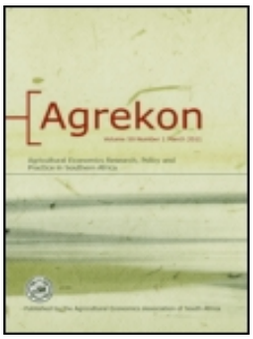

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Agricultural Economics Research, Policy and Practice in Southern Africa

ISSN: 0303-1853 (Print) 2078-0400 (Online) Journal homepage: www.tandfonline.com/journals/ragr20

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To cite this article: T.K. Worako, H. Jordaan & H.D. van Schalkwyk (2011) Investigating Volatility in Coffee Prices Along the Ethiopian Coffee Value Chain, Agrekon, 50:3, 90-108, DOI: 10.1080/03031853.2011.617865

To link to this article: https://doi.org/10.1080/03031853.2011.617865

INVESTIGATING VOLATILITY IN COFFEE PRICES ALONG THE ETHIOPIAN COFFEE VALUE CHAIN

T.K. Worako,* H. Jordaan** and H.D. van Schalkwyk***

ABSTRACT

The coffee sub-sector is a major contributor to the Ethiopian economy. In addition to accounting for approximately 40 per cent on average of total export earnings, coffee production provides a livelihood for a large proportion of the Ethiopian population in the form of jobs for farmers, local traders, transporters and exporters. Volatility in the price of coffee thus influences a large proportion of the population all along the coffee commodity chain within Ethiopia. This study uses the Autoregressive Conditional Heteroscedasticity/Generalized Autoregressive Conditional Heteroscedasticity (ARCH)/(GARCH) approach to quantify the volatility in the price of coffee. A distinction is made between producer, wholesale and export prices in order to compare the price risk as faced by the respective participants in the coffee chain. The volatility in coffee prices within Ethiopia is also compared to the volatility levels in Brazilian coffee prices, since Brazil is a major coffee producing country in the world. Coffee prices within Ethiopia were found to be more volatile than in Brazil. Producer prices were found to be the most volatile, followed by wholesale prices and export prices respectively. The high level of volatility in producer prices emphasises the need for efficient price risk management tools that should be available to coffee producers in Ethiopia.

Keywords: coffee, price volatility, ARCH/GARCH, producer price

1 INTRODUCTION

Recent evidence from developing countries has lead to the conclusion that broad-based economic growth driven by agricultural sector growth contributes more to poverty reduction than the expansion of industrial output. This is due to the instant trickle-down effect for the majority of the population who are engaged in agriculture. High and stable farm prices relative to those of other sectors can increase profitability of agriculture, thereby encouraging investment and growth of the sector and vice versa (Hanmer & Nashold, 2000). During the last two

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Agrekon
Vol. 50 (3) 2011 • ISSN Print 0303-1853/Online 2078-0400

DOI: 10.1080/03031853.2011.617865

decades, market reforms were undertaken in most developing countries with the aim to present agricultural producers with "right prices" as a means of stimulating productivity and growth. However, valid concerns have been raised on both the direct and indirect effects of market reform on the level of price volatility (Kruger *et al*., 1998).

As an agricultural commodity, the production of coffee over the years has proven to be a good source of income for many countries around the world. It provides a livelihood for 25 million farmers and countless employees in 50 countries. Moreover, the coffee market provides jobs for millions more who are employed in coffee-related industries (Lewin *et al*., 2004). In Ethiopia, coffee has accounted on average for 50 per cent of total export earnings over the last three to four decades. The sub-sector affects approximately a quarter of the population's livelihoods by providing jobs for farmers, local traders, processors, transporters, bankers and exporters (CTA, 2002). Thus, clearly, the coffee industry is of major importance to the Ethiopian economy.

According to Mohan (2007), coffee producers are exposed to three main types of risk, namely: (i) price risk, which results from volatility in product prices; (ii) production (yield) risk, especially due to variable climatic conditions; and (iii) currency risk due to exchange rate fluctuations. Although each of these three types of risk has a direct impact on profitability, International Trade Center (ITC) (2002) field studies found that most producers considered product price volatility to be a greater source of risk than volatility in production. They also found price risk for coffee to be substantially higher than for other crops. The reason for the higher risk is that coffee is a commercial commodity rather than a high value crop. Coffee is also a major export product from Ethiopia. Since Ethiopian farmers are price takers, changes in the world production and prices of coffee directly affect Ethiopian coffee prices. While the neoclassical assumption may create the expectation that the price will tend towards the equilibrium price, it is less likely to hold true given the nature of developing countries. For coffee producers in Ethiopia, this is a major source of uncertainty when making predictions with regard to the amount of money they would earn from their production.

The volatility in the price of coffee, however, does not only influence producers. Exporters' decisions of how much to purchase, process and export are also heavily influenced by the volatility in the price of the product they wish to export. High price volatility can also reduce the welfare of the poor (e.g., smallholders and consumers) who have limited price risk management tools and who spend a large share of their income on food. This high price risk associated with coffee production is not only limited to smallholder coffee producers, but may also have some serious implications for the overall economy of the country.

The objective of the study is to investigate the price risk associated with coffee production in Ethiopia. The volatility associated with coffee prices is quantified

for two regions (Wollega and Harar) as well as the national average price. Furthermore, a distinction is made between the producer price, the auction price and the Free-On-Board (FOB) price in order to compare the volatility to which the respective agents in the Ethiopian coffee chain are exposed. The volatility in the price of coffee in Brazil is also quantified to compare the respective volatilities within Ethiopia to that of Brazil, which is a major player in the global coffee market. Finally, the level of volatility prior to the deregulation of the coffee market is compared to the level of volatility after the deregulation in order to determine the influence of market deregulation on the volatility in the price of coffee.

The rest of the study is structured as follows: The data and procedures that were used to meet the specific objectives of the study are discussed in section 2; section 3 covers the presentation and discussion of the obtained results; while some conclusions are drawn from the results and implications highlighted in section 4.

2 METHODOLOGY

2.1 Data sources

The three major time series prices used in this analysis were the producer, auction/terminal, and FOB coffee prices. Each price series consists of monthly prices that extended from October 1981 to September 2006. The two major types of Ethiopian coffees by origin of growing region (Wollega and Harar) and national average coffee prices were used in this analysis. Producer prices were compiled from published survey reports by Central Statistical Agency (CSA) Bulletins Nos. 44 to 377. For the purpose of analysis, they were converted to US cents/lb by using the official exchange rate from the National Bank of Ethiopia (NBE). Auction and FOB prices were compiled from the current Agricultural Market Promotion Department (AMPD) of the Ministry of Agriculture and Rural Development (MoARD) or from the former Coffee and Tea Authority.

2.2 Method of analysis

Recent literature suggests two prerequisites when quantifying volatility. Firstly, Moledina *et al*., (2003) argue that the predictable and seasonal component in the price process should not be considered as part of volatility. They argue that producers can reasonably be expected to recognise regular features in the price process, such as seasonal fluctuations. Since producers can use such knowledge in their decision-making process, they are exposed only to the unpredictable or stochastic component in the price process. By implication, the inclusion of predictable components in price volatility may lead to the overestimation of the actual price risk that producers face. The second prerequisite hinges on

the assumption that volatility behaves in a deterministic fashion. Just and Pope (2002) cite Campbell *et al.*, who argue that it is "… both logically inconsistent and statistically inefficient to use volatility measures that are based on the assumption of constant volatility over some period when the resulting series move through time" (1997). Thus, it is clear that the appropriate approach to be used to quantify price volatility should distinguish between the predictable and the unpredictable components in the price process, and should also allow volatility to change over time.

The Autoregressive Conditional Heteroscedasticity/Generalized Autoregressive Conditional Heteroscedasticity (ARCH/GARCH) approach meets the above two requirements and has been used to quantify volatility of food and agricultural commodities, financial, stock and oil price volatilities, amongst others (Shively, 1996; Jooste, *et al*., 2003; Karanja *et al*., 2003; Moledina, *et al.* 2003; Engle, 2004; Jordaan *et al*., 2007). ARCH/GARCH models focus on the assumption of homoscedasticity by treating heteroscedasticity as a variance to be modelled instead of a problem to be solved. It thus corrects the deficiencies of least squares and also the computation of a prediction for the variance of each error term (Engle, 2001).

Since only the unpredictable or stochastic component in the price process is considered part of volatility, the first step is to remove the known components (i.e. seasonal fluctuations) from the coffee prices before volatility is quantified. Like all agricultural products, coffee production is also heavily dependent on growing seasons. By implication, seasonal fluctuations in the supply of coffee, and hence in the price of coffee, could reasonably be expected. Seasonal fluctuations in the coffee price are accounted for by the use of seasonal dummy variables (Moledina, *et al*. 2003). Following the approach by Jordaan *et al*. (2007), 11 seasonal dummy variables are included for the 12 months in a year. The twelfth month is used as the base category to which the effects of the different months are compared. Interestingly, seasonal fluctuations were only identified in the producer price of Wollega coffee. While December was used as the base category, the producer price of Wollega coffee was found to be significantly higher from May to October compared to December. This may account for the fact that coffee harvesting, processing and supply to auction market for most western Ethiopia coffee growing regions (including Wollega) begin in May, peak around October, and then decline. None of the other prices under consideration exhibited any significant seasonal behaviour in the price process.

Once the known components have been removed from the price process, the next step is to perform the unit root test to determine whether the de-seasonalised price series is stationary. This needs to be done since most empirical work based on time series data assumes that the underlying time series is stationary (Gujarati,

2003). The Augmented Dickey Fuller (ADF) test was applied to test for the presence of unit root (Dickey & Fuller, 1981). The presence of a unit root suggests that the underlying price series is non-stationary and may need to be differenced in order to become stationary. The ADF test was also used to determine how many times the non-stationary series needed to be differenced in order to make it stationary. In other words, it was used to determine the order of integration of the underlying price series. The results of the ADF tests for the respective price series are shown in Table 1.

Table 1: ADF test results to determine the number of times the series needed to be differenced to make it stationary

Coffee prices by origin of production[1]	ADF statistics[2]		Critical value (95 %)	No. of lags	DW statistic
	At levels[3]	With first difference			
Wollega (PP)	–2.4728	N/A	–1.9419	1	2.0393
Wollega (AP)	–2.5600	–21.5223	–2.8713	0	2.0411
Wollega (FOB)	–1.7835	–22.2629	–2.8713	0	2.0338
Harar (PP)	–4.1875	N/A	–3.4254	1	1.9740
Harar (AP)	–2.1347	–15.6496	–2.8712	0	1.9841
Harar (FOB)	–2.4719	–17.4272	–3.4255	1	2.0311
National (PP)	–2.3508	–21.4802	–2.8710	0	2.0072
National (AP)	–2.5140	–14.6928	–2.8710	0	1.9912
National (FOB)	–1.4606	–15.1626	–2.8709	0	2.0086

Notes:

1 Specific price series referred to are shown in parentheses (PP refers to Producer Price, AP refers to Auction
Price, and FOB refers to Free-On-Board price).

2 Absolute value of the ADF statistic needs to be higher than the absolute value of the critical value to reject the null hypothesis of unit root (non-stationarity).

3 Levels refer to the original series (before it was differenced).

From Table 1, it can be seen that while some of the price series were stationary even before they were differenced, other series needed to be differenced once to become stationary. The number of times the series needs to be differenced to become stationary refers to its order of integration and, thus, the value of *d* in the

Autoregressive Integrated Moving Average (ARIMA) (p, d, q) process. Once the underlying series is stationary, the next step is to determine the values of p and q in the ARIMA (p, d, q) process for which the Box-Jenkins methodology is used. The ARIMA process is presented as follows:

$$y_t = \alpha_0 + \sum_{p}^{p\max} \phi_p y_{(t-p)} + \sum_{q}^{q\max} \theta_q \varepsilon_{(t-q)} + \sum_{n}^{n\max} \eta_n D_t \qquad [1]$$

Where $y_{(t-p)}$ is the autoregressive term which corresponds to the use of a lagged value of the residual in the forecasting equation for the unconditional residual. On the other hand, $\varepsilon_{(t-q)}$ refers to the moving average term which uses lagged values of the forecast error to improve the current forecast. The last term, D_t, refers to the integration order term where each integration order corresponds to differencing the series being forecast (EViews, 1998).

The Box-Jenkins methodology is used together with the Akaike (AIC) and Schwartz (SBS) information criteria to determine the values of p and q in the ARIMA (p, d, q) process (Box & Jenkins, 1976). According to Pesaran and Pesaran (1997), the point where the highest value of either AIC or SBC lies is theoretically the point which determines the values of p and q. In general terms, the value of p indicates the number of times the intercept needs to be lagged; d indicates the number of times the series needs to be differenced to become stationary; and lastly, the value of q indicates the number of times the error term needs to be lagged in order to generate the desired results. The values of p, d, and q for the alternative coffee price series under consideration are shown in table 2.

Table 2: Values of *p*, *d* and *q* determined using the Box-Jenkins methodology

Coffee prices by origin of production[1]	Values of p, d, and q in the ARIMA (p, d, q) process using the Box-Jenkins methodology together with the AIC and SIC criteria		
	p	*d*	*q*
Wollega (PP)	5	0	5
Wollega (AP)	3	1	2
Wollega (FOB)	2	1	2
Harar (PP)	4	0	5
Harar (AP)	2	1	3
Harar (FOB)	1	1	2
National (PP)	6	1	6
National (AP)	1	1	2
National (FOB)	2	1	3

Note:

1. Specific price series referred to is shown in parentheses (PP refers to Producer Price, AP refers to Auction Price, and FOB refers to Free-On-Board price).

From table 2, it can be seen that in the case of, for example, the auction price of Wollaga coffee, the ARIMA (*p*, *d*, *q*) process can be identified as ARIMA (3, 1, 2). By implication, the intercept needs to be lagged three times, the series needs to be differenced once to become stationary, and the error term needs to be lagged twice in order to obtain the desired results. The same method of interpretation can be used for all the other prices under consideration. Once the ARIMA (*p*, *d*, *q*) process has been identified, the next step is to determine whether the underlying series varies over time. In other words, the next step is to test for significant ARCH effect.

The Box-Jenkins methodology is based on the assumption that the residuals are homoscedastic (remain constant over time). Since the standard error of Equation [1] is used as the measure of volatility, the homoscedasticity assumption implies that volatility is time invariant. ARCH equations were used to test the robustness of this assumption. Significant ARCH effect indicates that the level of volatility changes over time which implies that the standard error of the ARIMA (*p*, *d*, *q*) process cannot be used as the measure of volatility. In the presence of significant ARCH effect, the GARCH approach should be used instead to quantify volatility.

The presence of ARCH effect (time varying volatility) has to be tested in the conditional variance of:

$$h^2 = Var(u_t / \Omega_{t-1}) \qquad [2]$$

$$h^2 = \rho_o + \rho_1 u^2_{t-1} + \rho_2 u^2_{t-2} + ,,, \rho_q u^2_{t-q} \qquad [3]$$

Where u_t^2 is the squared residual in period *t*, and ρ_o, ρ_1, ρ_2, ρ_q are the parameters to be estimated. Lagrange Multiplier (LM) and F-tests were used to test the null hypothesis of no ARCH effect. The results for the ARCH-LM tests of the respective coffee prices are shown in table 3.

Table 3: ARCH-LM test results to test whether volatility remains constant over time

Coffee prices by origin of production[1]	F-Statistic	Probability
Wollega (PP)	2.5249	0.0214 **
Wollega (AP)	2.9519	0.0007 *
Wollega (FOB)	0.9462	0.5012
Harar (PP)	4.5517	0.0000*
Harar (AP)	1.7907	0.0497**
Harar (FOB)	0.1209	0.9999
National (PP)	2.3092	0.0081*
National (AP)	0.3023	0.5828
National (FOB)	0.3391	0.5608

Notes:

1 Single, double and triple asterisks show the rejection of the null-hypothesis of no ARCH effect at 1 per cent, 5 per cent and 10 per cent, respectively, thereby indicating time varying volatility.

2 Specific price series referred to is shown in parentheses (PP refers to Producer Price, AP refers to Auction Price, and FOB refers to Free-On-Board price).

It is interesting to note from table 3 that, while significant ARCH effect was detected both in the producer prices and in the auction prices of all the different coffee varieties under consideration, no ARCH effect was detected in the FOB prices of any of the varieties. Thus, although some volatility does exist in the FOB prices of the respective varieties, the absence of ARCH effect indicates that the volatility in the FOB prices remains constant over time. Since the volatility in the FOB price of coffee remains constant over the time period under consideration, there is some evidence that exporters face less uncertainty than producers and suppliers (*akrabys*).

As mentioned above, in the absence of significant ARCH effect, there is no need to perform the GARCH test, since the standard error of the ARIMA process is the appropriate measure of volatility. In the cases of the FOB prices of Wollega and Harar coffee, the standard errors of the ARIMA processes are very similar at 0.1006 and 0.0953, respectively. The standard error of the ARIMA process in the case of the FOB price in Brazil, however, is somewhat lower at 0.0709. The lower level of volatility in Brazil may possibly be attributed to a more efficient institutional environment which overlays the coffee export market within Brazil compared to the case of Ethiopia. Further research, however, is necessary to

formally test this hypothesis. For all the other prices, the conditional standard deviations needed to be calculated with the GARCH approach. The univariate GARCH (1,1) model is presented as:

$$\sigma_t^2 = \gamma_0 + \gamma_1 \varepsilon_{(t-1)}^2 + \gamma_2 \sigma_{(t-1)}^2 \quad [4]$$

Where σ_t^2 is the variance of ε_t conditional upon information up to period *t*. The conditional standard deviation is the square root of the fitted values of σ_t^2 and varies over time. As it is impossible to present the conditional volatility as a single value over a period, time varying volatility is presented graphically instead.

The discussion of the methodology used to estimate the GARCH (1,1) model concludes the section on the data and procedures that were used in the study. The results of the quantified price volatility in the respective coffee prices are shown and discussed in the next section.

3 VOLATILITY IN THE COFFEE PRICES

The research objective was to quantify the volatility faced by market participants by origin of coffee production area. The figures below show the extent of volatility faced by participants within Harar and Wollega, the national averages and coffee prices within Brazil. Each graph consists of the level of volatility faced by producers, wholesalers and the exporters to also allow the comparison of the level of volatility faced by the respective market participants. It is also important to note that all the graphs are scaled uniformly in order to simplify the comparison of the volatility levels for the different regions.

3.1 Volatility in the price of coffee produced in Harar

Figure 1 shows the volatility faced by producers, wholesalers and exporters participating in the Harar coffee market. Due to scaling, some part of the conditional standard deviation is not visible in figure 1A. An unscaled version of the same graph (figure 1B) is shown in appendix 1 where the behaviour of the conditional standard deviation in that period of high volatility can be seen. The straight line represents the time invariant level of volatility (the standard error of the ARIMA process) faced by coffee exporters, while the other lines represent the conditional standard deviations in the producer and auction prices in the Harar region, respectively.

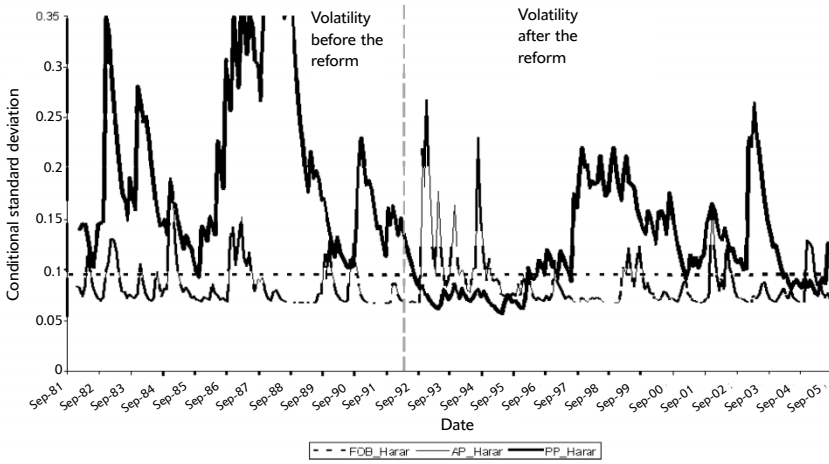

Figure 1A: Volatility of producer, wholesaler and exporter prices of Harar coffee

It is interesting to note from figure 1A that the level of volatility in the producer price always exceeded the levels of volatility in the auction and export prices, except for the period from 1992 to 1995. It is significant to recall that the coffee market in Ethiopia was deregulated during 1992. The increase in the volatility in the auction price after the deregulation may possibly be attributed to coffee producers' expectations of profit opportunities in the deregulated market. Such expectations may have convinced producers to rather market their crops through the auction market. As pointed out by Dercon and Ayalew (1995), devaluation of the Ethiopian Birr, together with other deregulation measures, has increased coffee flow through official channels since the early 1990s. The supply to the auction market increased substantially from merely 90 000 tons in 1990 to 150 000 tons in 1995. Theoretical research has found that higher trading volumes are associated with higher levels of volatility. After 1995, however, the volatility in the producer price increased again to higher levels than the auction price. It may be that producers realised that the deregulated market did not bring about additional profit opportunities, as was initially expected. Since the volatility in both the producer and the auction price after 1995 resembles the volatility prior to the deregulation, there seems to be evidence that coffee producers returned to their original marketing behaviour during the late 1990s. It is also important to note that the straight line which represents the volatility in the FOB price does not imply that exporters face no volatility. As a matter of fact, exporters face a constant level of volatility which means that the level of volatility to which they are exposed is predictable. Since their level of volatility is predictable, it may be argued that

exporters face less uncertainty compared to producers and wholesales who are faced with varying levels of volatility.

3.2 Volatility in the price of coffee produced in Wollega

Figure 2 depicts volatility in the producer, auction and FOB prices of Wollega coffee. Similar to the case in Harar, the level of volatility in the producer price exceeded the levels of volatility both in the auction and in the FOB prices in the period prior to the deregulation of the coffee market. Also similar to the case in Harar, a period of increasing volatility started from the mid 1980s and lasted till the early 1990s. It is interesting to note, however, that the increase in the level of volatility in the auction price in Wollega was far more severe than was the case in Harar. On the contrary, the increase in the volatility level in the producer price in Wollega was substantially less severe compared to Harar. This may have been caused by the large number of coffee farmers using the auction market in Wollega compared to producers in Harar, who seem to prefer to market their own crops.

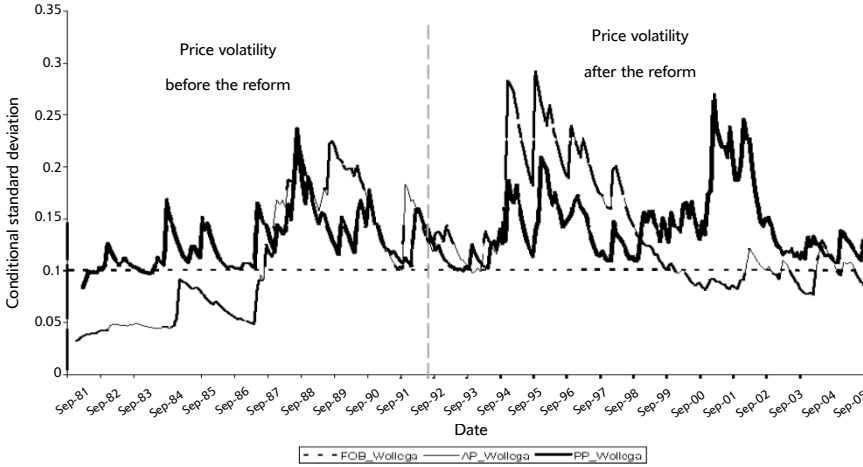

Figure 2: Volatility of producer, wholesaler and exporter prices of Wollega coffee

It is also interesting that from the increase in the level of volatility in the auction price during 1986 to a level similar to the producer price it continued to behave alike to the producer price until the late 1990s. Again, this behaviour was very different from the evidence found in Harar. Since the late 1990s, however, there was a definite decline in the level of volatility in the auction price to a level lower than that associated with the producer price. It is interesting to note again that the level of volatility in the FOB price remained constant over time.

3.3 Volatility in the national price of coffee in Ethiopia

The differences in the behaviour of the volatility levels in the two regions led to the question of how the volatility levels compare to those of the national average prices. Figure 3 shows the volatility levels in the respective prices for coffee on a national level. The national price series was generated by calculating the average price for all types of coffee in Ethiopia (e.g., Sidama, Yirgachefe, Illubabore, Wollega, Jimma and Arsi). The results support the early findings that the producer price exhibited a higher level of volatility compared to the auction and FOB prices. The shorter spikes in the national price compared to the prices in Harar and Wollega may be attributed to the national price being the average of all the prices; which, by implication, eliminates some of the variation in the underlying prices. Another interesting finding from figure 3 is that no ARCH effect was detected in the national average of the auction price. Thus, when taking the average auction price of all coffee types, the volatility in that average price remains constant over time. Constant levels of volatility imply predictable levels of volatility and hence also less uncertainty than in the case of time varying volatility levels. Further, as was expected, the level of volatility in the national average of the FOB prices remained constant over the whole period under consideration.

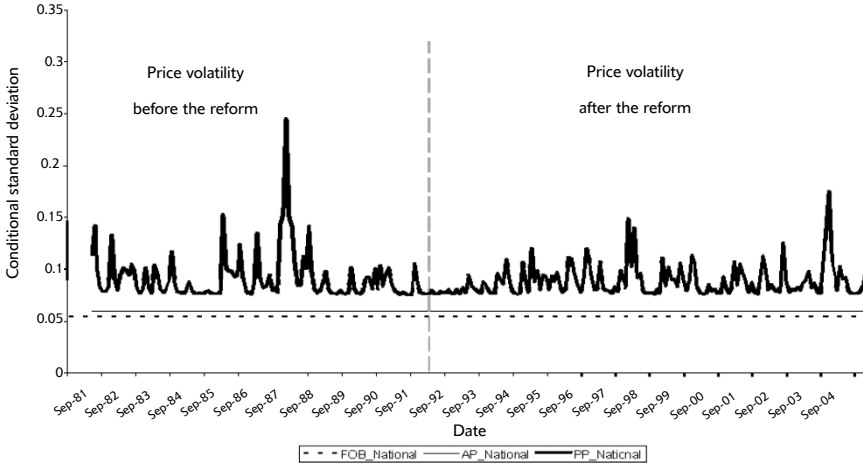

Figure 3: Volatility of producer, wholesaler and exporter prices of national average price

When taking the results of the volatility in the national prices as the average volatility levels within Ethiopia, there is evidence that producers are exposed to higher levels of volatility compared to wholesalers and exporters of coffee. As mentioned, the coffee sub-sector in Ethiopia affects approximately a quarter of the

population's livelihoods by providing jobs for farmers, local traders, processors, transporters, bankers and exporters (CTA, 2002). The high levels of volatility in the producer price thus directly affect approximately a quarter of the Ethiopian population and thus the purchasing power of a substantial proportion of the population in Ethiopia. Thus, ultimately the volatility in the producer price of coffee may have a substantial impact on the overall economy in Ethiopia.

Since the volatility levels in the producer price are substantially higher and more uncertain compared to the auction and FOB prices, the next question is how the volatility in the producer price within Ethiopia compares to that of other coffee producing areas around the world. Brazil is the most important international region from the Ethiopian perspective, since both countries produce Coffee Arabica. The volatility in the producer price of coffee in Brazil is thus quantified to compare it to Ethiopia. The next section discusses the volatility in the price of coffee produced in Brazil, and how the volatility in the Brazilian coffee prices differs from that of coffee produced in Harar and Wollega in Ethiopia.

3.4 Comparing volatility in the price of coffee produced in Brazil to that produced in Harar and Wollega in Ethiopia

Figure 4 shows the levels of volatility in the price of coffee produced in Brazil. It is interesting to note from figure 4 a substantial increase in the conditional standard deviation until 1987 followed by a downward trend thereafter. The initial period of high volatility from the late 1980s to the early 1990s also corresponds to a period of high volatility in all the regions under consideration within Ethiopia. This period of high volatility may be attributed to the severe drought both in Ethiopia and in Brazil during 1985. Moreover, the spikes in the volatility levels are almost non-existent since the mid 1990s, which implies less uncertainty with regard to the expected level of volatility. This may be due to the reduction in production risk which resulted from shifting the production zone within Brazil from a high to a low frost susceptible zone, coupled with the existence of a strong coffee growers' organisation which somehow plays a price stabilisation role. Also similar to all the other types of coffee under consideration, the level of volatility in the FOB price in Brazil remained constant over the whole period and at a lower level than the producer price. Thus, the extent of risk facing producers depends on the capacity and coping strategy available for producers.

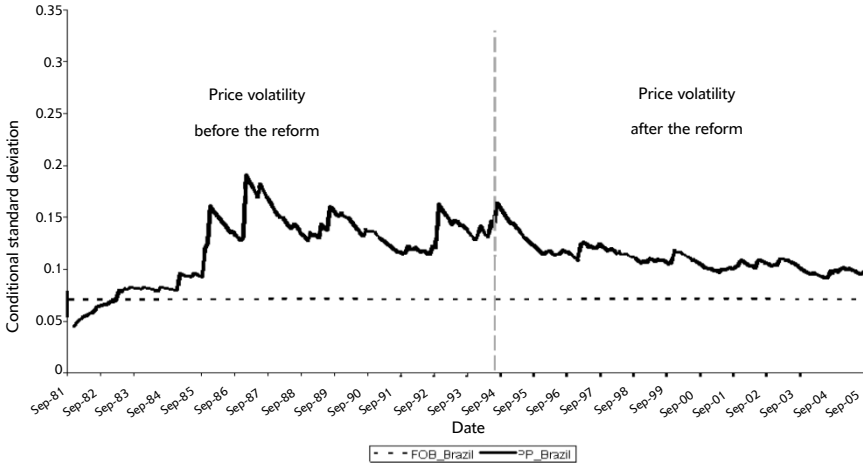

Figure 4: Volatility of producer and exporter prices of Brazilian coffee

From the above figures representing volatility levels in the producer prices within Ethiopia, there seems to have been a change in the volatility levels about the time of the deregulation of the Ethiopian coffee market. Similarly, the level of volatility in the Brazilian producer price also seems to have changed about the time when the coffee market within Brazil was deregulated.

3.5 Testing for structural breaks in the volatility levels in the price of coffee produced in respective locations under consideration

Although a change in volatility was expected, there seems to be some inconsistency with regard to the direction of the influence of market deregulation on volatility levels. Linear regression was used to formally test for a structural break in volatility levels at the time of the deregulation of the Ethiopian and Brazilian coffee markets and, furthermore, to determine the direction of the influence of market deregulation on volatility levels. The regression results are shown in table 4.

Table 4: Regression results to test for a structural break in volatility levels at the time of market deregulation

	Coefficient	Prob(t)
Wollega (PP)	0.0137***	0.0003
	(0.0037)[1]	
Harar (PP)	-0.0875***	0.0000
	(0.0092)	
National (PP)	-0.0022	0.3248
	(0.0023)	
Brazil (PP)	-0.0109***	0.0004
	(0.0031)	

Notes:

***, ** and * show the rejection of the null-hypothesis of no ARCH effect at 1 %, 5 % and 10 % respectively, thereby indicating time varying volatility.

Standard errors are shown in parentheses.

As initially expected, table 4 provides evidence that volatility levels in the producer prices within Wollega ($p < 0.01$), Harar ($p < 0.01$) and Brazil ($p < 0.01$) changed after the deregulation of the respective coffee markets. From closer inspection of the results, it can be seen that the deregulation had an opposite influence on the two regions (Wollega and Harar) within Ethiopia. While the deregulation caused an increase in the volatility level within Wollega, it caused a decrease in the volatility level in Harar. It is interesting, however, that the deregulation caused no significant change in the level of volatility in the national producer price within Ethiopia. The national producer price is the average producer price of all the regions within Ethiopia. Thus, when only investigating the volatility in the producer price on a national level, it may seem that producers have not been influenced in terms of volatility in the producer price by the deregulation of the coffee market. In actual fact, however, they have been influenced on a regional level and in addition to that, the direction of the influence differs from one region to the next. The challenge thus is to provide Ethiopian coffee producers with sufficient coping mechanisms which also meet their respective requirements based on the level of volatility they face.

From table 4, it can also be seen that volatility levels in the producer price of Brazil decreased significantly after the deregulation of the Brazilian coffee market. From figure 5, it can also be seen that the spikes in the conditional standard deviations became almost non-existent after the deregulation. A possible reason may be that the institutional environment governing the marketing of

coffee in a free market system within Brazil is more sophisticated compared to the institutional environment which overlays the free coffee market within Ethiopia. Further research, however, is necessary to formally test the influence of the institutional environment on the volatility levels in producer prices. The comparison of volatility levels prior to and after market deregulation concludes the section on the results. Some conclusions are drawn and implications highlighted in the next section.

4 CONCLUSION AND IMPLICATIONS

Coffee counts among the most important agricultural commodities in terms of value and volume traded. It has long been recognised as one of the most accessible sources of income for the rural poor across the developing world. Systemic price volatility and declining terms of trade in the international commodity markets over the course of the last decades, however, have made it far out of reach for many. Price volatility moreover affects all the participants along the marketing chain. However, the extent of risk and uncertainty varies with the capacity and coping options available to individual actors. Towards this end, the aim of this research was to measure and compare the price risk facing producers, wholesalers and exporters in order to identify the groups who have been most affected by price volatility over the last three decades.

Volatility levels in the respective FOB prices under consideration were found to remain constant over time. By implication, coffee exporters faced less uncertainty with regard to the prices they will receive for their exports than would have been the case with volatility levels that change over time. The presence of significant ARCH effect in the producer and auction prices within Ethiopia, however, implies time varying volatility levels and thus uncertainty with regard to the level of volatility in the underlying price series. In addition to time varying volatility levels, the volatility in the producer prices were found to be at a higher level compared to the auction and FOB prices. Thus, the results from this research suggest that producers are more exposed to price fluctuations and uncertainty with regard to price changes compared to the auction market, and that exporters face both lower levels of volatility and uncertainty due to constant volatility levels.

Coffee production either directly or indirectly affects the livelihood of a quarter of the Ethiopian population. The high levels of volatility and uncertainty associated with the producer price thus affect the lives of millions of smallholders and their families within Ethiopia, and thus also the overall economy of Ethiopia. The challenge is to provide Ethiopian coffee producers with sufficient coping tools in order to ensure sustainable coffee production and, thus, also to ensure and enhance the economic benefit of coffee production in the rural poor areas within Ethiopia. The problem, however, is that although Ethiopian coffee producers face

more price volatility and uncertainty with regard to the prices they will earn for their crop, there are insufficient price risk management tools available for them to cope in the risky price environment. Producers lack strong institutions to facilitate and support marketing activities. The lack of strong institutions may also be evident from the difference in the impact of market deregulation on volatility levels in different coffee production regions within Ethiopia. Thus, it is highly important to focus on this issue to enhance production and to minimise the risk that producers face.

Possible solutions from a long-term perspective may include, amongst others, the de-commodification of the sector, forward contracting, participating in fair trade, organic and other non-conventional marketing, and the establishment of direct trading relationships between producers and consumers. The effectiveness of these solutions, however, depends heavily on the institutional environment within which they operate. Further research is necessary to investigate the institutional environment that overlays the marketing of coffee in Ethiopia in order to determine which of the above-mentioned possible solutions may be the most effective as coping mechanisms in the risky environment faced by coffee producers in Ethiopia.

REFERENCES

Box, G. and Jenkins, G.M. 1976. Times series analysis: forecasting and control. San Francisco: Holden-Day.

Campbell, J.Y., Lo, A.W. and MacKinlay, A.C. 1997. *The econometrics of financial markets*, Princeton, NJ: Princeton University Press.

Coffee and Tea Authority (CTA). 2002. Annual report. Ethiopia, Addis Ababa.

Dercon, S. and Ayalew, L. 1995. Smuggling and supply response: coffee in Ethiopia. *World Development* 23(10):1795–1813.

Dickey, D.A. and Fuller, W.A. 1981. Likelihood ratio statistics for autoregressive time series with unit root. *Econometrica* 49:1057–1072.

Engle, R. 2001. GARCH 101: The use of ARCH/GARCH models in applied econometrics. *Journal of Economic Perspectives* 15(4):157–168.

Engle, R. 2004. Risk and volatility: econometric model and financial practice. *The American Economic Review* 43(3):405–420.

EViews. 1998. *User's guide.*

Gujarati, D.N. 2003. *Basic econometrics*. 4th Edition. New York: McGraw-Hill Higher Education.

Hanmer, L. and Nashold, F. 2000. Attaining the international development targets: Will growth be enough? *Development policy review* 18:11–36.

International Trade Centre (ITC). 2002. Field survey coffee reports: Cameroon, Cote D'Ivoire, El Salvador, Nicaragua and Tanzania. Washington, DC: International Task Force.

Jooste, A., Alemu, Z.G, Botha, E. and Van Schalkwyk, H.D. 2003. Investigation into the supply chain for beef for the FPMC appointed by the Minister of Agriculture. Report for the Food Monitoring Pricing Committee.

Jordaan, H., Grové, B., Jooste, A. and Alemu, Z.G. 2007. Measuring price volatility of certain field crops in South Africa using the ARCH/GARCH approach. *Agrekon* 46(3):306–322.

Just, R.E. and Pope, R.D. 2002. A comprehensive assessment of the role of risk in US agriculture. Boston: Kluwer Academic Publishers.

Karanja, A.M., Kuyvenhoven, A. and Moll, A.J. 2003. Economic reform and evaluation of producer price in Kenya: an ARCH-M approach. African Development Bank, UK: Blackwell Publishing Ltd.

Kruger, A.O., Schiff, M. and Valdes, A. 1998. Agricultural incentives in developing countries: measuring the effect of sectoral and economy wide policies. *World Bank Economic Review* 2:255–271.

Lewin, B., Giovannucci, V. and Varangis, P. 2004. Coffee markets: new paradigms in global coffee supply and demand. *World Bank Agricultural and Rural Development Discussion Paper 3.* Washington, DC: World Bank.

Mohan, S. 2007. Market-based price risk management for coffee producers. *Development Policy Review* 25(3):333–345.

Moledina, A.A., Roe, T.L. and Shane, M. 2003. Measurement of commodity price volatility and the welfare consequences of eliminating volatility. Working Paper at the Economic Development Centre, University of Minnesota.

Pesaran, M.H. and Pesaran, B. 1997. *Working with Microfit 4.0: interactive econometric analysis*. Oxford: Oxford University Press.

Shively, G.E. 1996. Food price volatility and economic reform: An ARCH approach for Ghana. *American Journal of Agricultural Economics* 78:126–136.

APPENDIX 1

Appendix 1 is the original version of the same graph as shown in figure 1. Figure 1 has been scaled for easy comparison of the volatility levels in the prices of the different coffee varieties. Appendix 1 is included to provide an idea of how the level of volatility in the producer price behaved during the period from September 1986 to September 1989, which is characterised by extremely high volatility levels.

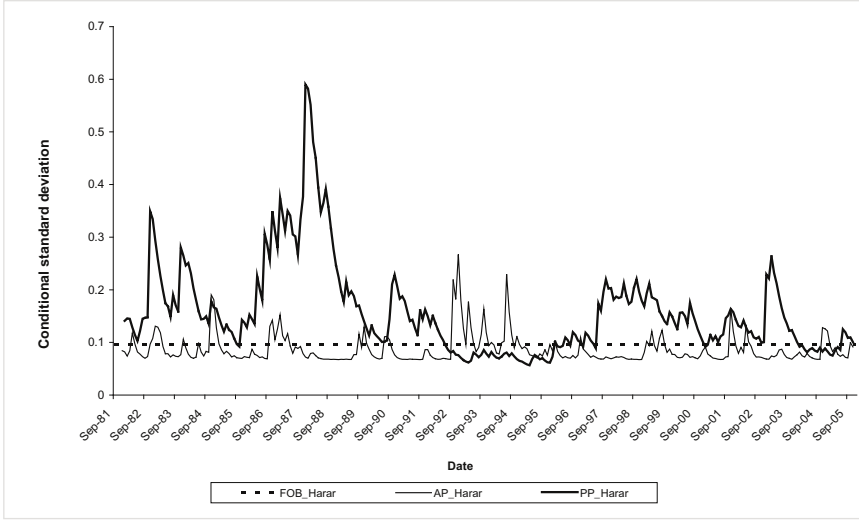

Figure 1B: Unscaled graph showing the volatility in the producer, wholesale and export prices of Harar coffee