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Effects of Market Reforms on Irish Potato Price Volatility in Nyandarua District, Kenya

Samuel Chege Mwangi* Oliver L.E.Mbatia Jonathan Makau Nzuma

Department of Agricultural Economics, University of Nairobi, P.O. Box 29053, Nairobi 00625, Kenya.

* E-mail of the corresponding author: mwangisamue2006@yahoo.com

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Abstract

This paper evaluates the effects of market reform policies on the volatility of Irish potato prices in Kenya through an analysis of a 20 year monthly time series data set from Nyandarua district using an autoregressive econometric approach. The empirical results show that there has been a rise in Irish potato prices and lowering of price volatility after the implementation of market reform policies. The real prices exhibit seasonal variations around an upward trend with the prices being depressed during the harvesting period. The price risk premia is found to be negative revealing that the cost of carrying out Irish potato business declined, and farmers were better off with the implementation of the reforms. The collection and distribution of price information, storage of Irish potatoes during periods of glut, improvement in productivity and use of commodity exchange markets can help to reduce price volatility.

Keywords: Price volatility, Market reforms, Autoregressive model

1. Introduction

Irish potatoes are an important source of food, income and employment in Kenya. They contribute approximately 1.9 percent of Kenya's agricultural Gross Domestic Product (GDP), which is about 0.5 percent of total GDP (Gitu, 2004). The crop directly supports about 500,000 farmers and indirectly supports over 2.5 million citizens (GoK, 2009). National annual output is approximately one million metric tons worth about Kshs. 10 billion at consumer prices, which represents 11 percent of the national fruit and vegetable value (GoK, 2005).

In the past, Kenya used to be a net exporter of Irish potatoes when the production was high. However, Irish potato production has stagnated over the years due to price volatility, poor marketing and storage, post harvest losses, poor crop husbandry and poor quality seeds. Price volatility is an important component of profit variability and it is therefore important to quantify the price volatility of agricultural products. The volatility in prices among agricultural commodities is critical for individual investment decisions in farming and farm product marketing.

The market reforms implemented in Kenya in the 1980's lead to direct and indirect effects on the level and volatility of agricultural produce prices. The effect of market reforms on the level and volatility of food prices in the Kenya is ambiguous. While some authors argue that the reforms lead to an increase in real prices (De Groote *et al.,* 2006; Karugia *et al.,* 2003), others report that the market reforms lead to a decline in food prices (Karingi & Nyangito, 2005; Nzuma, 2007). Moreover, many of the studies on the effect of market reforms on agricultural food prices in Kenya have concentrated on maize (De Groote *et al.,* 2006; Karugia *et al.,* 2003; Karingi & Nyangito, 2005).

2. Analytical Framework

The autoregressive conditional heteroscedasticity (ARCH) model was originally developed by Engle (1982) to describe the inflationary uncertainty in the United Kingdom. However, the ARCH class of models has subsequently found wide use in characterizing time-varying financial market volatility (Bollerslev, 1986). The model allows for simultaneous estimation of conditional means and variances of a dependent variable over time (Engle 1982; Bollerslev, 1986). An autoregressive conditional heteroscedasticity (ARCH) econometric model is used in this study to calculate Irish potato price volatility which cannot be directly observed.

The selection of this model was motivated by three reasons. The first reason is a theoretical belief that storable commodities have an ARCH process because current price volatility transmits itself into future period by creating volatility in the inventory carryover (Kilima *et al.*, 2004). Secondly, the model allows conditional volatility to directly influence the conditional mean (Kilima *et al.*, 2004). The model is not just interested in the determinants of prices as reflected in the conditional mean and various regressors but also in the factors that explain price risk as revealed in the series conditional variance and the interaction between the mean and variance of the prices, that is, the price risk premium prevailing in the market (Gujarati, 2005). Third, data limitations and modeling difficulties disqualify the adoption of alternative models.

The conditional variance means that variance at any given period is dependent on time and previous variance (Green, 2004). This indicates that the variance is conditional on time and previous variance. It is used in studying prices which go through periods of high volatility and periods of low volatility, to model them econometrically as having the variance at time t as coming from an autoregressive (AR) process. This is the basis of the ARCH model. In this model, the unconditional variance is the variance of the whole process, whereas the conditional variance can be better estimated since it is assumed that we can estimate the previous values of the variance (Green, 2004). In this study price volatility is modeled as the conditional variance of Irish potato mean prices.

The ARCH model assumes an error structure in which the sign of the disturbance is not predictable, but in which the size of the forecast error is. Thus the conditional variance is homoscedastic but the variance at any time t conditional on preceding period information, is heteroscedastic. An important assumption underlying ARCH model is that there is an inherent non-linear phenomenon that could lead to price volatility (Deaton & Loroque, 1992; Bera & Higgins, 1995; Shiverly 1986). This assumption is mainly satisfied in situations where stockholding play an important role in price determination in any two successive periods. In agriculture the model is used to measure price volatility mainly for non-perishable commodities like cereals (Karanja *et al.*, 2003).

The specifications of the ARCH model provides for the conditional mean equation, conditional variance and conditional error distribution. Following Engel (1982) the basic ARCH model can be defined as:

$$Y_t = X_t{}'\theta + \varepsilon_t \qquad (1)$$

Equation (1) can be expressed in general form as:

$$Y_t = f(X_t{}') \qquad (2)$$

The conditional variance equation,

$$\sigma_t{}^2 = \omega + \alpha\varepsilon_{t-1}{}^2 \qquad (3)$$

Equation (3) can expressed in general form as:

$$\sigma_t^2 = f(\omega, \alpha) \qquad (4)$$

Where Y_t is the dependent variable over time t, X_t is a vector of independent variables. θ and α are constants. ε_t represents the error term which is independently and identically distributed (i.i.d).

The mean equation (1) is written as a function of exogenous variables with an error term. X_t refers to exogenous or predetermined variables that are included in the mean equation while σ_t^2 is the one period ahead forecast variance based on past information and is therefore the conditional variance over time t. This allows for the existence of a direct correlation between price levels and volatility. Equation (3) of the conditional variance is a function of a constant term ω, news about the previous period volatility measured as the lag of the squared residual from the mean equation ε_{t-1}^2. The ε_{t-1}^2 refers to the presence of a first-order moving average and is called the ARCH term.

The ARCH fits regression models in which the volatility of a series varies through time. Usually, periods of high and low volatility are grouped together. ARCH models estimate future volatility as a function of prior volatility. To accomplish this, ARCH fits models of autoregressive conditional heteroscedasticity using conditional maximum likelihood method. The variance of the dependent variable is modeled as a function of past values of the dependent variable and independent or exogenous variables.

The completion of the basic ARCH model requires assumptions about the conditional distribution of the error term ε_t. The assumptions are: normal distribution, student's t-distribution and Generalized Error Distribution (GED). Given the distributional assumptions, the ARCH model is estimated using the method of maximum likelihood (MLE) which assumes that data is normally distributed. The equations (1) and (3) are estimated simultaneously by method of maximum likelihood yielding consistent and efficient estimates of θ, ω and α parameters of interest.

The autoregressive conditional heteroscedasticity in mean (ARCH-M) model suggested by Engle & Granger, 1987 is an extension of the ARCH model. The ARCH-M model was first used for modeling risk-return tradeoffs in the term structure of United States interest rates. The model extends the ARCH regression model in Engle

(1982) by allowing the conditional mean to depend directly on the conditional variance and thus risk thereby influencing equilibrium price levels. The conditional mean implies that the mean price is conditional on time and previous price (Gujarati, 2005). In the ARCH-M regression model the conditional variance is interpreted to represent volatility. The bounds of the conditional variance is from zero to one, with zero indicating no volatility at time t while the value one represents maximum volatility at time t.

The ARCH-M allows price modeling with time varying risk premium, that is, the increase in the expected rate of return (mean price) is associated with the increased risk in rate of return (variance). In the model, the risk term ψ included as one of the vectors of independent variables, estimates the relative risk premia. The ϕ estimate reflects a risk premium with respect to the conditional standard deviation (Engle & Granger 1987). This risk premia is that portion of observed price attributable to a risk premium. The short-term risk premia is the necessary mark-up by an existing firm to cover its price risk exposure (Barrett, 1997). The long-term risk premia captures general equilibrium effects on industry structure as risks impacts on entry, exit and investment levels. Long- term risk premia thus add to the short-term effects of risk.

The literature on risk and agricultural marketing in high-income countries indicates the risk premium to be positive (Barrett, 1997). This implies that equilibrium prices compensate suppliers for bearing price risk. In low income countries however, it is quite possible that consumers will require compensation for bearing food security risk induced by price variability thereby leading to a negative risk premia (Barrett, 1997). There are several advantages of using the ARCH-M model. First, the ARCH-M model addresses the potential problems with heteroscedasticity that would lead to inefficient estimators and possibly incorrect inferences (Brewer *et al.*, 2005). This model is appropriate to use when the variance of the residuals fluctuates significantly during the sample period. Further, the model allows for simultaneous estimation of the conditional mean and price volatility of a dependent variable over time. The model is more applicable to non-perishable agricultural commodities in an environment where stockholding is important (Karanja *et al.*, 2003).

3. Empirical model

Following Karanja *et al.,* 2003, an autoregressive conditional heteroscedasticity in mean (ARCH-M) model specified for this study is as follows:

$$P_t = \beta_0 + \beta_1 T + \beta_2 P_{t-1} + \beta_3 R + \beta_4 PR + \beta_5 SD + \beta_6 S + \phi h_t^{1/2} + e_t \qquad (5)$$

$$h_t = \alpha_0 + \lambda_1 e^2{}_{t-1} + \lambda_2 T + \lambda_3 P_{t-1} + \lambda_4 R + \lambda_5 PR + \lambda_6 SD + \lambda_7 S \qquad (6)$$

Where P_t is the Irish potato mean price, β_0 is a constant, β_t are estimation coefficients while T, P_{t-1}, R, PR, SD and S represent time, lagged price, reforms, value of production, season and sales respectively. The ϕ is the risk premia, h_t is the conditional variance over time (t), and e_t is the random error term.

The ARCH-M model was applied in this study due to its suitability in modeling price volatility in commodities such as Irish potatoes where stockholding by farmers and traders is important in regulating supply in the hope of benefitting from price movements (Karanja *et al.,* 2003). A two equation ARCH-M model is estimated for the Irish potato twenty year price series. Therefore, equation (5) gives the ARCH-M estimates for the mean equation which determines the level of the wholesale Irish potato prices. In this case, the dependent variable is the mean monthly Irish potato price. In equation (5) the estimation coefficients explain how the respective independent variables affect the Irish potato wholesale prices in the post reforms period. A positive estimation coefficient in this equation indicates that the respective independent variable lead to an increase in Irish potato prices. A positive risk term coefficient in equation (5) implies that the mark up to cater for price risk increased during the post reforms era.

Equation (6) estimates the Irish potato price variance which depicts the price volatility. The dependent variable is thus the conditional variance and the estimation coefficients show how the independent variables affect the price volatility. A positive estimation coefficient in equation (6) indicates that the respective independent variable lead to an increase in price volatility during the post reforms period. In this study the Irish potato conditional mean price is dependent on time and the previous price. The conditional variance or volatility of the Irish potato price is dependent on a monthly time trend t and the immediate value of the variance at time t-1. Both the conditional mean and variance were estimated by the univariate ARCH-M regression model by the maximum likelihood estimation (MLE) approach. The real monthly wholesale Irish potato prices (P) were obtained by deflating the nominal prices obtained from Nyahururu market using the monthly Consumer Price Index (CPI) from the Kenya National Bureau of Statistics (KNBS). The base year of analysis was 1997, such that October 1997 = 100.

4. Data

The data for this study was collected in Nyandarua district of the Central province of Kenya. This study used monthly time series secondary data on Irish potato prices, value of production and sales from the Ministry of Agriculture (MoA) in the district, for the period 1986-2005. This dataset comprises 240 observations and was collected from Nyandarua District Agricultural Office (DAO). The monthly time series Irish potato price data was collected by the MoA market enumerators using standard questionnaires on a weekly basis and the monthly average prices aggregated from the weekly prices.

Other sources of data included institutions involved in production, marketing, research and data collection of Irish potatoes in Kenya. These were the Kenya Agricultural Research Institute (KARI), Horticultural Crops Development Authority (HCDA) and German Technical Support (GTZ). The national Consumer Price Index (CPI) statistics were obtained from the Kenya National Bureau of Statistics (KNBS). However, rural CPI would have been preferred for this study but was not available for the period under consideration. In this study descriptive and econometric techniques were used to analyze the data using STATA computer software. The descriptive statistics included the mean and the coefficient of variation (CV). An ARCH-M regression model was used in the econometric analysis.

5. Results and discussion

5.1 Descriptive analysis

Figure 1 provides the results of the twenty year monthly real Irish potato time series price trend. The mean real Irish potato prices in Nyandarua district are highly variable and fluctuate in up and down fashion with an increasing trend. The fluctuations coincide with water availability, with low prices being experienced within the years when the rainfall levels are favorable for potato production and during the harvesting months. A likely cause of these seasonal price fluctuations is due to the fact that demand for Irish potatoes in the district is relatively stable, whereas supply fluctuates due to weather conditions, pests, diseases and farm management practices.

The descriptive statistics of the variables used to estimate price volatility are presented in Table 1. The pre-reform period represent the time from January 1986 to December 1995 while the post-reform period corresponds with the era from January 1996 to December 2005. The two periods were selected because this is where a structural change is assumed to have occurred in Kenya as a result of the implementation of the market reform policies. The real Irish potato price paid to farmers increased from an average of 1010 Kshs/ton during the pre-reform period to 5996 Kshs/ton during the post reform period. This represents a 494 percent increase in the wholesale price (Table 1).

In order to determine whether the mean prices were significantly different between the two periods, a two way t-test is done and the results are as reported in Table 2. As can be observed in Table 2 the test statistic falls in the rejection region and the null hypothesis is rejected at the 95 percent level of significance. The implication is that the Irish potatoes mean price before the implementation of the market reform policies was significantly different from the mean price after the implementation of the market reforms.

The variability of Irish potato prices as represented by the coefficient of variation (CV) declined during the post reforms period from 64 percent to 50 percent (Table 1). The increase in Irish potato prices and decline in the price variability show that Nyandarua farmers received higher and stable revenues from Irish potatoes during the post-reforms period as compared with the pre-reforms period. The implication is that the high and relatively stable Irish potato prices during the reforms period served as an incentive for Nyandarua district farmers to increase production. However, the high and stable prices in the post reforms period were not favorable to the consumers who had to pay consistently high prices for Irish potatoes. The decline in the variability of the mean Irish potato price during the post reforms period can be explained by the reduced variability in value of production (Table 1). Thus since the fluctuations in demand for Irish potatoes in the Kenyan markets is low, the source of price variability lies in fluctuation in value of production. In essence, value of production fluctuations arose out of variation in weather, pest and diseases and farm management practices.

The mean Irish potato value of production increased by 600 percent from 12.76 million Kshs. per month during the pre-reforms period to 89.38 million Kshs. per month in the post reforms period (Table 1). As can be observed in Table 1, the variability of Irish potato value of production reduced from 71 percent to 63 percent over the same period. The decline in value of production variability during the post reform period lead to a reduction of price variability during the same period. The mean Irish potato value of production for the pre-reforms period was lower than for the post reforms period. As depicted by the CV (Table 1), variability of value of production for the pre-reforms was higher than during the post reforms period. The high mean Irish potato value of production and low variability during the reforms period imply that the reforms lead to an increase in the overall potato value of production in Nyandarua district.

The mean sales volumes increased from 31 metric tons during the pre-reforms period to 49 metric tons during the post reforms period, an increase of 57 percent (Table 1). This increase in the sales volume can be explained by an increase in the supply and demand of Irish potatoes to the market. However, variability of the sales volume as represented by the CV was lower during the post reforms period compared to the pre- reforms period (Table 1).

The mean prices, value of production and sales volume increased but their variability declined (Table 1). These findings imply that the implementation of market reform policies by the Kenyan government lead to the realization of high and stable incomes by the Irish potato farmers. This leads to the conclusion that the potato farmers in Nyandarua district were better off with the implementation of market reform policies than without them. The consumers were however made worse off by the implementation of these policies.

5.2 Unit root test results

The Augmented Dickey-Duller (ADF) (1979) and Phillips-Perron (PP) (1988) methods were used to test for the existence or non-existence of unit roots in the variables used in estimating the Irish potato price volatility and the results of the tests are as presented in Table 3. The null hypothesis of nonstationaity or unit root is accepted if the absolute values of the computed ADF and PP statistics exceed the absolute critical values at 5 percent level of significance. The absolute value of the computed test statistic for the real price level series |-2.416| is less than the critical absolute value |-2.6 | at 5 percent level of significance in both the ADF and PP tests (Table 3). However, the absolute values of the computed test statistics for the real price first difference series (| -6.236| and |-7.574|) are greater than the critical absolute value |-3.50| at 5 percent level of significance in both the ADF and PP tests (Table 3).

These results reveal that the price series are nonstationary and are integrated of order one, that is, they are **I** (1). When similar comparisons of the computed and the critical ADF and PP test statistics are done for value of production and sales data series, the results show that these series are also nonstationary (Table 3). From the results of the unit root tests, the conclusion is that the data series used in the volatility model in this study are **I** (1) in the level series and the first differences series are **I** (0).

The nonstationarity of the level series of the real Irish potato prices, value of production and sales imply that the means and variances of these variables change over time. These nonstationary variables can separate from each other over time and lose their relationship. This phenomenon is called a spurious regression and is overcome by use of an autoregressive model (Gujarati, 2005). Hence given that the level series are **I** (1) and the first difference are **I**(0), this result is necessary and sufficient to justify the use of the ARCH-M econometric model, which is used to model varying mean and variance, in the evaluation of Irish potato price volatility in this study.

5.3 Factors influencing Irish potato prices

In table 4, the autoregressive conditional heteroscedasticity in mean regression estimates for the mean equation are presented. The lagged price of Irish potatoes (P_{t-1}) coefficient is positive (0.96) and significant at 1 percent level of significance (Table 4). The positive and significant Irish potato lagged price coefficient indicates that the lagged price is a significant factor that influences the mean price. Thus, the current mean price at any one given time period highly depends on the price in the preceding period. This finding shows that the preceding period price contributes 96 per cent in the prediction of the prevailing price at any given time.

The value of production (PR) of Irish potatoes coefficient is negative (-0.01) and significant at 1 percent level of significance (Table 4). This reveals that low equilibrium prices clear the market when production is high and high prices clear the market when production is low. The implication is that Nyandarua Irish potato farmers receive low prices during peak production periods. Thus, strategies to manage Irish potato supplies to the market are required so as to enable the farmers realize stable incomes from their Irish potato enterprises.

The reforms (R) coefficient is positive (164.31) and significant at 5 percent level of significance (Table 4). This finding indicates that the implementation of market reform policies leads to a 164 percent increase in the mean Irish potato price. The increase in mean real Irish potato prices during the post-reforms period was as a result of low supply growth as compared with the increase in demand. A rise in demand is attributed to an increase in population, rapid urbanization and change in tastes and preferences in favor of an increased consumption of Irish potatoes. Further, the large coefficient of the market reforms dummy variable is an indicator of multicollinearity between the reforms dummy and Irish potato prices, implying that the model is a good fit for the data and yields statistically robust estimates.

The season coefficient (SD) was negative (-186.21) and significant at the 1 percent level (Table 4) indicating that mean Irish potato prices are depressed during the harvesting season. The large season coefficient of -186 indicates that the mean Irish potato prices are highly dependent on the season. The estimation coefficient of the risk term (ϕ) is negative (-10^{-5}) and significant at 1 percent level of significance (Table 4). A negative risk premia found in this study implies that the cost of carrying out Irish potato business declined during the post reforms period. As can be seen in Table 4, the sales volume (S) has the expected negative sign (-3.91) but is insignificant in determining the mean monthly Irish potato price in Nyahururu market.

5.4 Conditional variance of Irish potato prices

Table 5 presents the results of the ARCH-M estimates for the Irish potato price variance, which represents price volatility. The coefficient of the lagged Irish potato price (P_{t-1}) is positive (0.91) and significant at 1 percent level (Table 5). Hence, a 1 percent increase in lagged price results to a 0.91 percent rise in Irish potato price volatility. This implies that the volatility of Irish potato prices in one given month is related to the prices prevailing in the preceding period. The coefficient of value of production (PR) is negative (-0.01) and significant at 1 percent level (Table 5). This implies that Irish potato value of production significantly influences price volatility with a 1 percent increase in value of production leading to a 0.01 reduction in Irish potato price volatility. This occurs because an increase in production leads to an improvement of supply and demand equilibrium thereby stabilizing the prices.

The coefficient of market reforms (R) is negative (-241.55) and significant at 1 percent level of significance (Table 5). Therefore, the implementation of the market reform policies by the government resulted to a 241 percent reduction in Irish potato price volatility. From these results, the conclusion is that the implementations of market reform policies by the Kenya government lead to a stabilization of Irish potato prices in Nyandarua district.

The coefficient of the seasonal dummy (SD) is negative (-165.09) and significant at 1 percent level of significance (Table 5). The economic implication is that the Irish potato price volatility declined by 165 percent during the harvesting season. The conclusion is that seasonality of Irish potato production is a key factor influencing price volatility. Therefore an Irish potato regulation system needs to be put in place in order to reduce the Irish potato price volatility in Nyandarua district. This would be to the benefit of producers, traders and ultimately the consumers as it would enable them manage the risk associated with price volatility. The sales volume (S) coefficient was negative (-2.88) and insignificant in the conditional variance equation model (Table 5). The explanation for this insignificant effect of sales volume on price volatility is the fact that Nyahururu market handles only a limited quantity of the Irish potatoes produced in Nyandarua district.

6. Conclusions and policy implications

This paper examined the effects of the implementation of market reform policies by the Kenyan government on the Irish potato sub-sector, using an autoregressive econometric technique. First, the trend in Irish potato prices in Nyandarua district was evaluated and then the effect of market policy reforms on Irish potato price volatility in the district was assessed.

The results from the descriptive statistics indicate that the mean Irish potato price at any one given month is dependent on the previous month price. Therefore the farmers, traders, processors and consumers can use the expected prices for decision making in their operations. The mean prices are negatively correlated with value of production implying that the Irish potato farmers receive low prices when the production is high. The Irish potato monthly real prices increased after the reforms as a result of the slow growth in supply as compared to the increase in demand. The supply increased as a result of increased production while the demand rose due to increase in population, rapid urbanization and change in tastes and preferences. The results also indicate that mean Irish potato prices are depressed during the harvesting months when supply is much higher than the demand. This occurs since there is low on-farm and off-farm storage because liquidity constraints force the farmers to sell most of their produce after harvest. The risk premia is found to be negative, implying that the cost of doing Irish potato business decreased after the reforms.

Further conclusions can be drawn from the autoregressive econometric model estimates of the real Irish potato price variance. Firstly, the reforms lead to a decrease in Irish potato price volatility as a result of increased production thus bridging the gap between production and demand. The lower price volatility served as an incentive for the Irish potato farmers to increase production during the reforms period. This implies that with reforms the Irish potato producers realized more stable incomes in comparison with the pre-reforms period. Secondly, the seasonality of Irish potato production is found to be a key factor influencing the volatility of the mean price. The Irish potato price volatility is weather dependent, with the volatility decreasing during the harvesting months. This affects the farmers' decision making since they are uncertain of the price to expect in the forthcoming period. To reduce this uncertainty Irish potato commodity exchange markets need to be introduced.

Lastly, the Irish potato value of production is found to significantly influence the price volatility. An increase in value of production results to a reduction of price volatility because of the improvement in supply and demand equilibrium. The implication is that an increase in value of production lead to a reduction in uncertainty and risk associated with price volatility. The farmers therefore realized more stable incomes with an increase in value of production.

The results of this paper found that price volatility in the Irish potato sector is as a result of factors having effects on supply and demand. Since the demand of the commodity is relatively inelastic, the price volatility can mainly be stabilized by controlling the supply of potatoes to the market through storage during periods of glut. This calls for improvement in the market infrastructure through provision of adequate storage space and installation of cold stores in the Irish potato markets.

The variability in value of production was found to be a major contributor to Irish potato price volatility because production follows the natural rainfall pattern. This variability can be controlled through improvement in production since with high production the volatility was observed to decline. Further, if the production is increased it will be possible to meet the national demand and with storage the supply to the market can be controlled between the glut and scarcity periods thus leading to price stability.

Overall, this study indicates that the implementation of market reform policies favored the Irish potato producers but made the consumers worse off. Thus market reform policies need to be considered together with complimentary measures to cushion consumers from price shocks. To achieve this, the Kenyan government and other stakeholders in the Irish potato sub-sector need to institute measures to improve production, storage and marketing.

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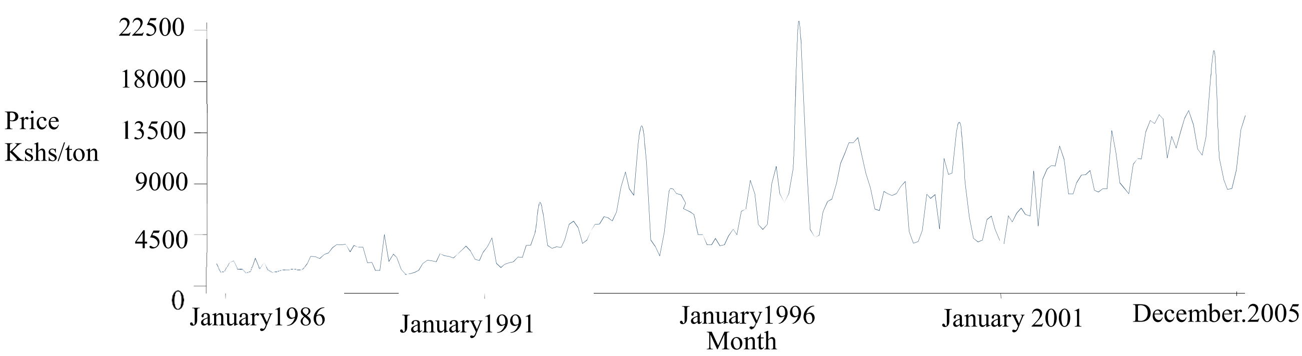

Figure 1. Monthly real Irish potato prices (Kshs/ton) trend (1986-2005)

Source: Computed from secondary data, 2009

Table 1. Descriptive Statistics of the variables used to estimate price volatility

		Pre-reform period		Post-reform period		Entire period	
Variable	Units	Mean	CV[a] (%)	Mean	CV[a] (%)	Mean	CV[a] (%)
Dependent variable							
Price	Kshs/ton	1010.13	64.04	5996.16	50.21	3503.15	94.51
Independent variable							
Value of production	Value of production in millions of Kshs.	12.76	70.78	89.38	62.66	13.20	66.78
Sales	Metric tons	31.13	60.71	48.96	53.37	40.05	61.05
Lagged price	Kshs/ton	999.00	62.98	5949.14	50.36	3474.07	94.67

Note: The Coefficient of Variation (CV) is a ratio of the standard deviation to the mean.

Kshs. represents Kenya shillings currency.

Source: Computed from secondary data, 2009

Table 2. Two way t test on the mean prices

Period	Number of observations	Mean	Standard error	Standard deviation
Pre reforms	120	101.13	59.33	649.91
Post reforms	120	5996.16	274.82	3010.54
Entire period	240	3048.65	236.71	3667.04
Difference		-4986.03	281.15	
t value	-17.73			
α	0.05			
Rejection region	t < -1.96 or t > 1.96			

Note: $^{\alpha}$ represents the level of significance and t is the test statistic.

Source: Computed from secondary data, 2009

Table 3.Unit root tests for the variables used in estimating price volatility

Series	Level series		First differences			I (d)
	ADF	PP	Lags	ADF	PP	
Dependent variable						
Real price (Kshs/ton)	-2 .416	-2 .416	1	-6.236 [c]	-7.574[c]	I (1)
Independent variables						
Value of production (Kshs)	-2. 538	-2. 538	1	-4.521 [c]	-5.613 [c]	I (1)
Sales (Metric tons)	-2.574	-2.574	1	-5.487 [c]	4.569 [c]	I (1)
5% Critical values	-2.60	-2.60		-3.50	-3.50	

Note : [c] Denotes rejection of the null hypothesis of a unit root at 5 percent level of significance (MacKinnon, 1991).

Source: Computed from secondary data, 2009

Table 4. Estimates of mean Irish potato prices

Dependent variable: Monthly mean Irish potato prices (Kshs/ton)

Independent variable	Estimation coefficient	Standard error	ρ
Constant (ρ_0)	-122.71	93.11	0.19
Lagged Price (P_{t-1})	0.96[a]	0.01	0.00
Value of production (PR)	-0.01[a]	0.00	0.00
Time (T)	4.15 [a]	0.67	0.00
Reforms(R)	164.31[b]	65.93	0.01
Season (SD)	-186.21[a]	33.68	0.00
Sales (S)	-3.91	1.75	0.32
Risk term (φ)	-0.00005[a]	7.60e-06	0.00
n	240		
AIC	3933.04		
BIC	3964.36		
Durbin Watson d statistic	1.71		

Note: [a] Significance at 1 percent level, [b] significance at 5 percent level while n, AIC, BIC denotes the number of observations, Akaike Information Criterion and Bayesian Information Criterion.

Source: Computed from secondary data, 2009

Table 5. Estimates of the Irish potato price volatility

Dependent variable: Conditional variance (ht)

Independent variable	Estimation coefficient	Standard error	ρ
Constant (α_0)	374.14[a]	80.07	0.00
Lagged Price (Pt-1)	0.91[a]	0.01	0.00
Value of production (PR)	-0.01 [a]	0.001	0.00
Time (T)	3.62[a]	0.581	0.00
Reforms(R)	-241.55 [a]	63.18	0.00
Season (SD)	165.09 [a]	36.59	0.00
Sales (S)	-2.88	2.05	0. 61
ARCH term (λ_1)	3.31 [a]	0.40	0.00
n	240		
AIC	3910.21		
BIC	3945.01		
Durbin Watson statistic	1.81		

Note : [a] significance at 1 percent level while n, AIC; BIC denotes the number of observations, Akaike Information Criterion and Bayesian Information Criterion.

Source: Computed from secondary data, 2009