in the sense that it contains the full history of y_t as well as any out-of-sample information which can be used to predict its value. On the other hand, the stochastic variable ε is said to be unpredictable since knowledge of the information contained in Ω_{t-1} does not improve its prediction.

[12] A similar approach is adopted in Gemech, Mohan, Reeves and Struthers (2014) in a study of coffee price volatility in India.

In the GARCH specification given by equation (15), the variance of today (h_t) depends on past news about volatility (the ϵ_{t-j}^2 term) and past variance forecast (the h_{t-i} term). If the parameters of equation (15) are positive, then shocks to volatility persist over time. The degree of persistence is determined by the magnitude of these parameters.

The unconditional (time independent) variance of the innovations can be written as:

$$h = E(\varepsilon_t^2) = \frac{\omega}{1 - \sum_{i=1}^{p} \alpha_i - \sum_{j=1}^{q} \beta_j} \qquad (16)$$

To capture all the relevant information contained in $y_t = f(\Omega_{t-1}, X)$, equation (16) can be rewritten as:

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i h_{t-i} + \sum_{j=1}^{q} \beta_j \epsilon_{t-j}^2 + \varphi D \qquad (17)$$

Price volatility is accounted for by the *conditional* variance (h_t) which is specified as a linear function of past squared errors; past values of the conditional variance and a market reform dummy D. The coefficients α_i and β_j are the ARCH and GARCH parameters respectively while *p* and *q* are lag lengths for the conditional variance and the squared residuals respectively. Equation (17) is designed to mimic the volatility clustering phenomenon, i.e. large disturbances, positive or negative, become part of the information set used to construct the variance forecast of the next period's disturbance. In this manner, large shocks of either sign are allowed to persist, and can influence the volatility forecasts for several periods. The lag lengths of *p* and *q*, as well as the magnitudes of α_i and β_j determine the degree of persistence. A sum lower than unity in equation (16) implies a tendency for volatility response to decay over time while a sum greater than (equal to) unity implies volatility persistence overtime.

4.1 Data

The data consist of 444 observations of monthly coffee producers' prices from January 1976 to December 2012 obtained from the International Coffee Organisation (ICO). The data are in US cents/lb and relate to the average price paid to the grower at the farm gate. Farm gate price is the price received by the producer for a transaction carried out at the first point of sale. The first point of sale occurs at the nearest market to the producer's farm (usually place of production), and therefore is assumed not to include transaction margins (transfer costs) such as transport costs. The Ethiopian Central Statistical Agency (CSA) reports coffee producers' prices on a monthly basis based on regular surveys of producers. The price data include four major Ethiopian coffee types by origin of growing region (Sidama, Harar, Wollega and Jimma) each with a distinct price paid to the producers. The weighted average of all coffee prices is converted from local currency to US cents per pound (at the contemporaneous exchange rate) and supplied to the International Coffee Organisation by the CSA. The nominal prices are converted to real prices using the unit value index of exports of manufactured goods from developed market economies as a deflator (UNCTAD, 2014).

Finally, following its use in the literature (Choi and Kim, 1991; Yang, Haigh and Leatham, 2001), the dummy variable *D* was set equal to one from January 1992 to December 1995; i.e. when market liberalisation was implemented, and zero otherwise. If *D* takes a positive sign and is statistically significant, then the market-orientated liberalisation policy can be said to have had an impact in increasing price volatility.

4.2 Results

A formal test was conducted for the null hypothesis to ensure that the price series is a random sequence of Gaussian disturbance (i.e. no ARCH effect). The White (1980) test rejects the null hypothesis of homoskedasticity in equation (13). Since there is clear evidence of heteroskedasticity in the squared residuals, GARCH modelling is appropriate. The non-stationarity of the levels and first differences for the price series were tested using the augmented Dickey-Fuller (ADF) test. The result for a random walk series with a drift (in levels) is equal to -3.5 while for the first difference is -14.8. Based on the relatively large negative value of the ADF statistic (5%, with a critical value for the ADF statistic = -3.4), we conclude that the first difference of the price series is stationary while the level has a unit root. Because GARCH modelling assumes a rate of return, we used the first difference of the logarithm of the price series which is equivalent to the monthly returns (i.e. $r_t = lnp_t$- lnp_{t-1}).

The GARCH (1,1) estimates for price variability summarised in Table 1 are the correct sign and are all statistically significant at the 5% level. (Higher order lag structures for 'p' and 'q' in equation (17) were tried but only the GARCH (1,1) estimates were statistically significant. The coefficient of the GARCH effect (0.517) is larger than the coefficient of the ARCH effect (0.143*)*, implying that large market surprises induce relatively small revisions in future volatility. The sum of the estimated coefficients is equal to 0.66, which satisfies the stationary boundary constraints, i.e. $\alpha_1 + \beta_1 < 1$. The Wald statistic for testing the restriction $\alpha_1 + \beta_1 = 1$ is 21.0 compared to the 5% critical value of 3.84. Thus, the hypothesis that the GARCH model is integrated is strongly rejected. Also, the coefficient of the reform dummy has the expected sign and is statistically significant, broadly supporting the hypothesis that there was an increase in producers' price volatility following the period of market reforms.

Table 1: Results of equation (17) estimated under the assumption of a normal distribution of the conditional variance

PARAMETER	VALUE	STANDARD ERROR	T-STATISTIC
ω	0.003	0.0018	1.7
α_1	0.143	0.055	2.6
β_1	0.517	0.152	3.4
φ	0.162	0.076	2.1

Our measure of the conditional volatility obtained from the fitted values of h_t in equation (17) is 0.002 while the estimated value of the unconditional variance, h obtained from equation (16) is 0.01.

5. Welfare gains from eliminating price volatility

To estimate the welfare gain from eliminating coffee price volatility, estimates of the overall variance, the conditional variance and the unconditional variance and the selected values of γ are combined to produce the welfare gains of eliminating coffee price volatility shown in Table 2. Using Lucas's welfare gain formula: $\lambda \approx 1/2\gamma\sigma^2$, values of λ are calculated for a range of γ from 0.6 to 2. We present a range of values for γ based on the values reported by studies in Section 3. Higher values of γ have been used to compare our results with those of Moledina et al (2003), though the preference is to go with the lower estimates which were the norm in the empirical work reviewed by Cardenas and Carpenter (2005). For values of γ less than 1, the calculated values of the welfare gain are very small, fractions of 1% of income. Only when we use values of γ greater than 1 does the welfare gain exceed 1% of income.

Table 2: Estimates of the welfare gain λ **(Equation 12)** ***from eliminating coffee price volatility***

Welfare gain $\lambda \approx 1/2\gamma\sigma^2$				
Values of γ **:**	**0.6**	**0.8**	**1**	**2**
Overall annualised variance = 0.04157	**0.01250**	**0.01663**	**0.02078**	**0.04157**
Conditional annualised variance =0.00693	**0.00208**	**0.00277**	**0.00346**	**0.00693**
Unconditional annualised variance = 0.03464	**0.01039**	**0.01386**	**0.01732**	**0.03464**

The magnitude of the potential gain from eliminating price uncertainty when we use a combination of γ = 0.6 and the unconditional annualised variance of 0.03464 gives us 0.01039, or 1.039 percent of revenue (income) from coffee.[13] We choose the value 0.6 and the unconditional variance to compute the welfare gain because it reflects the lower bound and rules out any over estimation of welfare gains.

We can obtain an estimate of the revenue from coffee production by multiplying the hectarage under coffee cultivation in Ethiopia with average yield in kg per hectare and the mean price of coffee per kg. If we take crop year 2012, the hectarage was around 450,000, average yield around 720kg per hectare, and average price received by the producer was

[13] Annual variance = monthly variance* $\sqrt{12}$

US cents 90 per kg (ICO, 2014). This gives a total revenue to coffee producers of US$291 million, giving a welfare gain to producers of a little over US$3.03 million (i.e. 0.01039 multiplied by 291) or US$6.73 per hectare. We noted in Section 2 that Ethiopia has 4 million producers, most with a very small holding. The gain per producer comes to a meagre US$ 0.76 (for crop year 2012). We can therefore say that under the assumptions made the welfare gain from eliminating coffee price volatility per producer and per hectare is negligible.

6. Conclusions and policy implications

This paper had a very specific purpose; namely to assess the possible welfare gain from eliminating the price risk from coffee price volatility faced by Ethiopian coffee producers. To estimate the price risk faced by producers, we de-couple the GARCH estimates of volatility into conditional (predicted) variance and the unconditional (unpredicted) variance. As the unconditional variance more truly reflects price risk, we apply these estimates to the relevant aspects of expected utility theory (specifically the CRRA concept drawn from Lucas' (2003) framework) to arrive at estimates of welfare gain to producers from eliminating this risk.

What is evident from these estimates is the very small welfare cost to producers of the high level of price volatility. What are the implications of this finding to producers faced with such price volatility? Does it suggest that price volatility is a feature of their livelihoods that they have to accept as the least bad outcome when the alternative of eliminating or reducing price volatility does not offer much gain. Furthermore, lower price volatility usually comes with a cost so it may not be a desirable outcome for producers. In the absence of detailed empirical (field) work, this paper simply suggests that any attempt to eliminate coffee price volatility at a cost may not be a preferred outcome for Ethiopian producers.

The paper also raises the issue of whether economic agents in developing countries (in this case, coffee producers) are *a priori* more risk averse than their counterparts in developed countries. On this issue there is ongoing debate, much of which is derived from the experimental economics (and anthropology) literature. To the extent that agents in developing countries may be more risk averse than those in developed countries, along with the high vulnerability of producers to coffee price volatility due to their high dependency on income from coffee for their livelihoods, governments often acquiesce in the creation of marketing boards and other forms of market interventions to mitigate price volatility. Historically such interventions also included the ICAs. Although the objective is to improve the welfare of producers, the outcome may not be in their best interest, more so as these interventions often have high implementation, monitoring and other regulatory costs. This paper casts doubt on the desirability of such schemes as the welfare gains to producers are very low or negligible.

A note of caution may be in order. Our result casts doubt on market interventions to stabilise prices. However, it may be desirable to develop mechanisms that allow producers (and other economic agents involved in the coffee supply chain in coffee producing countries) access to price risk management derivative instruments such as coffee futures and options. Although the use of these instruments also comes at a cost, these costs are known up-front to the producers and it is optional for them to use them depending on whether they wish to internalise the cost. Gemech, Mohan, Reeves and Struthers' (2011) study supports positive payoffs for producers from the use of such instruments, especially if producers themselves are able to allocate resources more efficiently in the production of coffee and improve their ability to access credit. On a practical level, there may be barriers to producers in accessing these instruments in terms of minimum size of contract, low liquidity, counterparty risk and basis risk. The challenge is to evolve an appropriate institutional and regulatory framework that would allow coffee producers in countries such as Ethiopia an easy and reliable mechanism to manage their price-risk according to their individual circumstances, even if such a choice comes at a cost. The setting up of the Ethiopian Commodity Exchange (ECX) in 2008 is a good example of such an institutional development. The ECX is regarded as a leader in the African continent since it provides greater certainty for coffee (and other) producers via an online real-time pricing system supported by an efficient warehouse receipt system and speedy payments into farmers' bank accounts. Such a market-based system, designed to reduce counterparty risk, is perhaps the way forward for coffee producing countries such as Ethiopia, as opposed to the previous forms of government intervention described earlier in this paper, such as marketing boards and ICAs.

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