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Testing for Oligopoly Power in the Kenyan Seed Maize Processing Industry

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1.0. Introduction

In the academic literature, a number of studies have attempted to measure domestic market power in agricultural markets. Markets examined have included beef, pork, beer, cigarettes, coffee, fruits, rice and textiles among others. As McCorriston *et al*, (1995) suggest these studies have been more frequent in North America and infrequent in Europe. Some recent examples have included studies by Azzam and Pagoulators (1990), Bhuyan and Lopez (1997) and Quagrainie *et al*, (2003). However, literature on agricultural market performance in many developing countries especially in Sub Saharan Africa (SSA) is scarce and hard to come by.

The performance of agricultural markets in Kenya has received little attention despite the critical role-played by the sector. Among the major staple Kenyan food crops is maize that accounts for about 20 and 25 percent of agricultural production and employment respectively (Kenya 2001). Currently, Kenyan maize consumption estimated at 3 million tonnes outstrips domestic supply at 2.3 million tonnes and its productivity has been declining prompting policy makers to questions the underlying reasons. These concerns have prompted empirical enquiries that have attributed the production/consumption gap to low use of certified seed owing to marketing tendencies that price the seed out of reach for most farmers.

About 30 percent of Kenyan maize producers continue using either traditional seeds (landraces) or recycled hybrids (Kamau, 2002). These seed use trends persist hand in hand with an established seed maize processing industry that is dominated by a few firms. Moreover, the concentration of seed processing has often raised public concerns especially given its inability to ensure lower certified seed retail prices.

The demand for certified seed maize in Kenya is derived from the consumption of maize that has been increasing in the country. It is therefore expected that farmers would purchase certified seed to boost domestic production. However, the high seed maize retail prices in Kenya relative to regional SSA markets may be hindering the adoption of high yielding varieties. In 2004 for example, the seed retail to commercial grain price ratio stood at 10:1 when compared to Zimbabwe (5:1), Malawi (7:1) and Zambia (8:1) (Kenya, 2004). The Ministry of Agriculture (MOA) estimated that seed processor margins accounted for about 20 percent of these prices in the same year.

These pricing trends suggest non-competitive behaviour, which is indicative of the existence of market power. As Quagrainie *et al*, (2003) reports, market power increases marketing margins, presumably at the expense of farmers and perhaps at the expense of consumers and this may be the case in Kenya's seed maize processing sector. This study evaluates the structure of the industry and tests the hypothesis of price taking behavior.

Kenya's experience with the marketing of certified seed maize spans over four decades that have been accompanied by changes in the supply chain. Traditionally, breeding research has been the preserve of the Kenya Agricultural Research Institute (KARI). KARI releases its publicly bred basic seed to seed companies who remit royalties in return. Seed companies then contract seed growers to undertake seed multiplication. The companies provide the growers with basic seed and mutually agree on the price to be paid. Seed companies also appoint their own distribution agents and set retail prices and the margins to be received by agents. It is evident from this structure that seed companies have an upper hand in the marketing chain.

The Kenyan seed maize processing industry is a 13 firm oligopoly that for a long time has been dominated by the Kenya Seed Company (KSC). KSC a quasi-private company inherited from the colonial times developed an extensive marketing system and enjoyed monopoly status until 1996 when the industry was liberalized. Typically, KSC sets the retail prices while other companies routinely adjust their prices to rhyme with those of the market leader in each growing season, which might suggest increased price coordination in the industry.

In literature, the traditional structure-conduct-performance (SCP) approach to understanding market behaviour has been the method of choice in studying market conduct. However, in the recent past, many studies have opted for the New Empirical Industrial Organization (NEIO) that utilizes structural models as opposed to profitability ratios that were prevalent in SCP approaches. The initial oligopoly power model developed by Appelbaum (1982) has since been applied on many other studies in testing for the existence of market power.

As Quagrainie *et al*, 2003 suggest, the common approach has been to assume a functional form for a dual cost function or a profit equation. The first order optimality conditions (Shephard's or Hotelling's Lemma) are then used to derive a system of input demands. In these models firms are hypothesized to simultaneously and independently choose their output levels given their beliefs about rivals reactions to their output choice and these beliefs are called conjectural elasticity of variations (Azzam *et al*, 1990). Azzam (1990) further argues that a firm's conjectural elasticity is its conjectural variations multiplied by its market share.

The conjectural elasticity of variations and the output demand elasticity are then used to compute a Lerner index that shows the degree of market power. A Lerner index value of one indicates presence of monopoly power while zero indicates perfect competition. The estimated econometric model consists of: an output demand equation that embodies marginal revenue, input demand equations that embody marginal costs and a pricing equation (Bhuyan *et al*, 1997). The pricing equation is based on the profit maximizing condition that marginal revenue equals marginal costs and embodies a parameter of industry conduct. This approach has been applied by Lopez (1984) on the Canadian food processing industry and is used in this study to test for oligopoly power in Kenya's seed maize processing.

2.0. Theoretical Framework.

This study adopts Appelbaum's (1982) approach to measure market power in the Kenyan seed maize processing industry. An indirect dual cost function is used to derive the industry's input demands (capital, labour, material and energy). For convenience, we assume a single material input (grower's seed) with all inputs being purchased in a competitive market by profit maximizing firms. We also suppose that the firm's technology exhibit constant returns to scale and that the firm uses inputs in fixed proportions.

Consider an industry in which N firms (indexed $j = 1, 2, \dots, N$) produce a homogeneous output (Y = certified seed) using M inputs: $X = (X_1, \dots, X_n)$. Let the cost function of the j th firm be given by;

$$(1) \quad C^j = C^j(Y^j, W)$$

where Y^j is the output of the j th firm and W is the price vector of the inputs. Since the firms are price takers in the input markets, Shephards Lemma can be used to derive the input demands;

$$(2) \quad X^j = \partial C^j(Y^j, W) / \partial W \quad j = 1, \dots, N$$

Where X^j is the j th firms input demand vector.

Consider the market demand facing the industry to be given by

$$(3) \quad Y = J(P, Z)$$

Where $\sum Y^j = Y$ (in this case demand is assumed to equal supply) and P is the output price (certified seed maize) while Z is a vector of exogenous variables.

The j th firm's objective is to maximize profits by choosing the right amount of Y to produce given its cost structure.

$$(4) \quad \text{Max}_{\{Y^j\}} \pi^j = [PY^j - C_j(Y^j, W) : Y = J(P, Z)]$$

The necessary first order condition from the profit-maximizing problem is;

$$(5) \quad P(1 - \theta^j / \eta) = \partial C^j(Y^j, W) / \partial Y^j$$

Where θ^j is the j th firm's conjectural variations elasticity and η is the absolute value of the price elasticity of output demand. The value of θ^j is a measure of price taking behavior and is used to test for the existence of market power. In a pure monopoly, $\theta^j = 1$ while in a competitive market $\theta^j = 0$ implying that price equals marginal cost.

Equation 5 can then be rearranged to derive the Lerner index a measure of the degree of market power as follows;

$$(6) \quad [P - MC^j] / P = \theta^j / \eta$$

Using market shares $S_j = Y_j / Y$ as weights, equation 5 can be written as;

$$(7) \quad S_j - [S_j MC_j] / P = S_j \theta^j / \eta = L_j$$

where L_j is defines the j th firm's Lerner index of oligopoly power. Under appropriate aggregating conditions, equation 6 can be summed up across all N firms to yield the industry aggregate Lerner index of oligopoly power (L)

$$(8) \quad L = \sum S_j L_j = -H / \eta$$

where H is the Herfindahl index (sum of the squared market shares). Equation 6 can also be aggregated to the industry Lerner index and rewritten as;

$$(9) \quad L = [P - MC] / P = \Theta / \eta$$

where MC and Θ are industry level (weighted) marginal cost and conjectural variations. The Lerner index shows the percentage difference between price and the marginal cost (indicating the level of the mark up) and just like Θ is bounded between 0 and 1 where $L=0$ implies a competitive market while $L=1$ indicates a monopolistic market structure.

3.0. Estimation Procedures and Data

The industry's cost function is assumed to be of the Generalized Leontief form while the output demand is taken to be Cobb-Douglas in nature. To satisfy industry aggregation, marginal processing costs are assumed to be constant across all firms while demands are assumed to be homogeneous of degree zero. To avoid singularity of the estimated covariance matrix that arises since the share dependant variables add up to unity, we drop one input (energy) and assume that the industry utilizes three inputs X_L labour, X_K capital and X_M material input (growers seed).

Let the cost function be represented as;

$$(10) \quad C = \sum \beta_i W_i + Y \sum \sum \beta_{ij} (W_i W_j)^{1/2}, \quad ij = K, L, M$$

Additionally, a Cobb-Douglas consumer demand function is specified as;

$$(11) \quad \ln Y = \alpha + \eta \ln (P/d) + \gamma \ln (Z/d) + \xi \ln (Q/d) + \mu_i$$

Where d is the consumer price index, Z is the price of the substitute (commercial maize) and Q is per capita Gross Domestic Product (GDP) that is used as a proxy for expenditure.

The input demands and the pricing equation in the model can therefore be given by;

$$(12) \quad X_K/Y = \beta_{KK} + \beta_{KL} (W_L/W_K)^{1/2} + \beta_{KM} (W_M/W_K)^{1/2} + \mu_k$$

$$(13) \quad X_L/Y = \beta_{LL} + \beta_{KL} (W_K/W_L)^{1/2} + \beta_{LM} (W_M/W_L)^{1/2} + \mu_l$$

$$(14) \quad X_M/Y = \beta_{MM} + \beta_{KM} (W_K/W_M)^{1/2} + \beta_{LM} (W_L/W_M)^{1/2} + \mu_m$$

$$(15) \quad P = (\beta_{KL} (W_K W_L)^{1/2} + \beta_{KM} (W_K W_M)^{1/2} + \beta_{LM} (W_L W_M)^{1/2}) / [1 + \theta/\eta] + \mu_p$$

In this study, we assume that θ is constant and hence $\theta = \Phi$ and estimate a system of 5 equations (11 through 15) with 11 coefficients.

Since equation 15 is non-linear, the structural model is estimated using a Seemingly Unrelated Regression (SUR) approach in the SHAZAM econometric software. We test the null hypothesis that $H_0: \Theta = 0$ and measure the index of industry oligopoly power as defined by $\bar{L} = \Theta / \eta$. In addition, Θ and \bar{L} are hypothesized to be positive bounded between 0 and 1.

The estimation included a constant for the output demand and a disturbance term to account for those other variables that may be relevant in explaining these relationships. The output demand is measured as the quantity of certified seed consumed based on the Marshallian theoretical concept that quantity demanded is a function of prices and income and is adjusted to cater for measurement and aggregation problems. Among the independent variables, per capita GDP was chosen to characterize individual purchasing power and hypothesized to positively influence the quantity demanded.

The input demands are estimated as functions of relative prices. These factor demands are typically measured as shares of the total costs of production. However, since data on production costs was lacking, the factor shares were estimated as shares of the total value of production which proxies costs in this study. The factor shares were then specified as the cost of a particular input divided by the total value of production (total revenue). In the estimation, we assume that the cost function and the share equations are stochastic to account for technical and optimization errors respectively.

Own prices are hypothesized to have negative demand relationships while prices of substitutes and compliments would have positive and negative effects on quantity demanded respectively. The estimation of the pricing equation is nonlinear and is measured as a function of the marginal costs divided by one minus a ratio of the conjectural variations elasticity to the absolute demand elasticity. The estimation process imposes symmetry for all cross price elasticities and therefore limits the number of cross elasticities to equal the number of input demands estimated.

3.1. Data.

Annual time series data from Economic Surveys compiled by the Central Bureau of Statistics, Kenya (CBS) and the MOA reports for the period 1980 – 2000 was used in this study. The Kenya Institute of Public policy Research and Analysis (KIPPRA) has compiled this data into an Agricultural Data Compendium. The data used in this study consists of the quantity of certified seed maize planted per year, industry sales of certified seeds, per capita GDP, prices, quantity indexes for capital, labour and growers seed (material input) and a price deflator. All current prices are recorded in Kenya shillings per kilogram while agricultural wages are given per month. Interest rate data was collected from the Central Bank of Kenya.

The endogenous variables considered included the consumer demand for certified seed maize (Kgs), input factor shares and seed retail price. These constituted the dependent variables for the 5 equations estimated. The exogenous variables for the output demand included, own price, price of substitutes (commercial grain) and per capita GDP. All prices are deflated using the CPI (1982 = 100) and the equation was estimated in logarithmic form.

The independent variables for the factor demands included own prices and relative price ratios. The factor shares were calculated as the cost of the inputs relative to the total value of output and the square roots of the relative price ratios were taken before estimation. The data is then split into two periods 1980 – 1995 and 1996 – 2000 and the levels of market power before and after liberalization of the sector are compared. However, the comparison between the periods before and after liberalized yielded insignificant results and is therefore dropped from the discussion of the results.

6.0. Results

The estimated parameter coefficients, t - ratios and other relative statistics from the SUR regression model are presented in table 1. In general, the estimated own price demand relationships conform to economic theory except in the case of labour and capital where unexpected positive own price relationships were reported. The asymptotic t-ratios also indicate that all own price elasticities for the consumer and input demands were significant at least at the 10 percent level. However, the cross price elasticities in all cases were insignificant while income elasticity was negative and insignificant perhaps due to the low levels of purchasing power in the country. All estimates were corrected for first order autocorrelation.

Table 1. Parameter Estimates of the full equation system.

Parameter	Parameter value	t-ratio
α	20.313	7.859
η	-1.549	-1.309
γ	0.069	0.515
ξ	-0.089	-0.495
β_{KK}	0.055	2.865
β_{LL}	0.000007	5.305
β_{MM}	-0.0108	-4.852
β_{KL}	-0.000014	-0.340
β_{KM}	0.0012	0.757
β_{LM}	0.00037	0.537
Θ	0.702	1.109
L	0.453	-

The own price elasticity of demand for certified seed was estimated at -1.549 indicating that farmers are highly sensitive to price changes and any small price increase would drive them away from certified seeds. Perhaps the elastic demand could explain the low levels of certified maize seed use in the country in spite of their ready availability on the market. The sensitivity to price changes was compounded by the income elasticity that was negative but insignificant presupposing that certified seed maize is an inferior commodity. It is therefore not surprising that farmers in Kenya substitute commercial maize grain for certified seed maize though this cross price elasticity was not significant.

The average conjectural variations elasticity was estimated at 0.702 . This elasticity was assumed to be constant throughout the entire period and was significantly different from zero at the 10 percent level. The hypothesis of price taking behaviour ($H_0: \Theta = 0$) is therefore rejected implying that the seed processing industry in Kenya does not behave competitively. This elasticity is high when compared to those reported by studies such as Lopez, Schroeter, Azzam and Pagaulatos; and Bhuyan and Lopez. However, the current study may not be comparable to these studies because they analysed processed food industries in developed countries.

The ratio of Θ to η was used to compute the Lerner index that on average was 0.453 . This index indicates a substantial degree of oligopoly power in the industry and is also significant when considering that Θ is significant. The Lerner index supports the findings from Θ and is comparable to the estimates of the earlier studies discussed.

An analysis of the structure of the industry in 2004 by the ministry of agriculture indicated that the market leader (KSC) controlled over 86 percent of the market. In the same year, the leading four firms share of the market was 95 percent. These market shares indicate high concentration ratios and support the claim that the industry exerts market power. Unfortunately, market share data was only available for one year and as a result the concentration ratio (Herfindahl index) for all the years could not be computed.

Table 2 presents the estimated factor demand elasticities. The material (growers seed) own price elasticity was estimated at – 0.719 and was significant at the one percent level. The negative own price elasticity conformed to economic theory and the maintained hypothesis in this study. This inelastic demand may reflect the type of contractual arrangements that the processors make with growers.

Table 2. Estimated Factor Demand Elasticities^a

Elasticity	Capital	Labour	Material
Capital	0.928	-24.600	1.4870
Labour	-0.0001	0.709	0.0263
Material	0.002	6.660	-0.719

^a The rows in this table should be read before the columns.

The own price elasticities for capital and labour were positive and significant at the one percent level. However, these elasticities had unexpected signs. The unexpected signs could be due to estimation errors though typically interest rates in Kenya have been high while labour is abundant and inexpensive.

The cross price elasticities indicated that capital and labour were compliments while the two could be substituted for the material input but were insignificant. The input elasticities can further be used to illustrate the behaviour of the cost function. The concavity of the Generalized Leontief cost function is ensured by positive values for β_{KM} and β_{LM} . Symmetry is imposed and confirmed by the signs of the cross partials while adding up is assumed. Further, positive values for β_{KK} , β_{LL} , β_{KM} and β_{LM} guarantee that the cost function is positive and monotonic and thus the cost function is well behaved.

7.0. Conclusions.

This paper examined the market behaviour of processing firms in the seed maize industry in Kenya using the New Empirical Institutional Organization framework. A system of five equations was used to estimate market consumer demand, input demands and a pricing behaviour equation. The estimated conjectural variations elasticities and Lerner indices indicated that the sector was anti-competitive in the period under analysis. These findings give compelling evidence to conclude that the assumption of price-taking behaviour is inappropriate for the seed maize processing industry in Kenya.

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