Market Reforms and Commodity Price Volatility: the Case of East African Coffee Market

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Abstract

The goal of this paper is to examine the impact of commodity market reforms on producer price volatility using evidence from the East African coffee market. The results, based on time-varying volatility models and key summary statistics, show that coffee market reforms in the East African Community (EAC) are associated with changes in producer price volatility and volatility persistence at both country and regional levels. However, reforms were not the only cause of changes in price volatility. The study further shows that reforms had different effects on prices volatilities of Arabica and Robusta varieties of coffee grown in individual EAC countries. These findings have wider implication for commodity market reforms and producer price stabilization policies in the EAC and coffee producing countries in sub-Sahara Africa.

JEL Classification: N57; 013; 019; 024; P42

Key words: Coffee, Market Reforms, Producer Price, Volatility, East Africa, GARCH

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1. Introduction

The reform of primary commodity markets were at the centre of wider structural adjustment policies implemented in commodity-dependent countries that were facing balance of payment and mounting external debt problems in 1970s and 1980s. The reforms, which commenced under the aegis of the World Bank and IMF in the 1980s, principally targeted agricultural sectors of developing countries because of heavy dependence of those economies on primary agricultural products for foreign exchange earnings. In general, commodity market reforms emphasized liberalization policies aimed at transforming government-controlled commodity markets into more liberalized, market-driven structure aimed at increasing efficiency and boosting economic growth. Theoretically, liberalized markets are expected to create competition among commodity traders in both domestic and international markets and increase commodity prices and price volatility (Kruger et al., 1998; Hill, 2006); as well as increase market size (Voituriez, 2001). Despite having similar goals, different approaches have been used to implement commodity markets reforms across countries (Akiyama et al, 2001), leading to different outcomes (see for example, Han et al., 1990; Cuddington, 1992; Laroque, 1992; Reinhart and Wickham, 1994; Crain and Lee, 1996; Shively, 1996; Larson, 1998; Cashin et al. 2000; Chaudhuri, 2001; Yang et al. 2001; Cashin and McDermott, 2002; Swaray, 2007). Specifically, the literature provides contradicting results on the impact reforms have had on commodity producer price volatility: evidences varying from increase, decrease and no impact.

These contradictions have important implications for policy and strategic decisions relating to market reforms and economic growth. In particular, they imply that generalized strategies such as measures proposed in the Doha Development Agenda of 2004, which place emphasis on market liberalization as a path towards managing commodity price risk poses a challenge because the benefits of reforms could not be realized in the same way in reforming countries (FAO, 2006; Martin and Anderson, 2008). This particularly warrants further evidence on reforms on producer price volatility for two major varieties of coffee grown in the East African Community (EAC)[1].

Principally, there is a common agreement that commodity price volatility is costly for both developing and developed economies (Larson et al., 1998, Karanja et al., 2003, Combes and Guillaumont, 2002, Bourguignon et al., 2004). However, the severity of price volatility tends to be higher for developing economies due to their high dependence on primary commodities for export revenues, investment growth, employment, income growth and debt servicing (Chaudhuri, 2001). Hence, the search for rigorous answers on the impact of reforms is vital for policy decisions pertaining to: price stabilization programs (Deaton and Miller, 1995, Cashin et al., 2000), international market-sharing agreements (Cuddington and Urzua, 1989, Cuddington, 1992), risk management strategies (Reinhart and Wickham, 1994), and sensible development and economic policies (Deaton, 1999). The literature mentions several major drivers of commodity price volatility, including domestic market structures and policies, international price influences,

[1] The EAC is a regional organization of five East African countries viz. Kenya, Uganda, Tanzania, Rwanda and Burundi, Rwanda that formally came into existence in the year 2000.

non-compliance with International Commodity Agreements (ICAs), breakdown of ICAs and exchange rate volatility, among others (Borenszrein and Reinhart, 1994; Reinhart and Wickham, 1994; Gilbert, 1995, Morgan, 2001, Swaray, 2011). Therefore, the contribution of reforms needs to be envisaged and explained explicitly.

Although commodity price volatility is a challenging phenomenon to deal with, market reforms are said to have positive outcomes such as reducing production and transaction costs and increasing share of export prices, which in turn are viewed as a compensation for price risk (Akiyama, et al., 2001; Larson, 1993; Gilbert, 1997). Dealing with price volatility was not among the specific objectives of reforms but a vital auxiliary outcome with strong economic impact that raise several policy challenges, such as: how significant is the impact of volatility compared to the intended reform objectives? Since the impact of reforms differs across countries and commodities, should countries consider adjusting their reform policies as a measure to manage price volatility or should price risk management strategies be designed to suit the existing reform policies? These challenging questions cannot be answered with clarity without a profound knowledge of the magnitude of price volatility in specific countries, for specific commodities, and for specific market reform structures. However, since reforms involve liberalizing markets, it is reasonable to argue that price volatility is inevitable but manageable.

In sub-Sahara Africa (SSA hereafter), coffee was at the forefront of agricultural market reforms in the 1980s. Previous literature on the impact of commodity market reforms focus largely on market structures and policies that

explain market performance, but fall short of addressing the price volatility challenge in SSA (e.g. Putterman, 1995; Temu, 1999; Temu et al. 2001; Ponte, 2001; Baffes, 2003; Hill, 2006; and Baffes, 2006). This study, therefore, focuses on Africa, and specifically on coffee[2] producer prices in the EAC.

Specifically, the need for more rigorous up-to-date empirical study on coffee producer price volatility in the EAC is apparent for several reasons. Firstly, coffee is a major contributor to the economy of the EAC. On country-wise basis, the contribution of coffee to merchandise exports is 13.4 percent for Tanzania, Kenya (13.7%), Uganda (40.1%), Burundi (72.2%) and Rwanda (58.1%). Secondly, coffee is one of the most price-volatile primary commodities whose degree of volatility differs from country to country, with the impact on producers varying across countries, depending on the level of economic development (FAO, 2004). Akiyama et al. (2003) emphasize the importance of empirical work on the impact of reforms on commodity price volatility due to the rarity of literature on the topic, especially pertaining to developing countries. Thirdly, previous studies on the EAC coffee sector did not supply sufficient empirical evidence on the magnitude of producer price volatility and the level of volatility persistence. Finally, linking the impact of liberalization to producer price risk is important for policy-makers. This is because the literature, on the one hand, suggests that liberalization reforms tend to affect commodity prices (Akiyama, 2001; Yang et al., 2001); while on the other hand price risk affects producers' investment decisions and the economy as a whole (Ponte, 2002; Cooksey, 2003). The relationship between producer decisions and price risk is paramount because producers are said to be risk-averse (Ady,

[2] Unless specified otherwise coffee means coffee beans or unhulled coffee.

1969; Just, 1975; Holt and Aradhyula, 1990; Pope and Just, 1991; Rambaldi and Simmons, 2000), hence their decisions are functions of their risk preferences.

Moreover, empirical evidences on the EAC coffee reforms provide contradicting and inconclusive results. On one hand, they suggest that coffee market reforms in the EAC have some disappointing outcomes due several reasons like: political interference, bureaucracy, and incomplete liberalization (Ponte, 2004), and their tendency to raise transaction costs of financing farm activities (Winter-Nelson and Temu, 2002). For example, for Tanzania, studies show that a series of local coffee market regulations and reforms from 1970s to 2000s failed to meet declared expectations (Baffes, 2003) and led to a decline in producer prices (Putterman, 1995). Cooksey (2003) notes that the reforms were destined to fail because they could not take place to the extent claimed by the government and donors. On the other hand, they provide positive arguments in support of the reforms in the region, such as their ability to increase producer prices, reduce marketing margins, and improve efficiency in coffee auction (Temu, 1999; Temu et al., 2001, Akiyama, 2001, Baffes, 2006).

In response to the above arguments, this study aims at taking a step further by examining not only the effect of coffee market reforms on producer price volatility, but also linking volatility with differences in market structures and provide detailed discussion for policy implications. We employ the Generalised Autoregressive Conditional Heteroskedascity (GARCH) model, using the dollar value of local producer prices. Our main findings suggest that coffee market reforms in the EAC are generally associated with increase in producer price volatility, but the reforms are not the only main cause of the increase. Based on

previous studies, we argue that other factors like international coffee prices and exchange rates might have influenced these changes. Moreover, we show that differences in coffee market structures in the EAC explain the extent to which coffee producers are affected by price volatility. We use these differences to discuss general policy implications with specific emphasis on price risk management.

The remainder of the paper is organized as follows: Section 2 provides a general overview of coffee market reforms in the East African Region. Section 3 presents the modeling framework. Section 4 explains data and estimation procedures. Empirical results are displayed in section 5 and discussed in section 6. A brief conclusion is given in section 7.

2. An Overview of Coffee Market Reforms in EAC Countries

Before the 1990s reforms, coffee markets in Sub-Saharan Africa were under heavy government control, within the framework of state-owned coffee marketing bodies. At that time, state-controlled institutions were considered necessary because of coffee's importance in foreign exchange earnings and government revenue. However, coffee market reforms in EAC countries started in 1990s following a worldwide coffee sector reform agenda among producing countries. The reforms were motivated by many factors, including the demise of the ICA's quota system in 1989 (Akiyama, 2001), forces from international financial institutions (IMF and World Bank); the changing view of development economists; and world economic events since 1960s. Indeed, there were transformational political and ideological views in favor of market-based approaches in commodity

markets. According to Deaton (1999), fixed-price policies are sustainable when world prices are stable (as they were in the 1960s) or in the presence of a stabilizing system such as ICA's export quotas. However, in presence of price fluctuations, such policies were either difficult or impossible to maintain.

The post-reform period has been characterized mostly by free market structures and competitive pricing. However, the market structures, timing and features of the reforms differ amongst countries. According to Akiyama et al. (2003), market reforms follow a sequential pattern based on priorities, whereby their design and process depend on the conditions facing policy-makers during the initiation and implementation process.

Table 1 summarizes the features of coffee markets in EAC countries pre and post reforms. Specifically, the summary focuses on coffee production, organization and market structure from farm-gate to export channels. Overall, coffee production in the EAC region is done by smallholders, with the exception of Kenya where there are coffee estates. Before reforms, coffee markets were under strong government control in all countries, whereby these governments (through Coffee Boards) fixed producer prices. However, Ugandan producer prices were competitive even prior to reforms because private buyers and cooperatives were allowed to buy coffee from producers. Cooperatives played a significant role of unifying farmers and selling points at farm-gate, except in Burundi where they did not exist before reforms. In Tanzania and Rwanda, Coffee Boards were the sole buyers of coffee at farm-gate, through cooperatives and middlemen buyers, respectively. The other countries had a combination of cooperatives and private buyers. Mostly, producers sold unprocessed coffee beans (cherry) except in Kenya

where only semi-processed coffee (parchment) was allowed. Exports were channeled through government-owned auctions, except in Uganda and Burundi where the auction system did not exist. With the exception of Kenya, all coffee exports in EAC were done by governments.

-Table 1 about here-

The 1990s reforms brought some changes, but with differences across countries. The major changes included loosening government control in the coffee sector, thereby allowing private sector participation. The functional roles of most Coffee Boards were also reduced (except in Burundi). Private buyers were allowed at farm-gate, leading to competition with cooperatives. To some extent, this competition weakened the powers of cooperatives in Tanzania and led to their near disappearance in Uganda. In contrast, cooperatives became stronger in Kenya and Rwanda and were also established in Burundi (where they did not exist before reforms). At the export level, the legalization of private exporters led to the cessation of governments' monopoly but introduced large private sector players in the sector. For example large vertically integrated private firms took over farm-gate purchase and export of coffee. Detailed account of coffee market structures pre and post reforms is found in previous studies (see Ponte, 2001; Temu et al., 2001; Baffes, 2003, Baffes et al., 2004; Lewin et al., 2004; Hill, 2006; Kimonyo and Ntiranyibagira, 2007; Murekezi, 2009; Boudreaux and Ahluwalia, 2009). These studies generally show that coffee market reforms had several impacts on coffee producers.

3. The Modeling Framework

This study employs standard GARCH models in examining coffee price volatilities in the EAC countries. These models have become workhorse among time-varying risk models, replacing common measures of volatility such as standard deviation and coefficient of variation, which have no constant range and tend to overstate variability in non-trending series (Engle, 2001). A major advantage of GARCH models lies in their ability to handle the non-stationary conditional variance of the real stochastic process, which varies over time due to heteroskedastic properties of the time series (Bollerslev, 1986). Non-normal skewness, excess kurtosis and serial correlation are the common statistical features in commodity prices (Deaton and Laroque, 1992). These features explain a non-linear dynamic behavior of commodity prices. For storable commodities like coffee, non-linearity behavior prices is associated with the guarantee that these commodities never carry negative inventories. Hence, their prices are likely to show dynamic clustering patterns. GARCH models can capture these patterns and part of excess kurtosis in commodity prices (Tomek and Peterson, 2001).

The practical application of these models is noteworthy as they have attracted many researchers and authors in similar studies (see Engle, 1982; Aradhyula and Holt, 1989; Holt and Aradhyula, 1990; Yang and Brorsen, 1992; Yang and Brorsen, 1993; Holt, 1993; Hudson and Coble, 1999; Yang et al., 2001; Engle, 2001; Swaray, 2007). According to Engle and Victor (1993), the application of these models has shown strength in analyzing volatility in financial and commodity markets, with GARCH (1,1) being the most preferable (Bollerslev, 1987; Bollerslev et al., 1992; Engle, 1993; Rahman et al., 2002). Specifically,

GARCH models have been used in examining the impact of reforms on agricultural prices (see Yang et al., 2001; Alizadeh and Nomikos, 2005).

Generally, the normal-error and the Student-t GARCH process can be expressed as follows:

$$\ln P_t = m + \sum_{i=1}^{n} f_i \ln P_{t-i} + e_t; \qquad \varepsilon_t / \Omega_{t-1} \sim td(0, h_t, v) \tag{1}$$

$$h_t = w + \sum_{i=1}^{q} a_i e_{t-i}^2 + \sum_{i=1}^{p} b_i h_{t-i} \tag{2}$$

Where $\ln P_t$ is the natural logarithm of modeled prices at time t, whereas ϕ is its respective coefficient. ε_t denotes the error term which is considered to be normally distributed, in the standard GARCH model, with zero mean and variance h_t, conditional upon information set Ω_{t-1} available at time $t-1$. However, non-normality in commodity prices may not be inevitable. Under such circumstances, Bollerslev (1987) suggests the use of the student's t-density and relax the normality assumption (as applied in Yang et al (2001)). Thus, $td(0,h_t,v)$ represents the student's t-density with mean zero, conditional variance h_t, and degree of freedom v. The coefficients of GARCH effects (α_i and β_i) are used to measure the time-varying pattern of price variability, in which the sum of these coefficients measures the persistence of price volatility. If the sum of α_i and β_i is close to, but less than one, it implies the presence of high volatility persistence.

In equation (2), the mean of conditional variance (mean- h_t) can be used to measure the overall level of volatility. Moreover, in order to measure the magnitude of reforms on volatility (measured by the conditional variance, h_t), the variance equation was augmented with a reform dummy (D_t) as follows:

$$h_t = w + \sum_{i=1}^{q} a_i e_{t-i}^2 + \sum_{i=1}^{p} b_i h_{t-i} + rD_t \qquad (3)$$

Such that, $D_t \begin{cases} 0 = \text{pre reforms} \\ 1 = \text{post reforms} \end{cases}$

In equation (3), reforms will have the effect of increasing (decreasing) volatility if the coefficient of the reform dummy (r) is positive (negative) and statistically significant. This approach has been applied in other similar studies (e.g. Yang et al., 2001; and Karanja et al., 2003).

Sometimes, GARCH coefficients are subject to admissibility and stability restrictions such that: $\omega > 0, \alpha_i \geq 0, \beta_i \geq 0, (\alpha, \beta) \notin \{0\} \times (0, \infty)$, and $\alpha + \beta < 1, \beta < 1$ to guarantee the existence of unconditional second moment in ε_t^2 if $\alpha + \beta < 1$. Some studies have relaxed the usual non-negativity restriction on coefficients in the conditional variance equation. However, the relaxation of non-negativity restrictions can only apply under certain conditions, such as modeling higher GARCH orders (e.g. Cho et al.,2003) and in extended GARCH models like TGARCH and EGARCH (e.g. Veld-Merkoulova, 2003). Indeed, according to Nelson and Cao (1992), the non-negativity condition is overly restrictive, but the relaxation of non-negativity restrictions may not be applied to GARCH (1,1) models. Moreover, the non-negativity is necessary when GARCH models are applied to generate conditional forecasts to the mean and variance, like in Aradhyula and Holt (1989).

These stability restrictions also include the Integrated (IGARCH) in case $\alpha + \beta = 1$, whereby the unconditional variance of residuals is infinite (Engle and Bollerslev, 1986, Harvey et al., 1994, Caporale et al., 2003, Dionisio et al., 2007): hence, it may not satisfy the definition of a covariance stationary process.

Nevertheless, this does not necessarily pose as serious a problem as it appears (Wang, 2003) because even if a GARCH (IGARCH) model is not covariance stationary, it is strictly stationary or ergodic, and the standard asymptotically based inference procedures are generally valid if the constant ω is greater than zero (Nelson, 1990, Lumsdaine, 1995).

4. Data and Preliminary Tests

This study uses monthly producer prices coffee obtained from the International Coffee Organization (ICO). The data sets are categorized according to the two coffee varieties grown in the East African Region (namely Arabica and Robusta). Although producers in respective countries receive local currency prices, the ICO uses monthly average exchange rates published by the IMF to convert the prices in local currencies to US cents.

The study used monthly dollar value prices of coffee producers, implying that the respective price volatilities are likely to be induced by other external shocks including exchange rate volatility of local currencies against the dollar. Indeed, most studies tend to examine producer prices as a percentage of export prices (which are mostly denominated in US$). The importance of using producer prices in US dollars is that the US$, despite the European Union currency, (Euro), still remains the currency commonly used to measure economic performance worldwide. Using the US$ dollar price of coffee makes it possible to compare and analyze economic performance indicators (such as GDP, exports, per capital, etc.) to the value attributed to producer coffee prices. It also helps to understand the real value of producer earnings based on the purchasing power of a relatively stable currency like the dollar. Progress towards the EAC, a common market,

makes a standard benchmark currency, like the US$, important for analyzing economic phenomena in the region. Moreover, domestic coffee prices in producing countries are to a great extent influenced by prices in international markets such as the London International Financial Futures and Options Exchange (LIFFE) and the New York Board of Trade (NYBOT). Trading in these markets is mostly in dollar terms.

However, there were some limitations in the availability of data. Data for Arabica coffee for all countries was available from January 1980. For Kenya and Rwanda, data was only available until November 2004 and May 2005, respectively. For Tanzania and Burundi data was available until September 2008 and March 2010 respectively. Robusta coffee data was only available from June 1985 to September 2005 for Tanzania and from January 1980 to September 2009 for Uganda. Therefore, our study is based on the most up-to-date data available for each individual country. The data sets were deflated using Commodity Beverage Price Index (CBPI) reported by the IMF, based in 2005 (i.e. 2005=100). Then, the time series of respective prices (P_t) were further transformed to natural logarithms (lnP_t), where subscript t denotes monthly time series.

-Figure 1 about here-

Figure 1 depicts the movement of coffee prices for the periods covered. Overall, the graphs indicate the presence of some cycles and structural breaks in the price series. Structural breaks can be roughly observed in 1981 for Ugandan Arabica, in1993 for Kenyan Arabica, 1994 for Ugandan Arabica and Robusta, 1997-98 for Tanzanian Robusta, and 1994-96 for international Robusta prices. These structural breaks in 1990s seem to have narrowed the gap between

international prices and producer prices in Kenya (Arabica) and Uganda (Robusta), and appear to correspond to changes in international coffee prices. For example, in the International Herald Tribune, Ipsen (1994) reported that 'coffee prices soared by more than a third to their highest prices in more than seven years' on 27th June 1994 in London and New York coffee markets. The price rise followed the news about a snap-frost in the coffee growing regions of Southern Brazil. In addition, on 13th June 1994, Rogers (1994) reported news about expected coffee shortage, and a significant rise in futures prices. The period from 1997/1998 marks a sharp decline in world coffee prices due to significant expansion in coffee supply against sluggish demand growth (Hallam, 2003). Significant price differences among the countries are also noticeable in both Arabica and Robusta. For Arabica, Rwanda and Burundi seem to have the lowest producer prices, whereas Kenya had the highest. Regarding Robusta, producer prices in Uganda appear to have overtaken prices in Tanzania from 1994, except in 1997 where Tanzanian prices seem to deviate from the sharp decline in world coffee prices.

Descriptive statistics (see Tables 2) suggest non-normal distribution in both Arabica and Robusta price series, except Tanzanian (Arabica). The distribution suggests thin tails (except for Arabica in Kenya and Robusta prices in Tanzania) since the kurtosis in these series is far less than the normal value of 3. This platykurtic behavior may indicate that big shocks to prices were relatively infrequent during the sample periods. The evidence of positive skewness means that the density of the respective price series is extreme to the right, hence less chance of extremely negative outcomes. Where the statistics are based on price differences, the positive means indicate that the series have been dominated by

price increase in real terms. Negative means in Robusta prices (Tanzania and Indicative) suggest a long-run decrease in the respective coffee prices. Table 3 displays the correlation matrices, suggesting low correlations between producer prices in the five countries (Arabica) and in Tanzania and Uganda (Robusta), except Rwanda and Burundi with a positive correlation of 0.72 in Arabica.

-Table 2 and 3 about here-

In practice, estimation of GARCH processes generally requires stationary time series variables data. Initially, we tested the data for stationarity using the Augmented Dickey Fuller (ADF), which has been widely applied and discussed in previous works (see Wang, 2003; Milas et al., 2004; and Dionisio et al., 2007). The conclusions from ADF test (not reported in this paper available upon request) was that stationarity in all price series could only be achieved with log differences, whereas log levels showed the presence of unit root. However, these results were suspicious because the real coffee price cannot be 'truly' integrated due to its historical tendency of having upper and lower boundaries. Russell et al. (2012) provide evidence of stationarity in coffee prices (levels), while questioning the traditional norm of assuming unit root in coffee prices. Building on Perron (1989), it was reasonable to suspect the cause of unit root to be the possible presence of structural breaks in the real coffee price series, which are roughly evident in Figure 1.

Following Elliot et al (1996), we proceeded to apply the DF-GLS (Dickey Fuller-Generalized Least Square) test, a modified Dickey-Fuller test with improved efficiency to capture unknown mean and trend. We used both forms of DF-GLS: the GLS demeaning, which only include a constant in the first stage regression;

and the GLS detrending, in which the series to be tested is regressed on a constant and linear trend. The DF-GLS, presented in Table 4, provide strong evidence of stationarity in coffee price series (log levels), except for Robusta indicative prices. In this case, Robusta indicative prices were investigated further by dividing the series into two sub-samples corresponding to pre and post reform periods (before and after December 1994, respectively), and test them separately. The results provide strong evidence of stationarity in the pre-reform sample, with limited evidence in the post-reform sample. Notwithstanding, further corroborative tests (ADF and PP), Robusta indicative prices strongly suggest stationarity in the post-reform sample too. Eventually, our final conclusion was to assume stationarity in all coffee price levels.

-Table 4 about here-

Since we suspected the presence of structural breaks in the series, identifying breakpoints was vital before estimating GARCH models. With the exception of reform switching dates, an eyeball of the graphs could not easily identify breakpoints. Therefore, we applied a combination of Chow tests and Quandt-Andrews tests. The tests were applied for the entire samples and sub-samples (pre and post reforms) in sequential steps for identifying multiple breakpoints. The applications and limitations of these tests are explained in Hansen (2001). In the testing process, an autoregressive (AR) process was firstly estimated for each sample series using ordinary least square (OLS). AR(1) was favored for all series, except Arabica prices for Burundi, Rwanda and indicative which favored AR(2) processes. Then, stability tests for break points were performed on each of the estimated AR models in two steps. Firstly, we tested the

entire samples assuming the reform switching points as known breakpoints (only applied in Chow tests). Secondly, we tested each sub-sample (pre and post reforms) for both known and unknown breakpoints. Our results for breakpoints summarized in Table 5.

-Table 5 about here-

Chow tests require the breakpoint dates to be known a priori. Hence, for entire samples, the assumed breakpoints correspond to the beginning of respective coffee market reforms in each country. The tests suggest regime shifts following reforms, except for Tanzania and Burundi. For pre and post reform samples, breakpoints were roughly presumed with the aid of an eyeball of graphs on four corroborative tests (CUSUM, CUSUM-SQ, recursive residuals and N-step probability), which are depicted in Figure 2 and Figure 3. Quandt-Andrews tests do not require the break dates to be known a prior. Hence, they aimed at providing further evidence of structural breaks and corroborating the Chow tests. In most cases, the results from both tests appear to be consistent, with no evidence of breakpoints in Arabica indicative series.

In order to make sense of the unknown breakpoints, we use the literature to determine any major events (global and domestic) that are likely to have influenced the structural shifts. Brief notes on these events (economic and non-economic) are included in Table 5. As pointed out in Hansen (2001) and Russell et al (2012), it is unlikely for structural shifts to occur on the exact date of a major event; instead, a reasonable time lag tend to elapse for responses to take place. Overall, the identified break points roughly coincide with major events, suggesting the validity of the tests.

-Figure 2 and 3 about here-

5. Empirical Estimates

We estimate GARCH models in two forms. Firstly, corresponding with variance equation (2) without a reform dummy. Secondly, corresponding with equation (3) with a reform dummy in the variance equations. For each set of estimation, a series of dummies are introduced in the mean equation (1) in order to control for suspected structural breaks identified in Table 5. We use Maximum Likelihood in our estimations since this is the preferred method for univariate GARCH modeling (Engle, 2001). In the GARCH models without a reform dummy in the variance equation, our estimates were broken into three distinctive sub-samples (entire samples, pre reform samples, and post reform samples). In these models, the impact of reforms is measured by comparing the results from pre and post reform sub-samples. For variance equations with a reform dummy, the estimates were performed for entire samples only, whereby the impact of reforms is measured by the significance of the reform dummy coefficient.

The reform switching points were based on country-specific reform events as follows: Tanzania (from 1994), Kenya (from 1993), Uganda (from 1992), Burundi (from 1991) and Rwanda (from 1995). Indicative prices are merely modeled in order to have a rough comparison between producer prices volatility in East Africa (pre and post reforms) and international coffee markets. Therefore, their pre reform samples were truncated to 1991, the period roughly corresponding to pre reform markets in the whole East African region. Likewise, the switching point for the post reform sample was 1995, to cover the corresponding reform period in the whole region (that is, all the five countries had

undergone coffee market reforms). Estimates were made for the maximum possible available data as indicated in Table 2. That is, the estimated samples differ across countries.

All the GARCH analysis assumed normal distribution of error terms. Each estimation process involved imposing a restriction on the target conditional variance. Diagnostic tests for ARCH were performed up to lag 4, and suggest no ARCH problem (see Table 8).

-Table 6 about here-

Table 6 reports the empirical estimates from variance equations of the GARCH models (with and without a breakpoint dummy in the mean equation), for both Arabica and Robusta prices. The reported coefficients in Panel A are for models without a reform dummy in the variance equation, while Panel B reports the coefficients for models with a reform dummy in the variance equation. In most models, the estimated coefficients for volatility persistence (α and β) are statistically significant at 1 percent level.

Table 7 contains an analytical summary of the main results from the estimated models. In this table, percentage changes in volatility persistence and mean of conditional variance are calculated by subtracting the post-reform figures (current) from the pre-reform figures (previous), divided by pre-reform figures (previous), times 100. In case a reference sub-sample (pre-reform or post- reform) has two estimates (from dummy-controlled model and non dummy-controlled model), our selection of the appropriate model for comparison is aided by comparing information criteria (AIC, SIC, and HQIC), log likelihoods (LL) and the strength of the ARCH diagnostic tests. The target was to select a model, which is

more favorable based on these criteria. From this process, models with dummies appeared superior, except for Uganda (Arabica) and Tanzania (Robusta)

The analysis, interpretation and discussions in this paper focus on volatility persistence and price risk (measured by conditional variances and standard deviations) following market reforms across the five EAC countries. For conditional variances, our measure of the impact of reforms on producer price risk is two-fold. Firstly, we compare the pre and post reform estimates for models without a reform dummy in the variance equation (2) (see Table 7). Secondly, we use a reform dummy in the variance equation (3) to make inference on the magnitude of change in conditional variances following reforms (Table 6 panel B). Overall, the conclusions from the two approaches and from the traditional standard deviations are consistent.

-Table 7 about here-

Arabica Producer Prices

Our results suggest highly persistent volatility in Arabica prices for all countries, with more than 90 percent (but not all) of shocks carried forward monthly in all sample periods. Comparatively, volatility persistence in indicative prices seems to be relatively lower than each of EAC countries during all sample periods, with less than 90 percent overall and pre reform period. Overall, the 1990s coffee market reforms in the EAC seem to be associated with increased volatility persistence in Arabica producer prices in three countries (Tanzania, Kenya and Rwanda), but slightly persistent decrease in Uganda and Burundi. Kenyan prices appear to have the highest increase in volatility persistent (about

8 percent), which is the same as the increase in indicative Arabica prices during the corresponding period. The increases in other countries were approximately: 4 percent in Tanzania, and 2 percent in Burundi. The decrease in Uganda and Rwanda are approximately 1 percent and 2 percent, respectively.

Regarding the overall price risk, EAC Arabica coffee producers appear to bear more price risk following reforms, except in Uganda. Just like volatility persistent, the highest increase in volatility was in Kenya for both measures: conditional variance (761%) and standard deviation (99%). The increase in Tanzania was approximately 55 percent and 59 percent, while was 77 percent and 36 percent in Burundi, all based on conditional variances and standard deviations, respectively. Rwanda seems to have the lowest volatility increase: 30 percent (conditional variance) and 8 percent (standard deviation). In Uganda, the decrease in volatility is about 76 percent and 55 percent on conditional variances and standard deviation, respectively: with reforms showing statistically insignificant contribution.

Comparing the impact of reforms across the five EAC countries, Kenyan Arabica producers, despite being the most highly paid, seem to be the most exposed to price volatility. Ugandan producers appear to be the least volatile, followed by Burundi, Tanzania, and finally Rwanda. Before the reforms, producer prices in Uganda were the most volatile, while the other four countries had almost the same level of volatility (see Table 7).

Despite these post-reform changes, the reform dummies in the variance equation (3) suggest that reforms alone had very little impact on price volatility. While reform dummies are statistically significant for Kenya (about 0.9 percent),

Burundi (0.1 percent) and Rwanda (0.5 percent) the contribution of reforms to price volatility was less than 1 percent in all cases. The reform dummies were statistically insignificant in Tanzania and Uganda. Therefore, reforms alone had minimal impact on producer prices. The reform usher in noticeable competition because it largely replaced state-controlled monopolistic marketing bodies with large vertically integrated private sector firms in the coffee.

Robusta Producer Prices

Overall, Robusta prices seem to be highly persistent in both countries Tanzania and Uganda, consistent with international prices (see Table 7). The post-reform periods are associated with an increase in volatility persistence of approximately 16 percent and 12 percent in Tanzania and Uganda, respectively, while volatility persistence in international coffee prices appears to have increased by almost 29 percent. Specifically, the post-reform proportion of volatility shocks carried forward each month is relatively the same: about 95 percent, 96 percent and 97 percent in Tanzania, Uganda, and international prices, respectively.

About the overall price risk, Tanzanian producers appear to have carried higher price risk than Ugandan producers during all the sample periods, but they are both higher than international prices. Coffee market reforms seem to be associated with significant increases in volatility based on our measures: conditional variances and standard deviations. This increase is consistent with international prices and Arabica producer prices. Like the entire sample period, Tanzanian producers bear more risk than Uganda producers following reforms. Based on conditional variances the volatility increased by 431 percent in

Tanzania, compared to 131 percent in Uganda, while standard deviations show an increase of 133 percent in Tanzania and 27 percent in Uganda.

In the model with reform dummy in the variance equation, all the coefficients for r are positive, but statistically insignificant. Like on Arabica prices, this fails to provide strong evidence of the contribution of reforms on price volatility in the two countries. Interestingly, the magnitude of the coefficients is almost the same in the EAC countries like in international prices: that is approximately 0.2 percent in Tanzanian and international prices, and 0.3 percent in Ugandan prices. For Tanzania, this magnitude is similar with that of Arabica prices, while is it different on Uganda.

6. Discussion and Policy Implications

Our results on the increase in producer price volatility during coffee market reforms in the EAC are consistent with previous studies, including Gemech and Struthers (2007) on Ethiopia. However, unlike other studies, we show that reforms had very small impact overall (less than 1 percent), but more impact during the early stages of reforms (see Figure 4). This is likely to be due institutional adjustments during those early stages and as pointed out by Ponte (2002) that market reforms tend to increase price volatility because of the absence of stabilization mechanisms and involvement of the private sector in the marketing systems.

It is reasonable to consider other factors, apart from reforms, which have greater influence on producer price volatility during reforms in EAC countries.

Theoretically, the major price determinants of primary export commodities like coffee are international market factors (such as commodity agreements) and international prices (Karanja et al., 2003). Previous studies provide evidence of volatility transmission from international coffee markets to domestic markets in small producing countries (Akiyama, 2001; Baffes, 2003). Specifically, according to Krivonos (2004) and Lukanima (2009), following reforms, the transmission of global coffee prices increased in Tanzania, Kenya and Uganda. Mainly, this is because the EAC countries share of global coffee production is very small: not more than 1 percent in average (ICO data, 2011). Hence they do not have influence on prices (they are price-takers). Indeed, our findings show that changes in price volatility in EAC countries are consistent with changes in coffee prices in international markets for both Arabica and Robusta coffee. Also, from Figure 4, it is evident that the pattern of price volatility between domestic producer prices is identical to international prices, although volatility in international prices has always been lower than producer prices in respective countries. Overall, Figure 4 shows an immediate increase (but short-lived) in volatility during the early stages of reforms for all countries. This may have been a result of the adjustment process among market participants and systems in each country. Other remarkable periods of high volatility include immediately after the collapse of the ICA in 1989 and within the global coffee crisis between 2000 and 2005.

Another influencing factor may be exchange rates. According to Gilbert (1989) commodity price volatility has increased with the breakdown of the Bretton Woods currency agreements and that the consequence of higher volatility in meeting dollar-denominated debt has had an impact on commodity earnings. This

is consistent with other studies, mentioning exchange rate volatility as the major source of commodity price volatility (Doukas and Arshanapalli, 1991; Dupont and Juan-Ramon, 1996; and Jumah and Kunst, 2001). On Kenya, Karanja et al. (2003) comment, "coffee producer prices exhibit the highest and significant response to real exchange rates".

Moreover, we corroborate other studies suggesting that the magnitude of volatility and its impact on producers differ across countries depending on domestic market structures (Morgan, 2001, Akiyama, 2001, FAO, 2004). Therefore, although coffee producers in EAC countries face high price volatility in general, market structures are an important aspect for policy-makers. Looking at the mean prices (see Table 2), Kenyan producers receive the highest prices overall. This may be due to the fact that the Kenyan coffee structure allows producers to have direct link with roasters, giving them the opportunity to negotiate prices. Contrarily, Tanzanian coffee producers have been deprived from direct export until the end of 2003. If the Tanzanian coffee system does not take into account the extent of risk sharing, 'domestic price drivers' (like local traders and exporters) are likely to transfer their entire risk (volatility) burden to producers. This can be reflected in the price levels offered to coffee producers. On Kenya, Karanja et al., (2003) show the presence of risk premium content in coffee producer prices, implying that they carry a mark-up to cover against price volatility, and vice versa. Akiyama et al. (2003) point out that increased producer's share of export prices may well compensate them for increased price volatility. In Tanzania, although producer's share of export prices has increased following reforms (Temu et al., 2001), there is no evidence on whether such increase is significant enough to

compensate producer for price volatility.

-Figure 4 about here-

Market structures can also explain the magnitude of the post-reform price volatility in individual countries. These structures, in turn, dictate the degree of volatility transmission from international markets (Akiyama, 2001). For instance, the coffee market reforms in Uganda is said to be more advanced and successful, with producers receiving prompt payments and doubling their share of export prices (Akiyama, 2001; Baffes, 2006). The post-reform correlation between Ugandan Arabica prices and international prices is about 72 percent. Rapsomanikis et al. (2004) show a strong co-integration relationship between international prices and Ugandan producer prices. This is consistent with our results on both Arabica and Robusta. This strong relationship can be associated with the direct export system used in Uganda: unlike the other four countries, coffee exports in Uganda do not follow the auctioning channel. The post-reform correlations between producer prices and international coffee prices in other countries are less than 70 percent.

These findings have policy implications in countries with coffee auctioning systems. Temu et al., (2001) provide evidence of uncompetitive practices in coffee auctioning in Tanzania, thereby distorting the information contents of international prices and lowering competitiveness in the domestic market. On the other hand, there has been a concern on whether the coffee auction should be introduced in Uganda. Whether or not this is a good idea is still debatable. While the scrutiny of auction continues in Uganda, alternative views have started to emerge in other countries on whether or not their auction systems need reforms.

According to Baffes (2006), reforming the coffee auction systems will eliminate their mandatory nature, implying their eventual demise.

Moreover, the evidence of slight increase in price volatility in Kenya, Burundi, and Rwanda and insignificant impact in Tanzania and Uganda, implies market inefficiencies as a result of incomplete liberalization of the coffee sector in respective EAC countries. Although the post-reform Ugandan market appear to be the most successful in increasing the share of producer prices in the international market (Krivonos, 2004), it has very little to do with producer price risk. Previous studies have mentioned some indicators of inefficiencies amongst EAC countries, such as: poorly organized private sector, poorly defined institutional roles and oligopolistic behavior in Uganda (Baffes, 2006); uncompetitive behaviors among coffee traders in Tanzania (Temu et al., 2001); corrupt and poorly managed cooperatives in Kenya, Tanzania and Uganda (Karanja and Nyoro, 2002; Ponte, 2004, and Baffes, 2006); and delayed payments to smallholder producers, especially in countries with coffee auctioning systems.

For EAC countries producing both Arabica and Robusta (i.e. Tanzania and Uganda), we see the same post-reform response for both types of coffee in Tanzanian producer prices. In contrast, for Uganda, whereas Arabica prices responded with volatility decrease, Robusta prices responded with volatility increase. Although it is beyond the scope of this study to investigate the causes of these differences, we can reasonably relate them with coffee quality issues. Uganda mostly produces Robusta which does not require quality grading like Arabica. According to Ponte (2002), Robusta coffee prices are less sensitive to quality than Arabica, and price volatility tend to affect low-grade coffee more than

high-grade ones. Since the worldwide coffee market reforms were associated with incentives for quality improvement (Akiyama, 2001, Russell et al. 2012), it is possible to argue that the decrease in Arabica price volatility in Uganda is an outcome of quality improvement. Nevertheless, further studies may be necessary to find the exact reason for this difference and its policy implications.

The fact that coffee market reforms are associated with producers' exposure to price risk leads to an important strategic and policy challenge of price risk hedging. Reinhart and Wickham (1994) argue that hedging strategies can have substantial importance in presence of volatility increase and when the probability of large destabilizing shocks is high. For EAC countries, the presence of high volatility persistence suggest that direct market interventions, like stabilization schemes and price guarantees by government, are no longer feasible after reforms because they may be expensive to sustain (Cuddington and Urzua, 1989; Deaton and Miller, 1995; Cashin et al., 2000; Swaray, 2007). Instead, as emphasized in Russell et al. (2012), our findings support the efforts to enable the use of market-driven instruments (World Bank, 2003) like commodity options and futures for producers in EAC countries.

Some studies show the benefits of market-based instruments in developing countries. These benefits include forward pricing, pricing flexibility, storage hedging, and support of commodity prices (Thompson, 1985), and on merchandising or production decisions (Tomek and Peterson, 2001). Furthermore, the benefits not only allow efficient resources allocation amongst producers in the production process (Gemech et al., 2011), but also they outweigh the costs for most producers (Mohan, 2007). However, just like the non-market

measures, market-related instruments have a number of bottlenecks, such as market thinness in developing countries, hedging costs, creditworthiness, feasibility criteria, mistrust, ignorance, basis risk, and exchange rate risk (Sorenson et al., 1990, Thompson, 1985, Reinhart and Wickham, 1994, Morgan et al., 1999, Pennings et al., 1999, Mohan, 2007).

Therefore, recent initiatives by the World Bank and its partners prolong previous efforts to use market-based instruments for primary commodity producers because they are said to stabilize prices (McKinnon, 1967, Powers, 1970, Kawai, 1983, Netz, 1995). In 2001, the World Bank led some initiatives to enable coffee producers in Tanzania, Uganda, Mexico, Nicaragua and El Salvador to use coffee options available in LIFFE and NYBOT commodity exchanges. Although coffee producers are said to be aware of the benefits of options, they appear to be reluctant in incurring upfront premium costs (Mohan, 2007, Lukanima, 2009, Gemech et al., 2011). This is sustainability challenge because hedging should not depend on donor funding. Also, under the World Bank approach, hedging is made to base on cooperative societies, most of them suffering from poor governance and lack of risk management ability, rather than individual producers. In Tanzania, for example, the implementation of options hedging mechanism (facilitated by CRDB Bank at local level) has almost failed because cooperatives are reluctant to incur the upfront premium costs (Lukanima, 2009). Previous studies (see Tomek and Peterson, 2001, Mohan, 2007, Gemech et al., 2011) provide details and discussion on the implementation of the World Bank' initiatives as well as the mechanism of options hedging for coffee producers.

There is also a debate on the geographical location of exchanges from which hedging instruments are found (based in developed economies): whether producers in developing countries should rely on them or should establish their own options and futures exchanges. The basic prerequisites for establishment and existence of a successful options and futures exchanges have been outlines (Thompson, 1985, Johnson and McConnell, 1989, Tashjian, 1995, Morgan et al., 1999). These include demand for futures, existence of price uncertainty, asymmetries in characteristics of long and short participants, and the existence of competing contracts.

Although, previously there was lack of interest in market-based instruments on the part of producers in developing countries (see Rolfo, 1980), interest has grown significantly over time (Faruqee et al., 1997). Morgan et al (1999) argue that the demand for futures exists since commodity prices are uncertain. This implies a shift in emphasis from unsuccessful intervention approaches that had been favored since 1930s towards a system that allows individuals to cope with the impact of price volatility, such as commodity futures and options. However, according to the Rabobank International (2004) developing countries accounted for only 2 percent of these instruments traded worldwide by 2004. On the other hand, the answer to whether developing countries should opt for offshore markets or domestic market is a dilemma due to trading constraints for existing market and the cost of establishing domestic markets (Morgan et al., 1999, Morgan, 2001).

-Table 8 about here-

7. Conclusion

This paper has examined the impact of domestic market reforms on coffee producer price volatility in the EAC based on time series data spanning over three decades obtained from the ICO. The results from this study reveal changes in volatility of producer prices of coffee in EAC countries after market reforms, with evidence of increasing volatility persistence. Although market reforms have been associated with increased producer price volatility, their contribution seem to be more evident during early stages of reforms. Instead, there are other external factors that are likely to contribute to producer price volatility during the reform periods. In the global coffee market, EAC countries are price-takers, hence they are vulnerable to global price shocks. Other contributing factors may be the demise of the International Coffee Agreements (ICAs) and mismatch of coffee demand and supply in the global market. The use of dollar value prices of coffee producers may imply that the volatility of producer prices, to some extent, explains the volatility of respective local currencies against the dollar. Overall, producer prices appear to be more volatile than international market prices, suggesting higher exposure to shocks. We propose further studies to explore the exact contribution and timing of other factors on producer price volatility.

This study further shows some differences in the extent reforms affected the magnitude and direction producer price volatility in individual countries across the EAC countries. Previous studies show that agricultural market reforms have taken place in different forms amongst countries. Hence, the stages, levels of reforms and market structures differ among countries. These differences are

likely to have induced different responses in producer prices amongst EAC countries.

References

Ady, P. (1969), "Supply Response in Underdeveloped Agriculture: A Case Study of Major annual Crops in Thailand." *The Economic Journal,* Vol. 79, No.315: pp. 660-662.

Akiyama, T. (2001), Coffee Market Liberalization since 1990; in Akiyama, T., Baffes, J., Larson, D. F. & Varangis, P. (Eds.) *Commodity Market Reforms: Lessons from two decades, Regional and Sectoral Studies.* Washington DC, World Bank.

Akiyama, T., Baffes, J., Larson, D. F. & Varangis, P. (2003), "Commodity market reform in Africa: Some Recent Experience." *Economic Systems,* Vol. 27, pp.83-115.

Alizadeh, A. & Nomikos, N. (2005), Agricultural reforms and the use of market mechanisms for risk management London, Cass Business School.

Aradhyula, S. V. & Holt, M. T. (1989), "Risk Behavior and rational Expectation in the U.S. Broiler Market." *American Journal of Agricultural Economics,* Vol. 71, No.4: pp. 892-902.

Baffes, J. (2003), Tanzania's Coffee Sector: Constraints and Challenges in a Global Environment. *African Region Working Paper Series No. 56.* Washington, DC., World Bank.

Baffes, J. Lewin, B., and Varangis, P. (2004), Coffee: Market Settings and Policies, in Global Agricultural Trade and Developing Countries, pp. 297-309

Baffes, J. (2006), "Restructuring Uganda's Coffee Industry: Why Going Back to Basic Matters", *Development Policy Review,* Vol. 24, No.4, pp.413-436

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity " *Journal of Econometrics,* Vol. 31, No.3: pp. 307- 327.

Bollerslev, T. (1987), "A conditional Heteroskedastic Time Series Model for Speculative Price and Rates of Return." *Review of Economics and Statistics,* Vol. 69, No.3: pp. 542-547.

Bollerslev, T., Chou, Y. & Kroner, F. K. (1992), "ARCH Modeling in Finance: A Review of the Theory and Empirical Evidence." *Journal of Econometrics,* Vol. 52, pp.5-60.

Borenszrein, E. & Reinhart, C. M. (1994) The Macroeconomic Determinants of Commodity Prices. *IFM Staff Papers,* Vol. 41, pp. 236-261.

Boudreaux, K. C. and Ahluwalia, P. (2009), “Cautiously Optimistic: Economic Liberalization and Reconciliation in Rwanda’s Coffee Sector”, *Development Journal of International Law and Policy,* Vol. 37, No. 2, pp.147-200

Bourguignon, F., Lambert, S. & Suwa-Eisenmann. (2004), "Trade exposure and Income volatility in cash-crop exporting developing countries." *European Review of Agricultural Economics.,* Vol. 31, No.3: pp. 369-387.

Caporale, G. M., Pittis, N. & Spagnolo, N. (2003), "IGARCH Models in Structural Breaks." *Applied Economic Letters,* Vol. 10, pp.765-768.

Cashin, P., Liang, H. & McDermott, J. C. (2000), "How Persistent are Shocks to World Commodity Prices?" *IMF Staff Papers,* Vol. 42, No.2: pp. 177-217.

Cashin, P. & McDermott, C. J. (2002), "The Long-run behavior of Commodity Prices: Small Trends and Big Variability." *IMF Staff Papers,* Vol. 49, No.2: pp. 175-199.

Chaudhuri, K. (2001), "Long-run prices of primary commodities and oil prices " A*pplied Economics,* Vol. 33, No.4: pp. 531-538.

Cho, D. D., Russell, J., Tiao, G. C. & Tsay, R. (2003), "The magnet effect of price limits: evidence from high-frequency data on Taiwan Stock Exchange." *Journal of Empirical Finance,* Vol. 10, No.(1-2): pp. 133-168.

Combes, J. & Guillaumont, P. (2002), "Commodity Price Volatility, Vulnerability and Development." *Development Policy Review,* Vol. 20, No.1: pp. 25-39.

Cooksey, B. (2003), "Market Reforms? The Rise and Fall of Agricultural Liberalization in Tanzania." *Development Policy Review,* Vol. 21, No.1: pp. 67-91.

Crain, S. J. & Lee, J. H. (1996), "Volatility in Wheat Spot and Futures Markets, 1950-1993: Government Farm Programs, Seasonality, and Causality." *Journal of Finance,* Vol. 51, No.1: pp. 325-343.

Cuddington, J. T. (1992), "Long-run Trends in 26 Primary Commodity Prices: A Disaggregated Look at the Prebisch-Singer Hypothesis." *Journal of Development Economics,* Vol. 39, pp.207-227.

Cuddington, J. T. & Urzua, C. M. (1989), "Trends and Cycles in the Net Barter Terms of Trade: A New Approach." *The Economic Journal,* Vol. 99, No.396: pp. 426-442.

Deaton, A. (1999), "Commodity Prices and Growth in Africa." *Journal of economic Perspectives,* Vol. 13, No.3: pp. 23-40.

Deaton, A. & Laroque, G. (1992), "On the Behavior of Commodity Prices." *Review of Economic Studies,* Vol. 59, No.1: pp. 1-23.

Deaton, A. & Miller, R. (1995), International Commodity Prices, Macroeconomic Performance and Politics in Sub-Saharan Africa. *Discussion Paper 79. Princeton Studies in International Finance.* New Jersey, Priceton University.

Dionisio, A., Menezes, R. & Mendes, D. A. (2007), "On the Integrated Behaviour of Non-stationary Volatility in Stock Markets." *Physica A,* Vol. 382, pp.58-65.

Doukas, J. and Arshanapalli, B. (1991), "Decision Rules for Corporate Management of Foreign Exchange Risk", *Journal of Multinational Financial Management*, Vol.1, pp. 39-48.

Dupont, D. and Juan-Ramon, V. H. (1996), "Real Exchange Rates and Commodity Prices", IMF Working Paper, WP/96/27, Washington DC, IMF

Elliot, G., Rothenberg, T. J., and Stock, J. H. (1996), "Efficient tests for an autoregressive unit root", *Econometrica*, Vol.64, No.4, pp.813-836

Engle, R. F. (1993), "Statistical models for financial volatility." *Financial Analyst Journal,* Vol. 49, No.1: pp. 72-78.

Engle, R. F. & Bollerslev, T. (1986), "Modelling the Persistence of Conditional Variances " *Econometric Review,* Vol. 5, pp.1-50.

Engle, R. F. & Victor, K. N. (1993), "Measuring and Testing the Impact of News on Volatility." *Journal of Finance,* Vol. 48, No.5: pp. 1749-1778.

Engle, R. F. (1982), "Autoregressive Conditional Heteroscedasticity with Estimates of the variance of U.K Inflation." *Econometrica,* Vol. 50, No.4: pp. 987-1008.

Engle, R. F. (2001), "The Use of ARCH/GARCH Models in Applied Econometrics." *Journal of economic Perspectives,* Vol. 15, No.4: pp. 157-168.

FAO (2004) The State of Agricultural Commodity Markets: 2004. Rome, FAO.

FAO (2006) The State of Agricultural Commodity Markets: 2006. Rome, FAO.

Faruqee, R., Coleman, J. R. & Scott, T. (1997) "Managing Price Risk in the Pakistan Wheat Market". The World Bank Economic Review, Vol.11, No. 2, pp.263-292.

Gemech, F. & Struthers, J. (2007) "Coffee price volatility in Ethiopia: effects of market reform programmes", *Journal of International Development*, Vol. 19, pp. 1131–1142.

Gemech, F., Mohan, S., Reeves, A. & Struthers, J., (2011), "Market-based Risk Management: Welfare Gains for Coffee Producers from Efficient Allocation of Resources, *Oxford Development Studies,* Vol. 39, No. 1, pp. 49-68

Gilbert, C. L. (1989), "The Impact of Exchange Rates and Developing Country Debt on Commodity Prices", *The Economic Journal*, Vol.99. No. 397, pp. 773–784.

Gilbert, C. L. (1995) International Commodity Control: Retrospect and Prospect, *Policy Research Working paper 1545*, World Bank, Wasginhton DC.

Gilbert, C., 1997. Cocoa Market Liberalization: Its Effects on Quality, Futures Trading and Prices. The Cocoa Association of London, London.

Han, D. B., Jansen, D. W. & Penson (JR.), J. B. (1990) “Variance of Agricultural Prices, Industrial Prices, and Money”. *American Journal of Agricultural Economics*, Vol. 72, No.4. pp.1066-1073.

Harvey, A., Ruiz, E. & Shephard, N. (1994), "Multivariate Stochastic Variance Models." *Review of Economic Studies,* Vol. 61, pp.247-264.

Ho, K. Y. & Tsui, A. K. C. (2004), "Analysis of real GDP growth rates of greater China: An asymmetric conditional volatility approach " *China Economic Review,* Vol. 15, pp.424-442.

Holt, M. T. (1993), "Risk Response in the Beef Marketing Channel: A Multivariate Generalised ARCH-M Approach." *American Journal of Agricultural Economics,* Vol. 75, No.3: pp. 559-571.

Holt, M. T. & Aradhyula, S. V. (1990), "Price Risk in Supply Equations: An Application of GARCH Time-series models to the U.S. Broiler Market." *Southern Economic Journal,* Vol. 57, pp.230-42.

Hudson, D. & Coble, K. (1999), "Harvest Contract Price Volatility for Cotton." *Journal of Future Markets,* Vol. 19, No.6: pp. 717-733.

ICO (2011), Trade Statistics, available at: http://www.ico.org/trade_statistics.asp, (accessed on Monday, Sept 19th 2011)

Ipsen, E. (1994), 'Your Early Morning Jolt: Coffee Prices are Soaring' Available at: <http://www.iht.com/pages/>. (accessed Tuesday, June 28th 1994).

Johnson, E. T. & Mcconnell, J. J. (1989), “Requiem for a Market: An Analysis of the Rise and Fall of a Financial Futures Contract”. The Review of Financial Studies, Vol. 2, No. 2, pp.1-23.

Jumah, A., and Kunst, R. M. (2001), The Effect of Exchange Rate Exposure of Equity Asset Market, HIS Economic Series, No. 94, Vienna, Institute of Advanced Studied

Just, R. E. (1975), "Risk Response Models and their Use in Agricultural Evaluation." *American Journal of Agricultural Economics,* Vol. 57, No.5: pp. 836-843.

Karanja, A. M., Kuyvenhoven, A. & Moll, H. A. J. (2003), "Economic Reforms and Evolution of Producer prices in Kenya: An ARCH-M Approach." *African Development Bank*, pp.271-296.

Karanja, A. M. and Nyoro, J. K. (2002) Coffee prices and regulation and their impact on livelihoods of rural community in Kenya**,** Tegemeo Institute of Agricultural Policy and Development, Egerton University, Nairobi, Kenya.

Kawai, M. (1983) “Price Volatility of Storable Commodities under Rational expectation in Spot and Futures Markets”. *International Economic Review*, Vol. 24, No. 2, pp. 435-459.

Kimonyo, J. and Ntiranyibagira, D. (2007), Reform of the Coffee Sector in Burundi: Prospects for Participation, Prospects and Peace, USAID and International Alert.

Krivonos, E. (2004), The Impact of Coffee Market Reforms on Producer Prices and Price Transmission, *Policy Research Working Paper 3358,* Washington, DC, World Bank.

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*, vol. 2, pp 255-271.

Larson, D. F., Varangis, P. & Yabuki, N. (1998), Commodity Risk Management and Development. *Policy Research Working Paper 1963.* Washington, DC, World Bank.

Lewin, B., Giovannucci, D. & Varangis, P. (2004), Coffee Markets: New Paradigms in Global Supply and Demand *Agriculture and Rural Development Discussion Paper 3.* World Bank.

Lukanima, B. K, (2009), The Impact of Coffee Market Liberalization on Producer Price Behavior in Tanzania. University of Hull, PhD Thesis.

Lumsdaine, R. L. (1995) "Finite-Sample Properties of the Maximum Likelihood Estimator in GARCH(1,1) and IGARCH(1,1) Models: A Monte Carlo Investigation", *Journal of Business & Economic Statistics*, Vol. 13, No.1, pp. 1-10.

Martin, W. & Anderson, K. (2008). "Agricultural Trade Reforms under the Doha Agenda: Some Key Issues". *The Australian Journal of Agricultural and Resource Economics,* Vol. 52, 1-16.

Mckinnon, R. I. (1967) “Futures Markets, Buffer Stocks, and Income Stability for Primary Producers”. *Journal of Political Economy*, Vol.75, No.6. pp. 844-861

Milas, C., Otero, J. & Panagiotidis, T. (2004), "Forecasting the Spot Prices of Various Coffee Types Using Linear and Non-linear Error Correlation Models." *International Journal of Finance and Economics,* Vol. 9, No.3: pp. 277-288.

Mohan, S. (2007), “Market-based price-risk management for coffee producers”, *Development Policy Review*, Vol. 25, No 3, pp. 333-354

Morgan, C. W. (2001) “Commodity Futures Markets in LDCs: A Review and Prospects”. *Progress in Development Studies*, Vol.1, No. 2, pp.139-150.

Morgan, C. W., Rayner, A. J. & Vaillant, C. (1999) “Agricultural futures markets in LDCs: a policy response to price volatility?” *Journal of International Development,* Vol.11, No. 6, pp. 893-910.

Murekezi, A. C. (2009), Essays on the Effects of Coffee market Reforms, Supply Chain, and Income Improvement in Rwanda, Michigan State University, PhD Dissertation

Nelson, D. B. (1990), "Stationarity and Persistence in the GARCH(1,1) Model " *Econometric Theory,* Vol. 6, No.3: pp. 318-334.

Nelson, D. B. & Cao, C. Q. (1992), "Inequality Constraints in the Univariate GARCH Model." *Journal of Business and Economic Statistics,* Vol. 10, No.2: pp. 229-235.

Netz, J. S. (1995) “The Effect of Futures Markets and Corners on Storage and Spot Price Variability”. *American Journal of Agricultural Economics*, Vol.77, No.1, pp.182-193.

Pennings, J. M. E., Meulenberg, M. T. J. & Wetzels, M. G. M. (1999) “The marketing-finance interface towards financial services with special reference to the new services provided by futures exchanges”. *European Journal of Marketing*, Vol. 33, No.5/6, pp. 531-547.

Perron, P., (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis, Econometrica, vol. 57, no. 6, November, pp. 1361-1401.

Ponte, S. (2001), Coffee Markets in East Africa: Local Responses to Global Challenges or Global Responses to Local Challenges? Working Paper Series 01.5 on Globalisation and Economic Restructuring in Africa No XV. Copenhagen, Centre for Development Research.

Ponte, S. (2002), "Brewing a Bitter Cup? Deregulation, Quality and the Re-organisation of Coffee Marketing in East Africa." *Journal of Agrarian Change,* Vol. 2, No.2: pp. 248-272.

Ponte, S. (2004), “Politics of Ownership: Tanzanian Coffee Policy in the Age of Liberal Reformism”, *African Affairs,* Vol. 103, No.413, pp. 615-633

Pope, R. D. & Just, R. E. (1991), "On testing the Structure of Risk Preferences in Agricultural Supply Analysis." *American Journal of Agricultural Economics,* Vol. 73, pp.743-748.

Powers, J. M. (1970) “Does Futures Trading Reduce Price Fluctuations in the Cash Markets?” *The American Economic Review*, Vol.60, No. 3, pp. 460-464.

Putterman, L. (1995), "Economic reforms and smallholder agriculture in Tanzania: A discussion of recent market liberalization, Road rehabilitation and technological dissemination efforts " *World Development,* Vol. 23, No.2: pp. 311-326.

Rahman, S., Lee, C.-F. & Ang, K. P. (2002), "Intraday Return Volatility Process: Evidence from NASDAQ Stocks." *Review of Quantitative Finance and Accounting,* Vol. 19, pp.155-180.

Rambaldi, A. N. & Simmons, P. (2000), "Response to price and Production Risk: The Case of Australian Wheat." *The journal of Futures Markets,* Vol. 20, No.4: pp. 345-359.

Reinhart, C. & Wickham, P. (1994), "Commodity prices: Cyclical weakness or secular decline?" *International Monetary Fund - Staff Papers,,* Vol. 41, No.2: pp. 175-214.

Robobank International (2004) Insuring Fair Prices for Farmers in Developing Countries, Case Study. World Business Council for Sustainable Development.

Rogers, A. (1994), 'No Break for Coffee Prices' Available at: cnnmoney.com, retrieved on 13 June 1994).

Rolfo, J. (1980) “Optimal Hedging under Quantity Uncertainty: The Case of a Cocoa Producer”. *Journal of Political Economy*, Vol.88, No.1, pp. 100-116.

Russell, B., Mohan, S., and Banerjee, A. (2012), “Coffee market liberalization and implications for producers in Brazil, Guatemala, and India”, *The World Bank Economic Review*, January, pp.1-25

Shively, G.E. (1996). “Food price volatility and economic reform: An ARCH approach for Ghana”. *American Journal of Agricultural Economics*, vol. 78. pp. 126-136.

Sorenson, L. O., Schroeder, T. C. & Ouattara, K. (1990) “Potential use of Futures Markets for International Marketing of Cote d'Ivoire Coffee”. *The Journal of Futures Markets*, Vol.10, No.2, pp. 113-121.

Swaray, R. (2007), "How did the Demise of International Commodity Agreements Affect Volatility of Primary Commodity Prices?" *Applied Economics,* Vol. 39, pp.2253-2260.

Swaray, R. (2011), Commodity buffer stock redux: the role of International Cocoa Organization in producer price and income stabilization, *Journal of Policy Modelling*, Vol 33, pp 361-369.

Temu, A. A. (1999), "*Empirical Evidence of Changes in the Coffee Market After Liberalization: A Case of Northern Tanzania,"* Urbana, University of Illinois.

Temu, A. A., Winter-Nelson, A. & Garcia, P. (2001), "Market Liberalization, Vertical Integration and Price Behavior in the Tanzania’s Coffee Auction." *Development Policy review,* Vol. 19, No.2: pp. 205-222.

Thompson, S. (1985) “Use of Futures markets for Exports by Less Developed Countries”. *American Journal of Agricultural Economics*, Vol.67, No. 5, pp. 986-991.

Tomek, W. G. & Peterson, H. H. (2001), "Risk Management in Agricultural Markets." *The journal of Futures Markets,* Vol. 21, No.10: pp. 953-985.

Kimonyo, J. and Ntiranyibagira, D. (2007), Reform of the Coffee Sector in Burundi: Prospects for Participation, Prosperity and Peace. International Alert/USAID

Veld-Merkoulova, Y. V. (2003), "Price limits in futures markets: effects on the price discovery process and volatility." *International Review of Financial Analysis,* Vol. 12, No.3: pp. 223-346.

Wang, P. (2003), "*Financial Econometrics: methods and models,"* London and New York, Routledge.

Winter-Nelson, A. & Temu, A. A. (2002), "Institutional Adjustment and Transaction Costs: Product and Inputs Markets in the Tanzanian Coffee Systems." *World Development,* Vol. 30, No.4: pp. 561-574.

World Bank (2001), Tanzania Coffee Price Risk Management. Washington , DC, World Bank.

World Bank (2003) Using Markets to Manage Commodity Risk:. Washington, DC, World Bank.

Yang, J., Haigh, M. S. & Leatham, D. J. (2001), "Agricultural liberalization policy and commodity price volatility: a GARCH application." *Applied Economics Letters,,* Vol. 8, pp.593-598.

Yang, S.-R. & Brorsen, B. W. (1992), "Nonlinear Dynamics of Daily Cash Prices." *American Journal of Agricultural Economics,* Vol. 74, No.3: pp. 706-715.

Yang, S.-R. & Brorsen, B. W. (1993), "Nonlinear Dynamics of Daily Futures Prices: Conditional Heteroskedasticity or Chaos?" *The journal of Futures Markets,* Vol. 13, No.2: pp. 175-191.

Table 1 Key Features of Coffee Markets in EAC Countries

	Tanzania	Kenya	Uganda	Burundi	Rwanda
Start of Reforms	1994	1993	1992	1991	1995
Producers	Mostly small holders	Smallholders (60%), private estates (40%)	Mostly smallholders	Mostly small holders	Mostly small holders
Coffee Market Control (Pre)	Heavy government control	Heavy Government control	Heavy Government control	Heavy Government control	Heavy Government control
Coffee Market Control (Post)	Less government control but more regulatory role	Less government control but more regulatory role	Less government control but more regulatory role	No change	Less government control but more regulatory role
Coffee Boards (Pre)	Owned by government; Controlling and coordinating all coffee functions from production to marketing	Owned by producers with majority representation on the Board	Owned by government; Controlling and coordinating all coffee functions from production to marketing functions	Owned by government; Controlling and coordinating all coffee functions from production to marketing functions	Owned by government; Controlling and coordinating all coffee functions from production to marketing functions
Coffee Boards (Post)	Less control by the Coffee Board but maintained the regulatory role.	By 2002, the Coffee Board was the sole marketing agent; later on a number of marketing agents have been licensed; Less control by the Coffee Board but maintained the regulatory role	In 1991 the Coffee Board was split into two: Coffee Marketing Board Ltd (for trading and processing) and Uganda Coffee Development Authority (UCDA) (for regulatory role)	The coffee board (OCIBU) became a mixed private-public company with government majority share; but maintained the coordinating and regulatory role of the industry	Less control by the Coffee Board but maintained the regulatory role
Coffee Purchase at farm-gate (Pre)	Farmers sold coffee cherry (unprocessed coffee); channelled through cooperatives; The Coffee Authority was the sole buyer	Illegal to sell cherry coffee; Small farmers sold processed coffee through cooperatives; estates sell directly to the auction	Farmers sold coffee cherry (unprocessed coffee); Competitive market, cooperatives and private buyers	Farmers sold coffee cherry (unprocessed coffee); channelled through local intermediary traders	Farmers sold mostly parchment coffee; channelled through middlemen buyers; The Coffee Board was the sole buyer
Coffee Purchase at farm-gate (Post)	Competitive between cooperative and private buyers (until 2002, some of the private buyers were also exporters)	no change	Competitive between cooperative and private buyers	Private companies	Competitive between cooperative and private buyers ; Farmers sell coffee cherries and parchment coffee
Cooperatives (Pre)	Coffee buying points	Coffee buying points	Coffee buying points	none	Coffee buying points
Cooperatives (Post)	Weakened by competition and poor governance	Increase in the number of cooperatives and strengthen marketing role	Almost disappeared	Creation of coffee farmers associations, unions, federation and confederation from 1996	Strengthened role of cooperatives to promote specialty coffee, but some unsatisfactory governance
Coffee Dealers (Pre)	Not allowed	Not allowed	Private buyers allowed; large number of small traders	Private companies acted as subcontractors to government in collecting washed coffee	Middlemen buyers at farm-gate
Coffee Dealers (Post)	Private buyers at farm-gate and export	Private buyers at farm-gate and export	Emergence of middlemen buyers	Emergence of private buyers	No change
Coffee pricing at farm-gate (Pre)	Minimum buying price fixed by the Coffee Board (government); Delayed payments to producers	Minimum buying price fixed by government; Delayed payments to small producers (cooperative	Competitive prices; prompt payments	Minimum buying price fixed by government	Minimum buying price fixed by government (through OCIR Café);

		channel), estate formers received payment directly from traders			
Coffee pricing at farm-gate (Post)	Minimum price fixed but producers received competitive pricing; prompt payment from private buyers	No significant changes	More competitive prices		Minimum price fixed but producers received competitive pricing; prompt payment from cooperatives and private byters
Coffee processing factories (Pre)	State Owned, Cooperative/Producer Group Owned	State Owned, Cooperative/Producer Group Owned	State Owned, Cooperative/Producer Group Owned and private hullers	State owned	Farmers processed coffee using local means; RWANDEX the only miller
Coffee processing factories (Post)	Liberalized to allow private factories	Liberalized to allow private factories	Flourishing private firms causing almost disappearance of cooperatives	Liberalized to allow private hullers since 2002	Investment in private and cooperative factories; but majority farmers still use pre-reform means
Coffee Auction (Pre)	Owned by government, All hulled coffee sold at auction in Moshi; competitive bidding	Owned by producers, All hulled coffee sold at auction in Nairobi; Competitive bidding	No auction	Owned by the Coffee Board; All hulled coffee sold at the auction	No auction
Coffee Auction (Post)	The rise of Vertically Integrated Exporters (VIEs) and coffee repossession is said to affect bidding competition	Producers receive US$ rather than local currency	No change	No change	Mombasa auction (Kenya)
Coffee Export (Pre)	Exports by the Coffee Authority and private exporters (mostly MNCs based in Kenya); all exports through the auction	Exports by the Coffee Authority and private exporters (mostly local companies); all exports through the auction	All exports by the Coffee Board (UCDA)	All exports by Burundi Coffee Company (BCC), through the auction	All export by government agencies (OCIR café and RWANDEX)
Coffee Export (Post)	Significant changes; export by cooperatives and private companies; from 2003 producers were allowed to export directly, bypassing the auction	No significant changes; increasing joint ventures between local exporters and MNCs	Significant changes; the coffee board ceased to be the sole exporter, but UCDA resumed regulatory powers; private exporters (local and MNCs)	Significant changes; exports by organized private companies and the Burundi Coffee Company; direct export were allowed later	Government agents and private traders

Notes
Pre means Pre reforms
Post means Post reforms
MNCs- Multinational corporations

Table 2 Descriptive Statistics and Normality Tests

	ARABICA						ROBUSTA		
	Tanzania	Kenya	Uganda	Burundi	Rwanda	Indicative	Tanzania	Uganda	Indicative
Sample Start Date	Jan 1980	Jan 1980	Jan 1980	Jan 1980	Jan 1980	Jan 1980	Jun 1985	Jan 1980	Jan 1980
Sample End Date	Sep 2008	Nov 2004	Sep 2010	Mar 2010	May 2005	Dec 2010	Sept 2008	Sep 2010	Sep 2010
No. Observations	345	299	369	363	305	372	279	368	368
Mean (level)	60.236	89.555	40.826	52.290	52.859	102.260	23.307	25.479	69.576
Mean (change)	0.020	0.011	0.025	0.037	0.056	0.092	-0.016	0.023	-0.102
Standard Dev.	18.143	32.604	21.355	13.734	18.058	15.684	14.413	12.901	17.183
Skewness	0.054	0.851	2.613	0.526	0.892	0.522	2.114	0.473	-0.126
Kurtosis	-0.341	1.849	11.255	0.512	1.379	0.869	6.668	-1.011	-0.713
Minimum	22.262	17.862	10.871	24.386	18.293	62.464	3.683	5.641	33.499
Maximum	103.31	220.26	152.57	95.705	116.570	169.620	92.888	55.652	109.480
Normality, χ^2 (2)	1.543 (0.462)	29.382*** (0.000)	386.30*** (0.000)	16.036*** (0.000)	37.524*** (0.000)	16.107*** (0.000)	229.230*** (0.000)	80.906*** (0.000)	11.718*** (0.003)
Asymptotic, χ^2 (2)	1.841 (0.398)	78.714*** (0.000)	2367.600*** (0.000)	20.718*** (0.000)	64.593*** (0.000)	28.613*** (0.000)	724.590*** (0.000)	29.384*** (0.000)	8.786** (0.012)

Notes:
The data used in descriptive statistics is in real US$ cents (level), except for the mean (change) in which the first difference is used.
Numbers in parentheses are p-values
***, **Statistically significant at 1% and 5% respectively

Table 3 Correlation Matrices

	ARABICA (Jan 1980-Nov 2004)						ROBUSTA (Jun 1985-Sep 2008)		
	Tanzania	Kenya	Uganda	Burundi	Rwanda	Indicative	Tanzania	Uganda	Indicative
Tanzania	1.000						1.000		
Kenya	0.219	1.000							
Uganda	0.203	0.312	1.000				0.113	1.000	
Burundi	0.184	-0.270	-0.137	1.000					
Rwanda	0.191	-0.207	-0.182	0.716	1.000				
Indicative	0.437	0.491	0.163	-0.023	0.123	1.000	0.436	0.224	1.000

Table 4 DF-GLS Unit Root Tests

Coffee Type		With Constant			With Constant + Trend		
	Country	SIC	AIC	HQIC	SIC	AIC	HQIC
ARABICA	Tanzania	-3.153***	-3.153***	-3.153***	-3.225**	-3.225**	-3.225**
	Kenya	-4.061***	-4.324***	-4.061***	-4.075***	-4.339***	-4.075***
	Uganda	-3.600***	-2.703***	-3.600***	-3.695***	-2.810*	-3.695***
	Burundi	-2.318**	-2.024**	-2.024**	-2.789*	-2.471	-2.471
	Rwanda	-2.352**	-1.743*	-2.065**	-2.442	-1.812	-2.153
	Indicative	-2.973***	-2.975***	-2.975***	-3.562***	-3.562***	-3.562***
ROBUSTA	Tanzania	-2.220**	-2.220**	-2.220**	-2.719*	-2.719*	-2.719*
	Uganda	-2.573***	-2.252**	-2.573***	-2.812*	-2.485	-2.812*
	Indicative	-1.038	-1.038	-1.038	-2.435	-3.578***	-2.435
	#Indicative (Pre)	-12.039***	-3.773***	-3.773***	-13.356***	-13.356***	-13.356***
	#Indicative (Post)	-1.317	-0.719	-1.189*	-5.854***	-2.257	-2.555

Notes:
The reported numbers are Elliott-Rothenberg-Stock (E-R-S) DF-GLS test statistics
***, **, *Statistically significant at 1%, 5%, and 10% level, respectively
MacKinnon Critical values (with constant): 1% = -2.572; 5% = -1.942; 10% = -1.616
MacKinnon Critical values (with constant + trend): 1% = -3.474; 5% = -2.901; 10% = -2.590
#Further tests were conducted using Augmented Dickey Fuller (ADF) and Phillip-Perron (PP) for two sub-sample (pre Dec 1991 and post Jan 1992) in order to avoid the influence of trend. The ADF and PP suggest stationarity in levels for each sub-sample. Pre sample: ADF statistics (-10.285), PP statistics (-16.004), ADF and PP critical values are 1% = -3.465; 5% = -2.877; 10% = -2.575. Post sample: ADF statistics (-8.996), PP statistics (-13.261), ADF and PP critical values for post sample: 1% = -3.459; 5% = -2.874; 10% = -2.574.

Table 5 Structural Break Tests

		Chow Tests (For known regime shifts)			Quandt-Andrews Tests (For unknown regime shifts)		
		Entire	**Pre**	**Post**	**Entire**	**Pre**	**Post**
ARABICA	Tanzania	Jan 1994 (R) 0.2232 (0.800)		Jun 2000 (a) 4.5292*** (0.012) May 2005(b) 6.3718*** (0.002)			May 2005(b) 6.3718** (0.030)
	Kenya	Jan 1993 (R) 2.6581* (0.071)	Jan 1991(c) 6.0540*** (0.003)		Oct 1993 (R) 19.9476*** (0.000)	Jan 1991(c) 6.0540** (0.039)	
	Uganda	May 1981(d) 4.9179*** (0.008) Jan 1992 (R) 3.7164** (0.025)	May 1981(d) 10.7351*** (0.000)		Oct 1990(e) 6.3129** (0.032)		
	Burundi	Jan 1991 (R) 0.3742 (0.688)	April 1986(f) 6.3164*** (0.002)	April 2005(g) 21.8431*** (0.000)	April 2005(g) 24.4134*** (0.000)	April 1986(f) 6.3164** (0.032)	April 2005(g) 21.8431*** (0.000)
	Rwanda	Jan 1995 (R) 4.7793*** (0.003)			Jul 1993(h) 5.0511** (0.029)		
ROBUSTA	Tanzania	Jan 1994 (R) 0.0059 (0.994)		April 2005(b) 4.8657*** (0.009)	April 2005(b) 6.4079** (0.029)		April 2005(b) 4.8657 (0.105)
	Uganda	Jan 1992 (R) 5.0517*** (0.007)	Jun 1981(d) 4.7991*** (0.009)		Jan 1994 (I) 7.4210*** (0.012)		
	Indicative	Jul 1989 (ICA) 3.0118** (0.050)	Jul 1989 (ICA) 2.5109* (0.084)				

Notes:

The reported figures are F-statistics from Chow tests and Quandt-Andrews tests. Numbers in parentheses are p-values of the respective F-statistics. ***, **, *Statistically significant at 1%, 5%, and 10% level, respectively

(R) Break points within the year in which major reforms began. (ICA)The date marking the collapse of the International Coffee Agreement (ICA) in 1989 (a) There was a major plunge of coffee prices in the world market in from 2000 to 2002. In 2000 the Tanzanian government revokes buying licenses of private buyers from farm-gate as a measure to ensure loans guaranteed to cooperatives (which had financial difficulties) are paid. The restriction continued until 2002 (Krivonos, 2004). (b) The year 2005 marks the end of the coffee crisis that began in 1999. (c) Establishment of the Kenyan Coffee Growers Association (KCGA), followed by several policy measures in the Kenyan coffee sector. (d) From February 1981, the Uganda experienced a civil war until 1985. In 1986, the new government (under Yoweri Museveni) started to implement structural adjustment programmes, including exchange rate adjustments. Coffee being one of Museven´s priority, the government started coffee rehabilitation programmes in the same year, which included raising producer coffee prices in May 1986 and February 1987. (e) Following the demise of the International Coffee Agreement (ICA) in July 1989, Ugandan coffee prices began to decline like the rest of coffee producing countries. Coffee production declined by almost 20% in 1990. This forced the implementation of several reforms in 1990, as part of structural adjustment programmes, followed by major coffee reforms from 1992 (Akiyama, 2001, Baffes, 2006). (f) The year 1986 marked partial privatization of public enterprises following worldwide structural adjustments advocated by the World Bank and IFM. The coffee sector, which was entirely under government control, was a major priority for privatization in 1986. (g) Major policy reforms were made in 2005 aiming at deregulating and privatizing the coffee sector in Burundi. In January 2005 a presidential decree was signed to allow full access of the private sector, in the same year the Burundian government ended guaranteeing funds to the coffee sector, including loans to coffee companies and growers. In June 2005, a ministerial decree was signed to end the monopoly of the Coffee Board (OCIBU), deregulating prices, and direct coffee export (without passing through OCIBU). The same year also witnessed the rise of coffee prices in the global market (Kimonyo and Ntiranyibagira, 2007). (h) 1993 was the peak of the Rwandan Civil war, which affected the coffee sector and the whole country economy. (i) More reforms took place in Uganda. The Uganda Coffee Development Authority (UCDA) was established in April 1994, followed by the Coffee Regulation of 1994. Among other things, the regulation focused on the registration of coffee dealers in the internal and export supply chain, coffee quality control, and publication of marketing and pricing information. Also 1994-1995 witnessed the rise of international coffee prices and booming of the Ugandan coffee sector.

Table 6 GARCH (1,1) Estimates of Producer Coffee Prices in EAC Countries

Coefficients	Sample	ARABICA						ROBUSTA		
		Tanzania	Kenya	Uganda	Burundi	Rwanda	Indicative	Tanzania	Uganda	Indicative
Panel A (i) $\omega^{\#}$	**Entire**	0.0078*** [a]0.0073***	0.0028*** [c]0.0043***	0.0122*** [e]0.0043***	0.0038*** [g]0.0024***	0.0031*** [j]0.0040***	0.0027***	0.0200*** [k]0.0179***	0.0269*** [l]0.0112***	0.0067*** [m]0.0013***
	Pre	0.0059***	0.0022*** [d]0.0023***	0.0084*** [f]0.0086***	0.0018*** [h]0.0024***	0.0031***	0.0024***	0.0193***	0.0097*** [f]0.0117***	0.0012*** [m]0.0010***
	Post	0.0073*** [b]0.0058***	0.0003***	0.0030***	0.0021*** [i]0.0025***	0.0067***	0.0029***	0.0279*** [i]0.0189***	0.0071***	0.0031***
Panel A (ii) α	**Entire**	0.9437*** (0.000) [a]0.9469*** (0.000)	0.5791*** (0.000) [c]0.8644*** (0.000)	0.8597*** (0.000) [e]0.7566*** (0.000)	0.9957*** (0.000) [g]0.9751*** (0.000)	0.9574*** (0.000) [j]0.9625*** (0.000)	0.9461*** (0.000)	0.9605*** (0.000) [k]0.9681*** (0.000)	1.0032*** (0.000) [l]0.9569*** (0.000)	1.3529*** (0.000) [m]1.0249*** (0.000)
	Pre	0.9291*** (0.000)	0.9815*** (0.000) [d]0.8813*** (0.000)	0.9579*** (0.000) [f]0.9191*** (0.000)	1.0532*** (0.000) [h]1.0949*** (0.000)	0.9758*** (0.000)	0.8773*** (0.000)	0.9350*** (0.000)	0.9577*** (0.000) [f]0.9102*** (0.000)	1.0256*** (0.000) [m]0.8069*** (0.000)
	Post	0.9673*** (0.000) [b]0.9434*** (0.000)	0.2634*** (0.000)	0.5760*** (0.000)	0.7860*** (0.000) [i]0.9265*** (0.000)	0.9547*** (0.000)	0.9155*** (0.000)	0.9673*** (0.000) [i]0.9801*** (0.000)	0.7576*** (0.000)	1.2800*** (0.000)
Panel A (iii) β	**Entire**	-0.0082*** (0.000) [a]-0.0078*** (0.000)	0.4026*** (0.000) [c]0.0853** (0.044)	0.0921 (0.231) [e]0.1937*** (0.012)	-0.0474*** (0.004) [g]-0.0087 (0.878)	0.0177 (0.132) [j]-0.0095 (0.934)	0.0562 (0.344)	-0.0128*** (0.000) [k]-0.0115 (0.917)	-0.0851 (0.488) [l]-0.0389* (0.095)	-0.4419*** (0.000) [m]-0.0480 (0.659)
	Pre	-0.0280 (0.773)	-0.0149 (0.837) [d]0.0468 (0.492)	0.0147 (0.833) [f]0.0304 (0.752)	0.0892 (0.129) [h]-0.1474*** (0.000)	-0.0180 (0.860)	-0.0431 (0.649)	-0.1178 (0.584)	-0.0315*** (0.000) [f]-0.0460*** (0.000)	-0.0884 (0.485) [m]-0.0578 (0.599)
	Post	-0.0078*** (0.000) [b]-0.0091 (0.869)	0.7354*** (0.000)	0.3821*** (0.000)	0.1890*** (0.001) [i]0.0421 (0.637)	-0.0143 (0.927)	-0.0113 (0.955)	-0.0179*** (0.000) [i]-0.0121 (0.928)	0.2062*** (0.000)	-0.3133*** (0.007)
Panel B Models with reform dummies in the variance equation (3)	$\omega^{\#}$	0.0057***	0.0022***	0.0058***	0.0017***	0.0019***	0.0027***	0.0174***	0.0094***	0.0010***
	α	0.9610*** (0.000)	0.9836*** (0.000)	0.7441*** (0.000)	0.9975*** (0.000)	0.9934*** (0.000)	0.9451*** (0.000)	0.9702*** (0.000)	0.9622*** (0.000)	1.0221*** (0.000)
	β	-0.0079*** (0.000)	-0.0090 (0.841)	0.2007*** (0.009)	-0.0213 (0.715)	-0.0151 (0.834)	0.0574 (0.341)	-0.0123 (0.787)	-0.0307 (0.474)	-0.0422 (0.606)
	r	0.0016 (0.416)	0.0087*** (0.007)	-0.0010 (0.466)	0.0013* (0.096)	0.0048** (0.019)	[m]-0.0001 (0.907)	0.0018 (0.529)	0.0026 (0.368)	[m]0.0018 (0.106)

Notes:
Numbers in parentheses are p-values of the respective estimated coefficients.

***, **,* Statistically significant at 1%, 5% and 10% levels respectively.
#All the constant coefficients have no standard error, indicating that it is on the boundary of the parameter space: hence it is effectively zero.
For each sample (Entire, pre and post), the top row reports the results for models without breakpoint dummies in the mean equation, while the bottom row reports the results for models with breakpoint dummies in the mean equation (where applicable). Superscript letters in brackets identify models with breakpoint dummies in the mean equation, such that: [(a)] Reform year dummy Jan 1994; [(b)] Breakpoint dummies June 2000 and May 2005; [(c)] Reform year dummies Jan 1993 and Oct 1993; [(d)] Breakpoint dummies June 2000 and May 2005; [(e)] Breakpoint dummies May 1981, Oct 1990, and Jan 1992; [(f)] Breakpoint dummy May 1981 (for Arabica) or Jun 1981 (for Robusta); [(g)] Reform year dummy Jan 1991 and breakpoint dummy April 2005; [(h)] Breakpoint dummy April 1986; [(i)] Breakpoint dummy April 2005; [(j)] Reform year dummy Jan 1995 and breakpoint dummy Jul 1993; [(k)] Reform year dummy Jan 1994 and breakpoint dummy April 2005; [(l)] Reform year dummy Jan 1992 and breakpoint dummy Jan 1994; [(m)] Breakpoint dummy Jul 1989 for ICA collapse. Otherwise, coefficients without superscript letter are for models without breakpoint dummies in the mean equation.

Table 7 Persistence and Volatility in Producer Prices in EAC Countries and Reform Effects: Summary

Type of Coffee		Sample	Tanzania	Kenya	Uganda	Burundi	Rwanda	Indicative
			GARCH	GARCH	GARCH	GARCH	GARCH	GARCH
ARABICA	Persistence $\alpha+\beta<1$	**Entire**	0.9354 [a]0.9390	0.9817 [c]0.9497	0.9518 [e]0.9504	0.9484 [g]0.9654	0.9751 [j]0.9530	0.8899
		Pre	0.9010	0.9666 [d]0.9281	0.9726 [f]0.9496	0.9640 [h]0.9474	0.9578	0.8342
		Post	0.9595 [b]0.9343	0.9988	0.9581	0.9750 [i]0.9686	0.9403	0.9042
		Change	Increase (4%)	Increase (8%)	Decrease (-1%)	Increase (2%)	Decrease (-2%)	Increase (8%)
	Mean of conditional variance (h_t)	**Entire**	0.1189	0.1553	0.2533	0.0736	0.1226	0.0240
		Pre	0.0585	0.0316	0.3087	0.0461	0.0738	0.0144
		Post	0.0905	0.2718	0.0745	0.0814	0.1105	0.0306
		Change	Increase (55%)	Increase (761%)	Decrease (-76%)	Increase (77%)	Increase (30%)	Increase (113%)
	Standard deviation of log prices	**Entire**	0.3350	0.3943	0.4691	0.2680	0.3476	0.1527
		Pre	0.2380	0.2471	0.5508	0.2162	0.2701	0.1171
		Post	0.3796	0.4909	0.2469	0.2930	0.2910	0.1748
		Change	Increase (59%)	Increase (99%)	Decrease (-55%)	Increase (36%)	Increase (8%)	Increase (49%)
ROBUSTA	Persistence $\alpha+\beta<1$	**Entire**	0.9477 [k]0.9566		0.9181 [l]0.9179			0.9110 [m]0.9768
		Pre	0.8172		0.9262 [f]0.8642			0.9372 [m]0.7491
		Post	0.9494 [i]0.9681		0.9638			0.9667
		Change	Increase (16%)		Increase (12%)			Increase (29%)
	Mean of conditional variance (h_t)	**Entire**	0.3826		0.3282			0.0755
		Pre	0.1044		0.0863			0.0189
		Post	0.5539		0.1998			0.0927
		Change	Increase (431%)		Increase (131%)			Increase (391%)
	Standard deviation of log prices	**Entire**	0.6077		0.5392			0.2673
		Pre	0.3007		0.3601			0.1287
		Post	0.7009		0.4558			0.2763
		Change	Increase (133%)		Increase (27%)			Increase (115%)

Notes:

Change: indicates the impact of reforms (either increase, decrease or unchanged) of a volatility measure

For each sample (Entire, pre and post), the top row reports the results for models without breakpoint dummies in the mean equation, while the bottom row reports the results for models with breakpoint dummies in the mean equation (where applicable). Superscript letters in brackets identify models with breakpoint dummies in the mean equation, such that: [a] Reform year dummy Jan 1994; [b] Breakpoint dummies June 2000

and May 2005; [c] Reform year dummies Jan 1993 and Oct 1993; [d] Breakpoint dummies June 2000 and May 2005; [e] Breakpoint dummies May 1981, Oct 1990, and Jan 1992; [f] Breakpoint dummy May 1981 (for Arabica) or Jun 1981 (for Robusta); [g] Reform year dummy Jan 1991 and breakpoint dummy April 2005; [h] Breakpoint dummy April 1986; [i] Breakpoint dummy April 2005; [j] Reform year dummy Jan 1995 and breakpoint dummy Jul 1993; [k] Reform year dummy Jan 1994 and breakpoint dummy April 2005; [l] Reform year dummy Jan 1992 and breakpoint dummy Jan 1994; [m] Breakpoint dummy Jul 1989 for ICA collapse. Otherwise, coefficients without superscript letter are for models without breakpoint dummies in the mean equation.

Table 8 ARCH Diagnostic Tests

		ARABICA						ROBUSTA		
	Sample	Tanzania	Kenya	Uganda	Burundi	Rwanda	Indicative	Tanzania	Uganda	Indicative
Without Dummies	**Entire**	0.2804 (0.89)	1.9261 (0.106)	0.1503 (0.963)	1.0266 (0.393)	1.4527 (0.217)	1.3993 (0.234)	0.0105 (0.999)	0.1471 (0.964)	1.1062 (0.353)
	Pre	1.1788 (0.32)	0.7451 (0.563)	0.0460 (0.996)	1.2542 (0.292)	0.8624 (0.488)	0.6688 (0.615)	0.0017 (1.000)	0.7852 (0.537)	0.6431 (0.633)
	Post	0.3206 (0.86)	1.6505 (0.165)	1.6330 (0.167)	0.4131 (0.799)	0.6728 (0.612)	1.0118 (0.403)	0.0170 (0.999)	0.3203 (0.864)	0.4569 (0.767)
With Dummies	**Entire**	0.2939 (0.88)	1.5192 (0.197)	0.7561 (0.555)	0.9135 (0.456)	0.5334 (0.711)	NA	0.0288 (0.998)	0.3746 (0.827)	0.5516 (0.698)
	Pre	NA	0.4602 (0.765)	0.0342 (0.999)	1.2674 (0.287)	NA	NA	NA	1.0430 (0.388)	0.3307 (0.857)
	Post	0.0814 (0.99)	NA	NA	0.1170 (0.976)	NA	NA	0.0584 (0.994)	NA	NA
	Entire (e3)	0.3179 (0.866)	0.7597 (0.552)	0.8801 (0.476)	1.2612 (0.285)	0.6370 (0.637)	1.4129 (0.227)	0.0258 (0.999)	0.4174 (0.796)	0.3805 (0.823)

Notes:
Numbers in parentheses are p-values of the respective estimated coefficients.
NA: not applicable because no breakpoint was identified.
Entire (e3): Tests for equation (3) with reform dummies in the variance equation