

LAYER PRODUCTION IN GHANA: A COST FUNCTION APPROACH

BY

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DEPARTMENT OF AGRICULTURAL ECONOMICS  
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**DECLARATION**

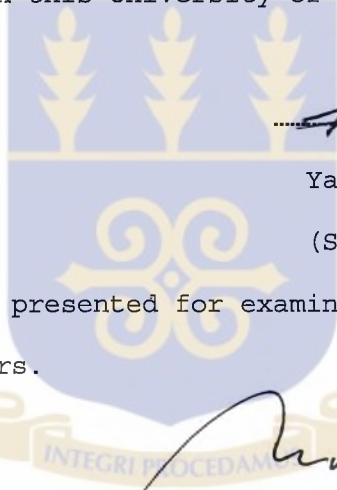
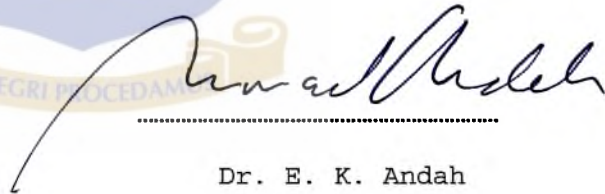
I Yaw Osei-Ofori, the author of this thesis do hereby declare that the work presented in this thesis titled 'Layer Production in Ghana: A Cost Function Approach' was done entirely by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon from September 1999 to June 2001.

This work has never been presented either in whole or in part for any degree in this University or elsewhere.

  
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This thesis has been presented for examination with our approval as supervisors.

  
  
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(Co-Supervisor)

**DEDICATION**

This piece is dedicated to my darling mum who is my role model, my lovely wife whose priceless contributions have brought this work to a successful end and finally to my two wonderful sons.



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Glory, honor and thanks, first and foremost go to God Almighty who gave me the strength, intellect to bring this work to a successful end.

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### ABSTRACT

This study tries to find out why the Ghanaian Poultry Industry is unable to produce enough poultry chicken to meet the local market demand which has led to the large importation of frozen chicken for the period 1988-1999. It determines how responsiveness major poultry inputs such as vaccines, feed, labor and institutional credit are to price change and the economies of scale of layer production in the poultry industry.

The study therefore estimates parameters of the input variables from the cost function and cost share equations, Allen Partial Elasticities of Substitution between inputs. These estimations are used in computing own price elasticities of demand for the poultry inputs, cross price elasticities of factor demand and scale elasticities in layer production over the period 1988-1999.

The study also sought to determine what production function that best describes layer production in the Ghanaian Poultry Industry.

The study's empirical econometric results indicate that a production function, which is characterized by non-homotheticity, non-homogeneity, non-unitary

elasticities of substitutions, and non Cobb-Douglas model is required to adequately represent the production of layers by the Ghanaian Poultry Industry implying no restrictions on the production function. It is therefore a Constant Elasticity of Substitution production function.

Inputs are found to be highly elastic which means that when their price rise the quantity demanded drastically falls. The relatively high price elasticities of the inputs indicate non-optimum production by poultry firms hence inability of meeting the market's demand.

Layer production in the Poultry Industry exhibited both economies and diseconomies of scale over the study period 1988-1999. There was eight years of positive economies of scale with only four years of diseconomies of scales.

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## CHAPTER ONE

### INTRODUCTION

#### Background and Problem Statement

The term 'poultry' is used to designate those species of birds which render man an economic service and reproduce freely under his care. It includes chicken, turkeys, ducks, geese, swans, guineas, pigeons, peafowls, pheasants, and ostriches and refers to them whether dressed or alive.<sup>1</sup>

Poultry products are used extensively in industries. For instance, eggs are used in the preparation of culture media for the growth of some species of bacteria and fertile eggs used in the preparation of vaccines. Chickens are being used extensively in biological research work because they are inexpensive and readily available, reproduce freely, have a sensitive metabolism and are good laboratory research materials.<sup>2</sup>

The exact ancestry of the chicken is obscured by the antiquity of its origin. For more than five thousand years the domesticated fowl has been one of man's benefactors. Authorities agree quite generally that the red jungle fowl, *Gallus bankiva*, was one of the ancestors. More recent investigations suggest that at least four species of the

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<sup>1</sup> Winter, A. R. and Funk, E. M., Poultry Science and Practice, ed. R. W. Gregory. Published by J. B. Lippincot Company, New York, 1956 p.3.

<sup>2</sup> Ibid. p.7.

jungle fowl may have contributed to the development of the domestic fowl.<sup>3</sup>

Chicken and turkeys dominate the world poultry industry with broiler (young or fryer) chicken and turkeys providing most of the world's production and consumption of poultry meat.<sup>4</sup> Broilers and layers are specialized types of chicken developed through the application of genetics with the former being efficient in meat production and the latter efficient in the production of larger number of eggs<sup>5</sup>; but in Ghana layers produce both eggs and about 60% of the poultry meat.<sup>6</sup>

Poultry have high turnover and if produced under efficient conditions, three batches of broilers can be raised in a year with the same facilities. Nevertheless, poultry being monogastric physiologically as man is tend to compete directly with man for the same basic food commodities especially maize and fish. The competition is particularly severe in a developing country like Ghana, where per capita food production is low and the major staple food is maize.

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<sup>3</sup> Ibid. p. 21

<sup>4</sup> Food and Agricultural Organization, 1985, Rome.

<sup>5</sup> Taylor, R. E. and Bogart R., 'The Poultry Industry' in Scientific Farm Animal Production, (Macmillan Company, 1988, New York). p.88

<sup>6</sup> Government of Ghana, National Livestock Services Project, Staff Appraisal Report, Accra, 1992, pp 9-10.

In order to satisfy higher demand for animal protein, notably poultry products, large-scale farms were established mainly in urban areas and between 1970 to 1980 an extensive poultry infrastructure was established in the country.<sup>7</sup>

The poultry industry in Ghana consists of a traditional sector, which supplies poultry meat and eggs for a lot of the rural people and a commercial sector that depends on imported inputs for production. The commercial poultry industry is dominated by egg production that gives a by-product (old layers), which contributes about 60% of poultry meat in Ghana.<sup>8</sup> Achieving food security requires the use of productivity enhancing inputs in the livestock and poultry industries, and not only in the crop production sub-sector. These inputs include hybrid layer and broiler strains of day-old-chicks (DOCs), raw materials (ingredients) to formulate feed, drugs, premixes and vaccines.

The Poultry Industry in Ghana has gone through a cycle of rapid growth. Annual output of birds rose from 3.1million (3.1M) in 1970 to a peak of 9.7 million (9.7M) in 1982 before easing to 8.8 million (8.8M) in 1989 and

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<sup>7</sup> Koney, E. B. M., Poultry Health and Production. The Adventist Press, 1993, Accra, p.1

<sup>8</sup> Government of Ghana, National Livestock Services Project, opcit, pp. 9-10

then rising again from 9.9 million (9.9M) in 1990 to 15.54 million (15.54M) in 1998 (Table 1.1).

Table 1.1: Poultry Population in Ghana 1970 - 1998 (Million Heads)

Year	Number
1970	3.1
1971	4.0
1972	4.0
1973	3.3
1974	4.2
1975	3.8
1976	3.8
1977	4.6
1978	6.3
1979	7.3
1980	7.5
1981	N/A
1982	N/A
1983	N/A
1984	N/A
1985	N/A
1986	N/A
1987	8.2
1988	8.0
1989	8.7
1990	9.7
1991	10.57
1992	11.23
1993	12.17
1994	12.29
1995	13.08
1996	14.59
1997	14.83
1998	15.54

Source: Ministry of Food and Agriculture, Veterinary Services Department, Accra.

N/A: Not Available.

The poultry industry has some excellent infrastructure consisting of about twenty-three commercial feed-mills with a capacity of over two hundred thousand metric tones (200,000 Mt) of feed per month and eleven commercial

hatcheries with a potential to produce twenty-five million (25M) day-old-chicks per year in the country.<sup>9</sup>

Prior to liberalization in 1990 and deregulation, government was the sole procurer of all agricultural inputs, as they could not rely on the tender and undeveloped private sector to deliver such inputs to achieve a sustainable food security. Government realized in the mid 1980s that it could no longer sustain the financial burden associated with subsidizing agricultural inputs and the guaranteeing of product prices for the farmers. A policy reform was therefore implemented in 1990 with the aim of liberalizing trade and privatising the agricultural inputs market. The implementation of this policy saw the exit of government in the importation and marketing of day-old-chicks, drugs and poultry feed and the entry of private firms into the market.

Poultry products alone contributed about ₵60 billion to Gross Domestic Product (GDP) in 1993 as against ₵9 billion for livestock.<sup>10</sup> As noted by Okantey, Ghana can

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<sup>9</sup> Koney, p. 1 Opcit

<sup>10</sup> Livestock Planning and Information Unit. Analysis of Meat and Animal Product Imports. Occasional Report, No. 1, 1994, Accra.

solve a national problem of protein deficiency in diets through poultry production.<sup>11</sup>

Although, the Ghanaian poultry industry has seen some growth yet Boa-Amponsem observed that from 1984 to 1986, the country produced less than 20 percent of its meat requirement with poultry contributing only 2.5 percent.<sup>12</sup> This led to a large importation of poultry meat and products into the country, which is enough to indicate that local production is not responding to the market demand. Ministry of Food and Agriculture (MOFA) data indicates that only 23 percent of the estimated total meat demand of about 195,000 Mt comes from domestic sources.<sup>13</sup> This implies that the excess demand is met through imports. In 1997, more than ₵88 million was expended on the importation of frozen whole chicken and this figure increased to ₵2.8 billion in 1998.

Given the potential high turnover of poultry production per year and the liberalization of the sale of poultry inputs, why is local production not responding to the local market demand?

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<sup>11</sup> Okantey, S. A. (1995) 'The Poultry Industry in Ghana: Past, Present and Future' in Osei (1995) (ed). The Poultry Industry in Ghana: Any Future? Proceedings of the First Anniversary Symposium of the Ghana National Association of Poultry Farmers (GNAPF) held at the Osu Children's Home, Accra.

<sup>12</sup> Boa-Amponsem, K. (1988), 'Status of the Poultry Industry in Ghana'. First Annual General Meeting of Ghana Society of Animal Production. Accra. p.10.

<sup>13</sup> Osei, S. A., 'The Poultry Industry in Ghana – Any Future?: An Overview' in 'The Poultry Industry in Ghana: Any Future?', ed. S. A. Osei. ( Proceedings of the First Anniversary Symposium of the Ghana National Association of Poultry Farmers ( GNAPF ) held at the Osu Children's Home, 1995, Accra.

## Objectives

The main objective of the study is to find out why local production of poultry meat is not responding to the local market demand. To attain this major objective some specific objectives are pursued. These include:

- ξ the determination of the responsiveness of poultry inputs to price;
- ξ the determination of economies of scale of layer production in the Ghanaian Poultry Industry.

In pursuance of these specific objectives, the following estimations are done:

- ξ the estimation of parameters of the input variables from the cost function and cost share equations;
- ξ the estimation of Allen Partial Elasticities of Substitution between inputs;
- ξ the estimation of own price elasticities of demand for the major poultry inputs;
- ξ the estimation of cross price elasticities of factor demand, and
- ξ the estimation of scale elasticities in layer production over the period 1988-1999.

### **Method of Analysis**

The structure of production is analyzed using the cost function approach. The quantification of the dual cost function is achieved by the joint estimation of the total cost function and the cost share equations as a multivariate regression system using the translog functional form. The system of equations forms a seemingly unrelated regression model and the parameters are estimated using maximum - likelihood approach.

The selection of model is done by testing different hypotheses when various restrictions are imposed on the parameters of the model using the Wald's test.

The dual cost function is characterized by the form,

$$C = C(P_{IC}, P_L, P_F, P_V, Q) \quad (1.1)$$

Where  $P_{IC}$  = the yearly price of institutional credit,

$P_L$  = the yearly price of labor,

$P_F$  = the yearly price of feed,

$P_V$  = the yearly price of vaccines and

$Q$  = annual total output.

### **Relevance of study**

The estimation of a production function or cost function is a useful tool for overcoming the problems of

casual observation, and providing for the better understanding of the production structure of a farm by way of making relationship among variables more explicit.

A cost function analysis is capable of providing quantitative insights into the response of producers to rising input prices, substitution possibilities between inputs and scale elasticities. Such information may aid poultry firms in making the best decisions concerning the use of scarce resources in production activities.

Moreover, the estimated values of the cost function might be useful for future planning purposes because they provide an indication of the increase in output that could be expected with some decrease in the cost of production. In addition, an increase in the production of layers will lead to the meeting of market demand, and therefore (all things being equal) an increase in poultry meat, which will enhance the protein supplement of the individual.

#### **Scope and Limitation**

This study is limited to intensive large-scale poultry firms in the Greater Accra and Ashanti Regions because commercial poultry farms are concentrated in these two regions, technology for intensive commercial poultry production exists and they supply the largest percent of

poultry meat. The study is restricted to live layers instead of broilers because the former is mostly produced all year round by most farms for eggs and meat and contributes about 60% of poultry meat in Ghana whilst the latter is produced by fewer farmers mainly on festive occasions on a lower scale.

The translog cost function, despite its flexibility, is not without problems. In using this model two estimation problems are envisaged. Firstly, as the number of inputs increase, the number of parameters to be estimated also increase rapidly. Secondly, the additional terms are squares and cross products of input variables, thus making multicollinearity a difficult problem.

Future studies could use earnings in the agriculture Sub-sector instead of average monthly earnings as an appropriate proxy for the price of labor.

Due to the small size of the dataset (1988-1999), the model selection procedure, which involves iterating on one small dataset, is prone to the data-mining problem.

## **Organization**

Chapter Two is devoted to Review of Literature. The theoretical method of estimation of the parameters and model specification of the cost function falls under

Chapter Three. Chapter Four gives an overview of the Ghanaian Poultry Industry. Data analysis and parameter estimations find a placement in Chapter Five. In Chapter Six, conclusions are drawn on the estimated parameters and policy recommendations presented.

## CHAPTER TWO

### LITERATURE REVIEW

#### Introduction

This Chapter is to purposely give an exposition of an econometric method for modeling producer behavior. Important innovations in specifying econometric models have arisen from the dual formulation of the theory of production. The main advantage of dual formulation is the specification of demand and supply functions as explicit functions of relative prices. By using duality in production theory, these functions can be specified without imposing arbitrary restrictions on patterns of production.

#### Theoretical Literature

The economic theory of production presented in classic treatises as Hick's *Value and Capital*<sup>14</sup> and Samuelson's *Foundations of Economic Analysis*<sup>15</sup> is based on the maximization of profit, subject to a production function. The objective of this theory is to characterize demand and supply functions, using the restrictions on producer behavior that arise from optimization. To achieve this objective the implicit function theorem is employed as the

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<sup>14</sup> Hicks, J. R. *Value and Capital*. 2<sup>nd</sup> ed. (1<sup>st</sup> ed. 1939),: University Press, 1946, Oxford.

main analytical tool.<sup>16</sup> The use of this theorem is not convenient for econometric application. The traditional approach, which makes assumption that the production function is additive and homogeneous was originated by Cobb and Douglas<sup>17</sup> and was used in empirical research by the latter and his associates for almost two decades.<sup>18</sup>

Limitations of this approach was made apparent by Arrow, Chenery, Minhas, and Solow<sup>19</sup> (ACMS), who pointed out that the Cobb-Douglas production function imposes a priori restrictions on patterns of substitution among inputs. In particular, elasticities of substitution among all inputs must be equal to unity.

The constant elasticities of substitution (CES) production function introduced by ACMS adds flexibility to the traditional approach by treating the elasticity of substitution as an unknown parameter.<sup>20</sup> However, the CES production function retains the assumptions of additivity and homogeneity and imposes very stringent limitations on patterns of substitution.

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<sup>15</sup> Samuelson, P. A. () *Foundation of Economic Analysis*. 2<sup>nd</sup> ed. (1<sup>st</sup> ed. 1947), Harvard University Press. 1983, Cambridge.

<sup>16</sup> This approach to production theory was employed by Carlson (1939), Frisch (1965), and Schneider (1934).

<sup>17</sup> Cobb, C. W. and P. H. Douglas (1928) "A Theory of Production", *American Economic Review*, March, 18(2), pp. 139-165.

<sup>18</sup> These studies are summarized by Douglas (1948), (1967), (1976).

<sup>19</sup> Arrow, K. J., H. B. Chenery, B. S. Minhas and R. M. Solow (1961) "Capital-Labor Substitution and Economic Efficiency", *Review of Economic and Statistics*, august, 63(3), pp. 225-247.

McFadden<sup>21</sup> and Uzawa<sup>22</sup> have shown, essentially, that elasticities of substitutions among all inputs must be the same.

The limitations of traditional approach to econometric modeling have been overcome by the dual formulation of production theory. This dual formulation was introduced by Hotelling<sup>23</sup> and later revived and extended by Samuelson<sup>24</sup> and Shepard.<sup>25</sup>

The main features of the dual formulation are the characterization of the production function by means of a dual representation such as a price or cost function and also to generate explicit demand and supply functions as derivatives of the price or cost function.<sup>26</sup> The dual formulation of production theory embodies the same implications of optimizing behavior as the theory presented by Hicks<sup>27</sup> and Samuelson.<sup>28</sup> However, the dual formulation has

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<sup>20</sup> Econometric studies based on CES production function have been surveyed by Griliches (1967), Jorgenson (1974), Kennedy and Thirlwall (1972), Nadiri (1970), and Nerlove (1967).

<sup>21</sup> McFadden, D. (1963) "Further Results on CES Production Functions", *Review of Economic Studies*, June, 30(2), pp. 83, 73-83.

<sup>22</sup> Uzawa, H. (1962) "Production Functions with Constant Elasticity of Substitution", *Review of Economic Studies*, October, 29(4), pp. 81, 291-299.

<sup>23</sup> Hotelling, H. S. (1932) "Edgeworth's Taxation Paradox and the Nature of Demand and Supply Functions", *Journal of Political Economy*, October, 40(5), pp. 577-616.

<sup>24</sup> Samuelson, P. A. (1953-1954) "Prices of Factors and Goods in General Equilibrium", *Review of Economic Studies*, 21(1), pp.54, 1-20. and Samuelson, P. A. (1960) "Structure of a Minimum Equilibrium System", in: R. W. Pfouts, ed., *Essays in Economics and Econometrics*. Chapel Hill: University of north Carolina Press, pp. 1-33.

<sup>25</sup> Shepard, R. W. *Cost and Production Functions. and Theory of Cost and Production Function*. Princeton University Press, 1953 and 1970. Princeton:

<sup>26</sup> Surveys of duality in the theory of production are presented by Diewert (1982) and Samuelson (1983).

<sup>27</sup> Hicks, *opcit*.

<sup>28</sup> Samuelson, *opcit*

a crucial advantage in the development of econometric methodology. Demand and supply functions can be generated as explicit functions of relative prices without imposing the arbitrary constraints on production patterns required in the traditional methodology. In addition, the implications of production theory can be incorporated more readily into an econometric model.

### **Price and Cost Function**

Producer equilibrium implies the existence of a price function, giving the price of output as a function of the prices of inputs and the level of technology. The price function is dual to the production function and provides an alternative and equivalent description of technology.

A cost function is so referred to when the total cost is defined as the sum of expenditures on all inputs and the minimum value of cost can be express as a function of the level of output and the prices of all inputs.

### **Empirical Application of Duality Formulation**

Functional forms for cost functions have been developed by researchers over the years, which have two attractive features: they imply derived demand equations which are linear in parameters and at the same time they

represent very general production structures, even though they cannot be derived from explicit production functions. Several specific flexible functional forms have been proposed. A partial list of these includes the Generalized Leontief (GL), the Translog (TL), the Generalized Cobb-Douglas (GCD), the Generalized Square Root Quadratic (GSRQ), and the Generalized Box-Cox (GBC).<sup>29</sup> For many of the production and price frontiers employed in econometric studies of production the translog frontiers provide accurate global approximations.<sup>30</sup> The translog function can exhibit non-constant marginal productivity, that is increasing, decreasing and negative marginal products, singularly, in pairs, or all three simultaneously. As a result, this form of production function is useful in describing input-output data encompassing all the three traditional stages of production with increasing positive, and declining positive and negative marginal products. It also permits variable elasticity of production and variable elasticity of substitution over the range of inputs.

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<sup>29</sup> The GL, GCD and GSRQ forms were introduced by Diewert ( 1971, 1973, 1974 ). The TL was developed by Christensen, Jorgensen and Lau ( 1971, 1975 ). Berndt and Khaled proposed the GBC form.

<sup>30</sup> Christensen, L. R. et al. ( 1973 ), 'Transcendental Logarithmic Production Frontiers', Review of Economics and Statistics LV, 29.



Wales,<sup>31</sup> in his Monte Carlo study to investigate the ability of GL and TL forms to represent two-commodity homothetic preference exhibiting a constant elasticity of substitution, found that in some cases the GL performed better, whilst in other cases the TL performed better.

Berndt, et. al,<sup>32</sup> using Canadian expenditure data to estimate three-commodity non-homothetic GL, TL, and GCD forms, on the basis of better fit and conformity to neoclassical restrictions, concluded that the TL form was the preferred form for their data set.

Christensen and Greene employed the Translog cost function,<sup>33</sup> in their study of economies of scale in the United States (U.S.) electric power generation because the function places no 'a priori' restrictions on substitution possibilities among the factors of production. It also allows scale economies to vary with the level of output and this feature is essential to enable the unit cost curve to attain the classical U shape. Berndt and Wood,<sup>34</sup> in their attempt to characterize more completely the structure of

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<sup>31</sup> Wales, T. J. ( 1977 ), 'On the flexibility of flexible functional forms: An empirical approach', *Journal of Econometrics* 5, 183-193.

<sup>32</sup> Berndt, E. R. et al. ( 1977 ), 'Flexible functional forms and expenditure distribution: An application of Canadian consumer demand functions', *Int. Econ. Rev.* 18, 651-675.

<sup>33</sup> Christensen, L. R. and Greene, W. H. ( 1976 ), 'Economies of Scale in U. S. electric power generation', *Journal of Political Economy* 84 (4), 655-676.

<sup>34</sup> Berndt, E. R. and Wood, D. O. ( 1975 ), 'Technology, prices, and derived demand for energy', *Review of Economics and Statistics* 57, 259-268

technology in United States manufacturing, arbitrarily chose to employ the translog cost function.

Bigsby <sup>35</sup>, gave the following reasons for using the translog function in the study of production structure of the Australian saw milling industry: the estimates of the elasticity of substitution and technological change bias can be obtained even though it may not be possible to specify the exact form for the production function: the elasticity of substitution does not need to be restricted to any particular value or to be restricted to any particular value over time; the assumption of constant returns to scale is not necessary; the bias of technological change can be calculated rather than be assumed to be Hicks-neutral; and the rate of technological progress can be estimated. The translog cost function was used by Nautiyal and Singh,<sup>36</sup> Singh and Nautiyal,<sup>37</sup> Martinello,<sup>38</sup> and Sherif<sup>39</sup> in studies of the pulp, paper and

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<sup>35</sup> Bisby, H. R. ( 1994 ), 'Production structure and the Australian saw-milling industry', *Australian Journal of Agricultural Economics* 38(3), 271-288.

<sup>36</sup> Nautiyal, J. B. and Singh, B. K. ( 1985 ), 'Production structure and derived demand for factor inputs in the Canadian lumber industry', *Forest Science* 31(4),871-881. (1986), 'Long-term productivity and factor demand in the Canadian pulp and paper industry', *Canadian Journal of Agricultural Economics* 34, 21-44.

<sup>37</sup> Singh, B. K. and Nautiyal, J. B. ( 1986 ), 'A comparison of observed and long-run productivity of and demand for inputs in the Canadian lumber industry', *Canadian Journal of Forest Research* 16, 443-455.

<sup>38</sup> Martinello, F. ( 1987 ), 'Technology, cost structure and rates of technical progress in the British Columbia Coast lumber industry', Working paper, Economics Branch, Canadian Forest Service, Ottawa.

<sup>39</sup> Sherif, F. ( 1983 ), 'Derived demand for factors of production in the pulp and paper industry', *Forest Products Journal* 33(1), 45-49.

sawmilling industries in Canada and by Stier<sup>40</sup> for the United States.

Denny and May<sup>41</sup> disaggregated labor input into white collar and blue collar labor, capital input between equipment and structures and grouped all other inputs into a single aggregate input for Canadian total manufacturing, using a translog functional form.

Field and Grebenstein<sup>42</sup> analyzed substitution among physical capital, working capital, labor, and energy for ten two-digit U.S. manufacturing industries on the basis of translog price functions, using cross section data for individual states for 1971.

Cameron and Schwartz,<sup>43</sup> Denny, May, and Pinto,<sup>44</sup> Fuss,<sup>45</sup> and McRae<sup>46</sup> constructed econometric models of substitution among capital, labor, energy, and materials inputs based on translog functional forms for manufacturing

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<sup>40</sup> Stier, J. C. ( 1980 ), 'Estimating the production technology in the U. S. forest products industries', *Forest Science* 26(3), 471-482., Stier, J. C. ( 1985 ), 'Implications of factor substitution, economies of scale, and technological change for the cost of production in the U. S. pulp and paper industry', *Forest Science* 31(4), 803-812.

<sup>41</sup> Denny, M. and J. D. May (1978) "Homotheticity and Real Value-Added in Canadian manufacturing", in: M. Fuss and D. McFadden, eds., 2, pp. 53-70.

<sup>42</sup> Field, B. C. and C. Grebenstein (1980) "Substituting for Energy in U.S. Manufacturing", *Review of Economic and Statistics*, May, 62(2), pp.207-212.

<sup>43</sup> Cameron, T. A. and S. L. Schwartz (1979) "Sectoral Energy Demand in Canadian Manufacturing Industries", *Energy Economics*, April, 1(2), 112-118.

<sup>44</sup> Denny, M. and J. D. May and C. Pinto (1978) "The Demand for Energy in Canadian Manufacturing: Prologue to an Energy Policy", *Canadian Journal of Economics*, May, 11(2), pp.300-313.

<sup>45</sup> Fuss, M. (1977a) "The Demand for Energy in Canadian Manufacturing: An Example of the Estimation of Production Structures with Many Inputs", *Journal of Econometrics*, January, 5(1), pp. 89-116.

<sup>46</sup> McRae, R. N. (1981) "Regional Demand For Energy By Canadian Manufacturing Industries", *International Journal of Energy Systems*, January, 1(1), pp.38-48.

in Canada. Friede<sup>47</sup> analyzed substitution among capital, labor, energy, and materials inputs for total manufacturing in the Federal Republic of Germany. He assumed that technical change is neutral and utilized a translog price function, disaggregated the results to the level of fourteen industrial groups, covering the whole of West German economy, separated materials inputs into two groups- manufacturing and transportation services as a group and other non-energy inputs as a second group.

Ozatalay, Grubaugh, and Long<sup>48</sup> modeled substitution among capital, labor, energy and materials inputs, on the basis of a translog price function using time series data for total manufacturing for the period 1963-74 in seven countries.

Friedlander and Spady<sup>49</sup> disaggregated transportation services between trucking and rail service and grouped other inputs into capital, labor and materials inputs using cross section data for ninety-six three-digit industries in the U.S. for 1972 employing translog functional form with fixed inputs.

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<sup>47</sup> Friede, G. (1979) Investigation of Production Behavior in the Federal Republic of Germany Using the Translog Price Function. Cambridge: Oelgeschlager, Gunn and Hain.

<sup>48</sup> Ozatalay, S., S. S. Grumbaugh and T. V. Long III, "Energy Substitution and National Energy Policy", *American Economic Review*, May, 69(2), pp. 369-371.

<sup>49</sup> Friedlaender, A. F. and R. H. Spady (1980) "A Derived Demand Function for Freight Transportation", *Review of Economic Statistics*, August, 62(3), pp. 432-441.

Humphrey and Wolkowitz<sup>50</sup> grouped energy and materials inputs into a single aggregate input in a study of substitution among inputs in several U.S. manufacturing industries utilizing translog price functions.

Berndt and Wood<sup>51</sup> generated an econometric model, by expressing the price of aggregate inputs as a function of the prices of capital, labor, energy, and materials inputs of the total manufacturing sector of the U.S. economy and found that capital and energy inputs are complements, while all other pairs of inputs are substitutes.

Employing the Fourier functional model for price function, Elbadawi, Gallant, and Souza<sup>52</sup> estimated price elasticities of demand for inputs.

In using the translog parametric form, Woodland<sup>53</sup> tested separability and modeled substitution among two types of capital input and two types of labor inputs for the U.S. total manufacturing.

Parameter estimates on the patterns of substitution among industries in a study done by Jorgenson and

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<sup>50</sup> Humphrey, D. B. and B. Wolkowitz (1976) "Substituting Intermediates for Capital and Labor with Alternative Functional Forms: An Aggregate Study", *Applied Economics*, March, 8(1), pp. 59-68.

<sup>51</sup> Berndt, E. R. and D. O. Wood (1975) "Technology, Prices, and the Derived Demand for Energy", *Review of Economics and Statistics*, August, 57(3), 376-384.

<sup>52</sup> Elbadawi, I., A. R. Gallant and G. Souza (1983) "An Elasticity Can Be Estimated Consistently Without a Prior Knowledge of Functional Forms", *Econometrica*, November, 51(6), pp.1731-1752.

<sup>53</sup> Woodland, A. D. (1975) "Substitution of Structures, Equipment, and Labor in Canadian Production", *International Economic Review*, February, 16(1), pp. 171-187.

Fraumeni<sup>54</sup> revealed that the elasticities of the shares of capital with respect to the price of labor are nonnegative for thirty-three of the thirty-five industries, so that the shares of capital are non-decreasing in the price of labor for these thirty-three sectors. Similarly, elasticities of the share of capital with respect to the price of energy are nonnegative for thirty-four industries and elasticities with respect to the price of materials are nonnegative for all thirty-five industries. The share elasticities of labor with respect to the prices of energy and materials are nonnegative for nineteen and for all thirty-five industries, respectively. Finally, the share elasticities of energy with respect to the price of materials are nonnegative for thirty-five industries.

Jorgenson<sup>55</sup> employed translog price functions with capital, labor, two kinds of energy, and materials inputs to model substitution and technical change for thirty-five industries of the U.S., dividing energy inputs between electricity and non-electrical energy inputs and found that technical change is electricity-using and non-electrical

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<sup>54</sup> Jorgenson, D. W. and B. M. Fraumeni (1981) "Relative Prices and Technical Change", in; E. R. Berndt and B. C. Field, eds., 17-47; revised and reprinted in : W. Eichhorn, R. Henn, K. Neumann and R. W. Shepard, eds., 241-269.

<sup>55</sup> Jorgenson, D.W. (1984b) "The Role of Energy in Productivity Growth", in: J. W. Kendrick, ed., *International Comparisons of Productivity and Causes of the Slowdown*. Cambridge: Ballinger, 279-323.

energy-using for most U.S. industries. Stevenson<sup>56</sup> employed a translog total cost function incorporating output and time to analyze cross sections of electric utilities for 1964 and 1972.

Gollop and Roberts<sup>57</sup> used a similar approach to study annual data on eleven utilities in the U.S. for the period 1958-1975. The results were used to decompose the growth of the total cost among economies of scale, technical change, and growth in input prices. Griffin<sup>58</sup> modelled substitution among different types of fuel in steam electricity generation four cross sections of twenty OECD countries. Halvorsen<sup>59</sup> analyzed substitution among different fuel types, using cross section data for the U.S. in 1972.

Fuss<sup>60</sup> in his model-to-model substitution among inputs and economies of scale for seventy-nine steam generation plants for the period 1948-61 permitted the total cost function to differ ex ante, before a plant was constructed, and ex post, after the plant was in place, employing the generalized Leontief cost function with four

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<sup>56</sup> Stevenson, R> E. (1980) "Measuring Technological Bias", *American Economic Review*, March, 70(1), 162-173.

<sup>57</sup> Gollop, F. M. and M. J. Roberts (1981) "The Sources of Economic Growth in the U. S. Electric Power Industry", in: T. G. Cowing and R. E. Stevenson, eds., pp.107-145.

<sup>58</sup> Griffin, J. M. (1977b) "Interfuel Substitution Possibilities: A Translog Application to Pooled Data", *International Economic Review*, October, 18(3), pp. 755-770.

<sup>59</sup> Halvorsen, R. (1978) *Econometrics Studies of U.S. Energy Demand*. Lexington: Lexington Books.

<sup>60</sup> Fuss, M. (1977b and 1978) "The Structure of Technology Over Time: A Model for Testing the Putty-Clay Hypothesis", *Econometrica*, November, 45(8), pp.1797-1821. And "Factor Substitution in Electricity Generation: A Test of the Putty-Clay Hypothesis", in M. Fuss and D. McFadden, eds., 2, pp. 187-214.

input prices structures, equipment, fuel, and labor. Atkinson and Halvorsen<sup>61</sup> made use of the translog parametric form to test the effects of both rate of return regulation and fuel cost adjustment mechanism and for this purpose they analyzed cross section data for electric utilities in 1973. Gollop and Robertson<sup>62</sup> studied the effectiveness of regulations on sulfur dioxide emissions in the electric utility industry. They employed the translog cost function that depended on a measure of regulatory effectiveness. This measure was based on the legally mandated reduction in emissions and on the enforcement of emission standards. Gollop and Roberts analyzed cross sections of fifth-six electric utilities for each of the years 1973-1979 and employed the results to study the impact of environmental regulation on productivity growth.

#### **Advantages of Duality**

Binswanger,<sup>63</sup> and Sankhayan,<sup>64</sup> outlined the advantages of using the cost function instead of a production function in estimating production parameters, and stated that:

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<sup>61</sup> Atkinson, S. E. and R. Halvorsen (1980) "A Test of Relative and Absolute Price Efficiency in Regulated Utilities", *Review of Economics and Statistics*, August, 63(3), pp. 225-247.

<sup>62</sup> Gollop, F. M. and M. J. Roberts (1983) "Environmental Regulations and Productivity Growth: The case for Fossil-Fueled Electric Power Generation", *Journal Political Economy*, August, 91(4), pp. 654-674.

<sup>63</sup> Binswanger, H. P. ( 1974 ), 'A cost function approach to the measurement of factor demand and elasticities of substitution', *American Journal of Agricultural Economics* 56, 377-386.

<sup>64</sup> Sankhayan, p.85, opcit.

1. It is not necessary to impose homogeneity of degree one on the production process to arrive at estimation equations. Cost functions are homogeneous in prices regardless of the homogeneity properties of the production function, because a doubling of all prices will double the costs but will not affect factor ratios.
2. In general, the estimation equations have prices as independent variables rather than factor quantities, which, at the firm or industry level, are not proper exogenous variables. Entrepreneurs make decisions on factor use according to exogenous prices, which makes the factor levels endogenous decision variables.
3. If a production function procedure is used to derive estimates of elasticities of substitution of factor demand in the many - factor case, the matrix of estimates of the production function coefficients has to be inverted. This will inevitably exaggerate estimation errors. No inversion is necessary when a cost function is used.
4. In production function estimation, high multicollinearity among the input variables often causes problems. Since there is usually little

multicollinearity among factor prices, this problem does not arise in cost function estimation.

5. The researcher need not worry about the specific functional form of the production function.
6. Derivation of the input demand and product supply functions from the fitted production function is often quite difficult. On the contrary, the use of Shepard lemma helps in obtaining such estimations with relative ease when the cost function approach is used.

## CHAPTER THREE

### THE GHANAIAN POULTRY INDUSTRY

#### Introduction

The Ghanaian has over the years kept poultry either by one or the combination of two or more of the species. The birds are kept in a coop or a shelter where they spend the night, then in the morning provided with a handful of maize or sorghum and, for the rest of the day, they scavenge and pick up whatever comes their way. A member of the household is given the job of cleaning the coop or shelter each morning.

The indigenous bird population kept by the Ghanaian ranges between thirty to fifty or much less and this bird population is mostly chickens. In the southeast of Ghana, precisely in the Ada-Keta areas, the bird population is predominantly ducks whereas in the north they are both chickens and guinea fowls. In addition to these, some individuals may also have a few turkeys and pigeons. The cocks and hens mate indiscriminately. Thus a hen may be observed to hatch a brood of chicks that have different color plumage.

Diseases readily invade most of the birds which are poorly taken care of. However, a number of birds survive this invasion. The duck, on the other hand, is generally

properly fed with a mixture of corn chaff from the corn mill, fish and beach sand. The hens lay a few fertile eggs, on the average, ten or less in a clutch and sit to hatch. About twenty to thirty of such eggs are laid in a year.

### **History of the Poultry Industry**

In the late 1920's and in 1942 the Department of Animal Health established two breeding stations at Pong, Tamale and Pokuase, respectively which were to upgrade the local fowl.<sup>65</sup> This Department organised the first poultry exhibition in 1933 to show to the public the performance of crossbred chickens.<sup>66</sup> By 1937, these cross-breds had scattered throughout colonial Ghana. A number of independent backyard poultry farms sprang up on the coastal plains and were operated by farmers who had received training in poultry breeding, rearing and management from Pong Tamale.<sup>67</sup>

Commercial poultry production could be said to have started in 1952 with Ghana Egg Farm in a village near

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<sup>65</sup> Gold Coast, Department of Agriculture, Annual Report 1944-45 ( Accra, 1945 ). p. 1

<sup>66</sup> Gold Coast Farmer, ' The Poultry Exhibition in Accra ' ( Accra, 1934 ) p.162

<sup>67</sup> Gyasi, E. M. 'Economic Organization of the Poultry Industry of Ghana' Unpublished Dissertation 1970, p.14.

Accra<sup>68</sup> although by 1952, poultry husbandry was seriously being undertaken at Pokuase Agricultural Station.<sup>69</sup> Prior to this time, the country depended largely on the surrounding French colonies for poultry.

The Department of Agriculture in 1952 successfully implemented a poultry extension scheme, which served as an impetus to the rapid transformation from traditional way of rearing to large-scale commercial poultry farming. This was done through the importation and distribution of day-old-chicks to the farmers and a follow up with extension work. The first consignment of chicks was received from Denmark in that year but owing to delays in the transportation only a few survived. However, by the end of the same year about 5,600 chicks were delivered without delay therefore none died.<sup>70</sup> The Pokuase Station supplemented the chick imports by making available to farmers improved cross-bred or pure breeds and hatching eggs through its breeding programmes. The highest number of chicks imported in 1953 was 11,446 as officially recorded.<sup>71</sup>

In 1948, about 66,000 table birds were imported from Togo, Cote D'voire, United Kingdom, Netherlands and Israel.

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<sup>68</sup> William, G.E.S., 'Rural Poultry Development and Production System in Ghana' in: Rural Poultry in Africa, edited by E. B Soniaya ( Theila House Limited, Ile-Ife, 1990 ). p.155.

<sup>69</sup> La-Anyane, S., 'Poultry Marketing in Ghana', The Ghana Farmer 1969. Vol. XIII. No.2, p.50

<sup>70</sup> Gyasi, p.15, opcit.

<sup>71</sup> Gyasi, p.16, opcit.

However, by 1958 table bird imports had been reduced to half the 1948 figure.<sup>72</sup>

By 1959, expansion of the local industry begun with the direct involvement of private farmers in the importation of chicks as there was by then no foreign exchange control.<sup>73</sup> During that year more than 100,000 of the 121,000 total imports of day-old-chicks were made directly by farmers.<sup>74</sup> Chick imports in that year were four times those of 1958 which reached a peak of 458,300 in 1965, signifying an expansion over the years.<sup>75</sup>

By 1967, there were four hatcheries in operation in Ghana with 973,000 chick output.<sup>76</sup> In 1964, Ghanachix Farm was established by an individual to breed strains of chickens to produce day-old-chicks for the Ghanaian market.<sup>77</sup> Around the same period, the Ghana State Farms Corporation started the Odorkor State Farms which produced about 25,000 day-old-chicks a week<sup>78</sup> and another at Kwadaso.<sup>79</sup>

The Animal Husbandry Department of the Ministry of Agriculture also put up a hatchery to produce about

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<sup>72</sup> La-Anyane, p. 48, 50, opcit.

<sup>73</sup> Gyasi, p.17, opcit.

<sup>74</sup> Ghana, Central Bureau of Statistics Economic Survey 1959.

<sup>75</sup> Gyasi, p.17, opcit.

<sup>76</sup> Gyasi, p.18, opcit.

<sup>77</sup> Williams, p.157, opcit.

<sup>78</sup> Annang, p. 16, opcit

<sup>79</sup> Gyasi, p. 18 opcit

12,000,000 day-old-chicks a year at Pomadze near Winneba but the target was never achieved. This hatchery was in 1971 converted into a limited liability company known as Pomadze Poultry Enterprises Limited. In addition to producing day-old-chicks, the company produces and sells poultry feed. At present only 10 percent of its installed capacity for day-old-chicks is produced because of liquidity problems.

The poultry industry in the late 1950's encountered a number of problems that threatened its development. The problems included unavailability of high quality feed prepared from local ingredients, inadequate control of diseases, limited marketing outlets, and non-existing institutional credit facilities to farmers.<sup>80</sup> The problems of feed and feeding in extensive poultry systems, account for 70% of the total poultry production in Africa. In general, the poultry industry in Africa is plagued with high feed cost resulting from inadequate knowledge of the proper mix of local feed ingredients for the various classes of poultry.<sup>81</sup>

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<sup>80</sup> Gyasi, pp.18,19,opcit.

<sup>81</sup> Ologhobo, A. D. 'Feed and Feeding in Extensive Poultry Systems', *Entwicklung-und-Landlicher-raum* 1990, 24(4), pp.15-17.

### **Performance of the Poultry Sub-sector Overtime**

High demand deriving from the higher incomes of the increasingly urban population and the need to supplement one's income in later years due to economic depression gave a boost to intensive poultry rearing in Ghana.<sup>82</sup>

Several large-scale commercial farms emerged in different parts of the country between 1952 and 1960 with the growth of the industry greatest around Accra. By 1959, there were 406 certified poultry-keepers in the country, who were mainly involved in egg production with poultry meat production being a sideline enterprise.<sup>83</sup> Poultry production increased sharply during the decade 1962-72 registering an average annual increase of 300 percent over the other livestock.<sup>84</sup> In 1969, there were nearly 669,730 layer day-old-chicks and 1,337,580 broiler chicks.<sup>85</sup> Because the Ghanaian cherishes a large and tough bird, and the way the chicken is cooked in the home, the broiler was not a very popular product. It tended to disintegrate in the soup during cooking. The commercial poultry meat producer had to

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<sup>82</sup> Annang, J. Q., 'Poultry Production and Products' in Animal Science Symposium, University of Ghana, Legon 1969

<sup>83</sup> Gyasi, p.18, opcit.

<sup>84</sup> 'Domestic Livestock Population in Ghana', The Economic Survey 1969, Published by Central Bureau of Statistics. p.65.

<sup>85</sup> Pomadze Poultry Enterprises, Ghana Economic Review, edited by Moses Danquah. Published by Editorial and Publishing Services, 1971/72, p.34

keep his birds for 16 weeks to attain the size that the customer appreciated.<sup>86</sup>

The poultry sub-sector of the livestock industry is ranked fourth in terms of the growth rates, and contributed only 5 percent of the nation's agricultural output. However it also had the highest degree of modification of commercial activities.

As at 1993, there were 15 commercial hatcheries in Ghana, producing their own hatching eggs for subsequent day old chick production. Other private hatcheries do exist at the University of Ghana, Kwame Nkrumah University of Science and Technology (KNUST), University of Cape Coast, Pong Tamale Veterinary College, Presbyterian Secondary School, Ghanachix and Mount Pleasant. Their combined estimated total annual capacity is 1.8 million. At present in 2000, there are only two major commercial hatcheries namely Afariwaa and Darko farms.<sup>87</sup> The harsh economic conditions have resulted in most of these hatcheries producing on small-scale and resorting to the importation of day-old-chicks and/ or hatching eggs. Unfortunately some are folding up; for instance, Cebas Farms Ltd., which used to be a hatchery, is presently importing and distributing day-old-chicks.

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<sup>86</sup> Williams, p.157, opcit.

### **The Structure of the Poultry Industry**

Darko,<sup>88</sup> made an assertion that commercial poultry production is based on imported exotic breeds and is dominated by small-scale operators with holding capacities ranging from 100 to about 1000 birds. Birds reared under modern intensive commercial production system are sheltered properly, vaccinated regularly and fed on commercial or home made balanced rations containing maize, fish meal, oilcakes minerals and vitamins. There is little broiler production in the commercial sector. Most birds are reared primarily for egg production with spent layers supplying poultry meat.

Mensah,<sup>89</sup> made observations of labor input in the industry varying from farm to farm, even on farms of same size and with the same system of management; most small-scale farmers sell live instead of dressed birds because of the low demand of the latter.

The commercial system is concentrated around heavily populated urban centers in the Ashanti and Greater Accra

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<sup>87</sup> Natural Resources Institute (2000). Discussion Paper on Feed Production and Feed Ingredients in Ghana

<sup>88</sup> Darko, F. K. 'The Effect of Importation of Frozen Chicken on the Demand for Chicken in Ghana.' Unpublished Dissertation, University of Ghana, Legon, Faculty of Agricultural Economy and Farm Management, 1994, p.11.

<sup>89</sup> Mensah, I. Q. 'A Study of Pig and Poultry Production in the Accra: Agricultural District: A Linear Programming Approach.' Unpublished Dissertation, University of Ghana, Faculty of Agriculture, Department of Agricultural Economy and Farm Management 1976.

regions. Small-scale operators dominate commercial production, with holdings ranging from 100 to about 1000 birds of exotic breeds.<sup>90</sup>

#### **Nature of Demand**

According to Darko,<sup>91</sup> the price elasticity of demand for chicken was 0.532, indicating the inelastic demand for chicken. The positive sign of the own-price elasticity of demand for chicken might be due to the high demand for chicken during festivities. The cross-price elasticity of demand for live chicken with respect to frozen chicken was 5.304, which implied that frozen chicken was a close substitute for live chicken, and that high elasticity value implied that as the relative price of live chicken fell as a result of improvement in the production methods, the demand for live bird would increase to create job opportunities and also to conserve the scarce foreign exchange. Again, cross-price elasticity of live chicken with respect to beef was 2.394, which indicates that beef is a substitute for live bird but that of frozen chicken was closely related to live bird. This was in contrast to a

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<sup>90</sup>Basta, p. 20, *opcit.*

<sup>91</sup>Darko, p. 30, *opcit.*

previous finding by Baffoe-Bonnie<sup>92</sup> who found that chicken was not a close substitute for beef. Darko,<sup>93</sup> therefore argued that beef and chicken are considered substitutes only on festive occasions such as Christmas, Easter and Rhamadan. Cross-price elasticity for fish was -1.274 and this negative sign suggested that fish is a complement for chicken meat. The income elasticity of demand for chicken was -0.97, which was however, contrary to a priori expectations, since chicken is not an inferior commodity. The population elasticity was 112.8, which tends to suggest that as population increases the quantity demanded of chicken would increase significantly. Darko's study further revealed that high cost of production of domestic chicken was mainly due to the high cost of feed and drugs, where feed alone constituted 80% of the total cost of production of poultry. The high cost of feed was due mainly to protein carneys.

Smith,<sup>94</sup> also observed that during the last twenty years from 1970 to 1990 many countries have adopted intensive poultry production as a means of bridging the protein 'gap' and that intensively kept poultry have been seen as a way of rapidly increasing animal protein supplies

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<sup>92</sup> Baffoe-Bonnie, J., 'Statistical Analysis of the Demand for Beef in Ghana.' Unpublished Dissertation, University of Ghana, Faculty of Social Sciences, Department of Economics, Legon 1976.

<sup>93</sup> Darko, p.30, opcit.

for a rapidly growing population. The elasticities of labor measured in man days, buildings, equipment, feed and initial stock, all valued in cedis were positive except that of land which was measured in hectares that showed a negative sign which was due to the fact that different management systems could be practised on the same piece of land.

Nettey,<sup>95</sup> observed in her study in 1993 that direct losses associated with Newcastle, Gumboro and Coccidiosis on a batch of 100 broilers for a period of five years and four batches per year was 2,311.13 cedis. For layers, a batch of 100 layers for a period of five years and three batches within the period of five years was 117, 968 .75 cedis. In addition, the cost of disease control per batch of 100 broilers and 100 layers on the average was 32,529. 58 cedis and 114, 032 .11 cedis, respectively. Finally the benefits of control per batch of 100 broilers and 100 layers was respectively 54, 792 .75 cedis and 269,365.48 cedis.

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<sup>94</sup> Smith, A. J., The Tropical Agricultural Poultry. Macmillan Publishers, London. 1990. p.11.

<sup>95</sup> Nettey, M. N. 'The Cost of Poultry Diseases and the Benefits of their Control: A Case Study of three Important Diseases in the Greater Accra Region.' Unpublished Dissertation, University of Ghana, Faculty of Agriculture, Department of Agricultural Economy and Farm Management, 1993.

### Marketing of Poultry Products

The marketing of poultry products remains largely traditional with a small proportion marketed through restaurants and supermarkets. Marketing of spent layers and broilers is handled by wholesalers who make bulk purchase of live birds from producers and distribute through retailers at the markets. Some farmers process their broilers manually for restaurants and supermarkets. In marketing live broilers in Accra, Batsa,<sup>96</sup> found that transportation was 49.44% of the total cost, which was the major cost item. With regards to dressed broilers, processing formed the bulkiest cost item to the producer, which represented 44.44% of the total cost. This could be due to the high cost of labor employed for dressing the birds. The marketing margin for live birds was 28.63 percent which implies that 71.37% of the retail price goes to the producer. Similarly, a large proportion of 90.37% of the price paid by the consumer goes to the producer. These results confirmed earlier study by Shepherd<sup>97</sup> that sometimes the farmer got about half of the consumer's price and sometimes a little more than a third. He further stated

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<sup>96</sup>Basta, S. T. 'Broiler Meat Marketing Margins in Accra: A Study of Some Selected Poultry Farms.' Unpublished Dissertation, University of Ghana, Faculty of Agriculture, Department of Agricultural Economy and Farm Management 1993

<sup>97</sup> Sheperd, G. S. Marketing Farm Products, Economic Analysis. Fourth Edition. Iowa State University Press, 1962. p.250.

that for poultry products over 60 percent of the retail price often goes to the producer in Ghana.

Stoces,<sup>98</sup> stressed with special reference to Ghana that the inadequacy of marketing facilities could develop a pressure towards a reduction of the volume of production. Furthermore, he said no farmer is interested in producing surpluses if he cannot find a ready market for his produce at a reasonable price.

Production was geared toward egg production as the ratio of layers to broilers was found to be high for all farmers engaged in dual-purpose poultry production. Farmers also expressed that egg production was better than broiler production because they got stable income from the former than the latter.

Bevan<sup>99</sup> observed that rising cost of poultry production tended to narrow the profit margin on egg production, and it would appear that producers are obliged to pay little more attention to the returns from by-products of their egg-production enterprise.

Farmers have difficulty in marketing broilers except on festive occasions such as Christmas, Easter and Rhamadan hence they plan their production activities to coincide with these occasions.

## CHAPTER FOUR

### METHODOLOGY

#### Introduction

This chapter outlines the framework within which the problems raised by the present study are analyzed. The framework involves multivariate regression analysis to examine the production structure of layers in the poultry industry over the study period 1988-1999.

#### Theoretical Concepts and Framework of Analysis of Multivariate Regression

Agricultural production can be expressed in the form of a production function which relates the level of agricultural output to the level of factor-resources used in a particular process. The production function is normally used to perform economic analysis of agricultural production. According to Chiang<sup>100</sup> and Sankhayan<sup>101</sup>, the Cobb-Douglas production function is one of the most widely used functions in the economic analysis of the problems relating to empirical estimation in agriculture and industry but unfortunately it imposes serious and perhaps

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<sup>98</sup> Stoces, F., 'Agricultural Production in Ghana', *The Economic Bulletin of Ghana* 10(3).

<sup>99</sup> Bevan, J. W. 'Poultry Marketing in England', *The Farm Economist*, 1952, Vol. VII.

<sup>100</sup> Chiang, A. C. *Fundamental Methods of Mathematical Economics, Third Edition*. Mc Graw-Hall Book Company, 1984

unrealistic restrictions on the production process as indicated by Varian<sup>102</sup>.

In a classic paper, Arrow et al.<sup>103</sup> called into question the inherent restrictions of the Cobb-Douglas model that all elasticities of factor substitution are equal to one. The elasticity of substitution between each pair of factors must be identically one. That is, a constant unitary elasticity of substitution and this is a great limitation for a Cobb-Douglas technology. There seemed to be no particular reasons for the imposition of such restrictions on a prior grounds hence the development of the duality theory between the production, profit and cost function. Recent development of the duality theory has enhanced the appeal of a cost function approach.

The application of duality theory to economic analysis and the concomitant development of numerous flexible functional forms that allow substitution to be unrestricted and not even constant have grown over the years<sup>104</sup>. In this

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<sup>101</sup> Sankhayan, P. Introduction to the Economics of Agricultural Production. Printice-Hall of India Private Ltd., New Delhi, 1988.

<sup>102</sup> Varian, H.R. Microeconomic Analysis. W. W. Norton and Company, New York. London, 1984.

<sup>103</sup> Arrow, K. J. et al. (1961), 'Capital-labor substitution and economic efficiency'. *Review of Economics and Statistics*.

<sup>104</sup> Diewert, W. E. (1971), 'Application of the Shepard duality theorem: A generalized leontief production function', *Journal of Political Economy* 79, 481-507. And Lau, L. J. (1974a), 'Application of duality: A comment' in Frontiers of Quantitative Economics. edited by M. D. Intrilligator and D. A. Kendrick. (Amsterdam, North-Holland).

context flexibility as defined by Caves and Christensen<sup>105</sup> is the ability to represent production function without placing any a prior restrictions on the full set of price and elasticities of substitution and factor price elasticity of demand at a base point.

Basically, the class of flexible functional forms is defined by the property that those forms can provide a second order approximation to an arbitrary twice differentiable function<sup>106</sup>. This property of flexible forms has enhanced considerably the capabilities for testing structural hypothesis with fewer maintained hypotheses than was heretofore necessary. This expanded potential for hypothesis testing has in turn reinforced the nexus between theoretical and empirical research. Despite the attractive approximation property of flexible forms, most empirical works with these functions have, for econometric convenience, maintained the hypothesis that the flexible forms being used hold exactly rather than as an approximation. <sup>107</sup>The recent application of duality theory to problems in economics has resulted in many useful

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<sup>105</sup> Caves, D. W. and Christensen, L. R. (1980), 'Global Properties of Flexible Forms', *American Economic Review* 70(3), 422-432.

<sup>106</sup> Lau, L. J. (1974b), Unpublished memorandum.

<sup>107</sup> Jorgensen, D. W. and Lau, L. J. (1975a), 'The structure of consumer preferences', *Annals of economic and social measurement* 4, 49-102 and (1975b), *The integrability of consumer demand functions*, discussion paper (Harvard University, Cambridge, MA).

results for the study of production and cost relationships<sup>108</sup>. A fundamental result is that, given certain regularity conditions, there exist cost and production functions, which are dual to each other. The specification of a production function implies a particular cost function and vice-versa. Every cost function implies a set of derived demand equations.

Direct estimation of the production function is attractive when the level of output is endogenous. Estimation of the cost function is more attractive, however, if the level of output is exogenous. A cost function corresponds to a homothetic production structure if and only if the cost function can be written as separable in output and factor prices. A homothetic production function structure is further restricted to be homogenous if and only if the elasticity of cost with respect to output is constant.

The elasticity of production with respect to the  $i$ th input is not a constant but varies with the level of input  $j$  that is a linear function of its own level. This function, therefore, overcomes the limitation of constant elasticity of production of the power function. The returns to scale of the translog function which is non-

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<sup>108</sup> Diewert, W. E. (1974), 'Application of duality' in Frontiers of Quantitative Economics, edited by M. D.

homogeneous are equal to the sum of the production elasticities and are not invariant with input levels.

### The Theoretical Model

The study assumes that the poultry industry is characterized by a twice-differentiable production function given as

$$Q = Q(I_S, L, V, F) \quad (3.1)$$

Where,  $Q$  is output and  $I_S$ ,  $L$ ,  $V$ ,  $F$  are inputs of institutional credit, labor, vaccines, and feed respectively. If prices are exogenous and the firms minimize costs, then the duality principles of economic theory can be applied to derive a cost function which can reflect the production technology as indicated by Varian<sup>109</sup>. The dual cost function can be characterized by the form,

$$C = C(P_{I_S}, P_L, P_V, P_F, Q) \quad (3.2)$$

where,  $C$  is the total cost of production,  $P_{I_S}$ ,  $P_L$ ,  $P_V$ , and  $P_F$  are yearly prices of institutional credit from the banks, labor, vaccines and feed respectively, and  $Q$  is output.

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Intriligator and D. A. Kendrick. Amsterdam: North-Holland.

<sup>109</sup> Varian, H.R. Microeconomic Analysis. W. W. Norton and Company, 1984.

The translog cost function is written as a logarithmic Taylor series expansion to the second term of a twice differentiable analytic cost function around variable levels of 1,

(i.e.,  $\ln Q = 0, \ln P_i = 0, i = 1, \dots, n$ ).

Rewriting equation (3.2) in natural logarithms:

$$\ln C = f(\ln Q, \ln P_1, \dots, \ln P_n) \quad (3.3)$$

By expanding  $\ln C$  in a second-order Taylor series about the point  $\ln C(\cdot) = 0$  the following is obtained:

$$\begin{aligned} \ln C = & \alpha_0 + (\partial \ln C / \partial \ln Q) \ln Q + \sum (\partial \ln C / \partial \ln P_i) \ln P_i + \\ & \frac{1}{2} \sum \sum (\partial^2 \ln C / \partial \ln P_i \ln P_j) \ln P_i \ln P_j + \sum (\partial^2 \ln C / \partial \ln Q \partial \ln P_i) \ln Q \ln P_i \end{aligned} \quad (3.4)$$

All the derivatives are evaluated at the expansion point.

These derivatives are identified as coefficients and imposing the symmetry of cross-derivatives, the translog cost function becomes

$$\begin{aligned} \ln C = & \alpha_0 + \alpha_Q \ln Q + \frac{1}{2} \gamma_{QQ} (\ln Q)^2 + \sum_i \alpha_i \ln P_i + \\ & \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j + \sum_i \gamma_{Qi} \ln Q \ln P_i \end{aligned} \quad (3.5)$$

where  $\gamma_{ij} = \gamma_{ji}$ ,  $C$  is the total cost of inputs,  $Q$  is output, and the  $P_i$ 's are the prices of the factor inputs. To ensure that the underlying production function corresponds to a

well-behaved production function conforming to the theory of production, certain restrictions are placed on the parameters of the cost function. Symmetry requires that  $\gamma_{ij} = \gamma_{ji}$  and the cost function must be homogeneous of degree one in prices that is linear homogeneity in prices and therefore requires the following restrictions:

$$\sum_i \alpha_i = 1, \sum_i \gamma_{Qi} = 0, \sum_i \gamma_{ij} = \sum_j \gamma_{ji} = \sum_i \sum_j \gamma_{ij} = 0 \quad (3.6)$$

These restrictions imply that a proportional increase in expenditure on all factors must also cause a proportionate change in output, and that a proportionate change in all factor prices will not change the relative quantities of each factor used.

Homogeneity of degree one in prices does not impose homogeneity of degree one of the production function in inputs. Also, no constraints are imposed on elasticities of substitution or of factor demand, which makes the function more general than other functional forms in use.

Assuming competitive factor markets and cost minimization by firms, Shepard<sup>110</sup> lemma is used to easily compute derived demand functions for the factors of production by partially

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<sup>110</sup> Shepard, R. W., Cost and Production Functions. (Princeton University Press, Princeton, New Jersey 1953)

differentiating the cost function with respect to the factor prices, that is,

$$\partial C / \partial P_i = X_i \quad (3.7)$$

This result is conveniently expressed in logarithmic form for a translog cost function as

$$\partial \ln C / \partial \ln P_i = P_i X_i / C = S_i \quad (3.8)$$

Where  $S_i$  is the cost share of the  $i^{\text{th}}$ -factor input. By differentiating the logarithm of the cost function with respect to the logarithm of each input price, the factor cost shares or input-demand equations are derived. The translog cost function yields the cost share equation

$$S_i = \alpha_i + \gamma_Q \ln Q + \sum_j \gamma_{ij} \ln P_j \quad (3.9)$$

The system of share equations contains all the information required to estimate the substitution and price elasticities of factor demand.

Uzawa<sup>111</sup> and Allen<sup>112</sup> have shown that Allen partial elasticities of substitution between factors  $i$  and  $j$  can be computed from the cost function by the formula

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<sup>111</sup> Uzawa, H. (1962), 'Production functions with constant elasticities of substitution', *Review of Economic Studies* 29, 291-299.

$$\sigma_{ij} = (C)(C_{ij}) / (C_j)(C_i) \quad (3.10)$$

where subscripts on C indicate partial differentiation of the cost function with respect to factor prices. For the translog cost function, Berndt and Wood<sup>113</sup> and Binswanger<sup>114</sup> have shown that, the elasticities of substitution are particularly simple to compute once the substitution parameters and cost shares are estimated. The substitution parameters are related to elasticities of substitution and of factor demand.

In terms of the translog cost function, partial elasticities of substitutions become

$$\sigma_{ii} = \gamma_{ii} + S_i(S_i - 1)/S_i^2 \quad (3.11)$$

$$\sigma_{ij} = \gamma_{ij} + (S_i S_j) / S_i S_j \quad (3.12)$$

where  $i, j = FS, L, V, F$

These lead to the own and cross partial price elasticities of demand,  $\eta_{ii}$  and  $\eta_{ij}$  given by,

$$\eta_{ij} = \sigma_{ij} S_j \quad (3.13)$$

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<sup>112</sup> Allen, R. G. D. , Mathematical Analysis for Economists ( Macmillan, London, 1938), 503-509.

<sup>113</sup> Berndt, E. R. and Wood, D. O. (1975), 'Technology, Prices, and Derived Demand for Energy', *Review of Economics and Statistics* 57, 259-268.

<sup>114</sup> Binswanger, H. P. (1974), 'A cost function approach to the measurement of factor demand and elasticities of substitution', *American Journal of Agricultural Economics* 56, 377-386.

$$\eta_{ii} = \sigma_{ij} S_i \quad (3.14)$$

### **Economies of Scale**

The theory of production deals with two different concepts of returns to scale. The first, which is most widely used for defining returns to scale<sup>115</sup>, is the increase in output as all input quantities are increased proportionally along a ray through the origin. The second, which is the more relevant concept for micro-economic analysis, is the increase in output relative to costs for variations along the expansion path where input prices are constant and costs are minimized at every level of output<sup>116</sup>. These two concepts yield equal measures for elasticity of scale<sup>117</sup> at every minimum cost point in the input space.

Economies of scale are usually defined in terms of the relative increase in output resulting from a proportional increase in all or some inputs.

According to Hanoch<sup>118</sup> it is more appropriate to represent scale economies by the relationship between total cost and output along the expansion path — where input

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<sup>115</sup> See, e.g., Sune Carlson, Leif Johansen, Ranger Frisch, F. W. McElroy (1964).

<sup>116</sup> The distinction between these concepts dates back to Francis Edgeworth. But many subsequent writers failed to make this distinction, or to realize its full implications.

<sup>117</sup> The scale elasticity (see Johansen, p. 64) is known under various names: e.g. 'elasticity of production' (W. E. Johnson, p.507); 'passus coefficient' (Frisch, p65); 'function coefficient' (Carlson, p.17). Its reciprocal is the elasticity of costs, or 'the substitutional cost flexibility' (Frisch, p.167)

prices are constant and costs are minimized at every level of output. A natural way to express the extent of scale economies is as the proportional increase in the level of output, or the elasticity of total cost with respect to output.

Christensen and Greene<sup>119</sup> have shown for the translog cost function that scale economies are derived by calculating scale elasticities (SCE). The scale economies are quantified as scale elasticities with the relation.

$$\begin{aligned} \text{SCE} &= 1 - \partial \ln C / \partial \ln Q \\ &= 1 - (\alpha_0 + \alpha_Q + \gamma_{QQ} \ln Q + \sum_i \gamma_{Qi} \ln P_i) \end{aligned} \quad (3.15)$$

#### Method of Estimation

Parameter estimation of each cost function using ordinary least squares is feasible. The ordinary least squares was used by Nerlove<sup>120</sup> due to its simplicity. However, it neglected the additional information contained in the cost share equations, which were easily estimable. Furthermore, even for a modest number of factors of production, the translog cost function has a large number

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<sup>118</sup> Hanoch, G. (1975), 'The elasticity of scale and the shape of average costs', *American Economic Review* 65(3), 492-497

<sup>119</sup> Christensen, L. R. and Greene, W. H. (1976), 'Economies of scale in U. S. electric power generation', *Journal of Political Economy* 84(4), 655-676.

of regressors (many of which are second order terms) which, aside from the terms involving output, do not vary greatly across firms. Hence, multicollinearity may be a problem, resulting in imprecise parameter estimates.

If restrictions across equations ( $\gamma_{ij} = \gamma_{ji}$ ) are imposed, as symmetry requires, ordinary least square estimators are no longer efficient despite the fact that all equations contain the same explanatory variables on the right - hand side.<sup>121</sup> An estimation procedure, followed by Berndt and Wood<sup>122</sup>, was to estimate the cost shares as a multivariate regression system. This procedure was satisfactory for their purposes, since they treated constant returns to scale as a maintained hypothesis ( $\gamma_{Qi} = 0, \gamma_{QQ} = 0, \alpha_Q = 1$ ). Thus their cost share equations included all the parameters of the cost function except for neutral shift parameter  $\alpha_0$  and no economic information was lost by not including the cost function in the estimation procedure. This approach was not satisfactory, however, when constant returns were not imposed, since the crucial parameters in the scale elasticity formulas,  $\alpha_Q, \gamma_{QQ}$ , appear only in the cost function. This study employs joint estimation of the cost

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<sup>120</sup> Nerlove, M., 'Return to scale in electricity supply' in Measurement in Economics- Studies in Mathematical Economics and Econometrics in Memory Yahuda Grunfeld, edited by Carl F. Christ. (Stanford University Press, Stanford, California, 1963).

<sup>121</sup> Binswanger, opcit,

function and the cost share equations as a multivariate regression system as the optimal procedure using the method of maximum likelihood to estimate the parameters.<sup>123</sup>

Including the cost share equations in the estimation procedure and estimating a system of equations reduces possible multi-co-linearity problems and provides many additional degrees of freedom without adding any restricted regression coefficients.<sup>124</sup> This results in more efficient parameter estimates than can be obtained when by ordinary least squares is used for the cost function alone.

Removal of squares and cross products terms whose t-ratios are non-significant or below certain critical value is one way of solving the multicollinearity. Another way of resolving this problem is to have a modified functional form by the exclusion of the square terms. However, this is going to destroy flexibility in the relationships.

### **Multivariate Regression System**

Most of the recent applications of the multivariate regression model have been in the context of demand equations, either commodity demands or factor demands in

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<sup>122</sup> Berndt and Wood, *opcit.*

<sup>123</sup> Christensen and Greene, p. 662-663 *opcit.*; and Bigsby, p. 280-281 *opcit.*

<sup>124</sup> Nautiyal, J. B. and Singh, B. K. (1986), 'Long-term productivity and factor demand in the Canadian pulp and paper industry', *Canadian Journal of Agricultural Economics* 34, 21-44.

studies of production. Other examples include the systems of factor demands and factor cost shares from production. The system of four cost share equations obtained by differentiating the logarithmic cost function provides a seemingly unrelated regressions model (SUR), which is used to estimate the parameters of the model. Estimating a set of seemingly unrelated regressions jointly yields more efficient estimates than each one of them separately. This system of four equations forms a singular system because the disturbance covariance matrix is singular, the cost shares of the four equations must always add to unity and the sum of the disturbances across the four equations must be zero at each observation. This singularity problem can further be explained, as only  $N-1$  equations are linearly independent due to the homogeneity constraint. The cost share of financial services equation is dropped from the system of equations to obtain a non-singularity system which permits estimation.

It was shown by Berndt and Wood<sup>125</sup> that any of the share equations can be dropped arbitrarily and the parameters associated with the missing equation estimated residually. This required that the errors in each equation are homoskedastic and non-autocorrelated, and that there is

non-zero correlation between contemporaneous error terms across equations. To further make the model operational, the first  $M-1$  prices are divided by the  $M_{th}$ , in that, all the prices are divided by the price of financial services which is interest rate.

The  $\alpha_0$ ,  $\alpha_Q$ ,  $\alpha_{QQ}$ ,  $\alpha_i$ ,  $\gamma_{Qi}$ ,  $\gamma_{ij}$ ,  $\gamma_{ji}$  are estimated from the Seemingly unrelated regression model using maximum Likelihood estimator because of the achievement of invariance in the non-singular system of equations. Maximum likelihood estimator is asymptotically unbiased, consistent, and efficient. Maximum likelihood estimates would be bias for small samples, but would have the desired properties of consistency and efficiency. The assumption of normality and the assumption of any random sample being representative of the parent population are strong, especially in small samples.

### **Model Selection**

The model selection procedure involves the testing of different hypotheses about the structure of the underlying production function through the placement of restrictions on the parameters of the model. This creates new models which are nested in the unrestricted model. The

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<sup>125</sup> Berndt and Wood, opcit

restrictions deals with assumptions such as the effect of scale economies, and input substitution.

The validity of different restrictions is tested using the Wald test statistic which is preferred to Lagrange Multiplier test and Likelihood Ratio test although all are asymptotically equivalent under the null hypothesis and distributed as chi-square. The former's computation is simple as it requires the unrestricted estimator. The testing is conducted between a particular hypothesis and the one immediately preceding it. In the testing procedure to either accept or reject the null hypothesis, restrictions are gradually imposed on the unrestricted model. The parameters are re-estimated and their calculated chi-squares are compared with the critical chi-square at the 99 and 95 percent level of significance. The degrees of freedom are the difference between unrestricted free parameters and restricted free parameters. The various restrictions form a sequential order of nested models within the unrestricted model that are created by gradually imposing restrictions.

### **Statistical Test**

The study employs the Student t-test and the probability values from the regression output in the

econometric analysis to determine the appropriateness and significance of the estimates. The White heteroskedasticity test is employed to check for the presence of homoskedasticity. A simple operational version of the test is carried out by obtaining  $nR^2$  in the regression where  $n$  is the number of observation and  $R^2$ , the coefficient of determination. The statistic is asymptotically distributed as chi-squared with  $P-1$  degrees of freedom, where  $P$  is the number of regressors in the regression. A significant value of Chi-square at both 99 and 95 percent levels implies a rejection of the null hypothesis heteroskedasticity in favour of homoskedasticity.

Breusch-Godfrey Lagrange Multiplier Test statistic is used to test for the presence of serial correlation. This test is carried out by regressing the ordinary least squares residuals  $e_t$  on  $X_t$ ,  $e_{t-1}$ ,-----  $e_{t-p}$  and referring  $nR^2$  to the tabled critical value for the chi-squared distribution with  $P$  degrees of freedom where  $P$  is the number of lags or using the F-statistics.

#### **Statement of Hypothesis**

Four hypotheses, which are tested and validated are as stated below; where  $H_0$  and  $H_1$  denote the null hypothesis and the alternative hypothesis respectively.

$H_0$ : Cost function is homothetic;  $\gamma_{Qi} = 0$ .

$H_1$ : Cost function is not homothetic;  $\gamma_{Qi} \neq 0$ .

$H_0$ : Cost function is homogeneous;  $\gamma_{Qi} = 0$

$H_1$ : Cost function is not homogeneous;  $\gamma_{Qi} \neq 0$ .

$H_0$ : Cost function is unitary elastic;  $\gamma_{ij} = 0$ .

$H_1$ : Cost function is not unitary elastic;  $\gamma_{ij} \neq 0$ .

### **Expected Results**

The cost function is expected to exhibit linear homogeneity, positivity, monotonicity and concavity. Own price elasticities of demand of inputs are supposed to have negative signs. The cross price elasticities of financial services and labor are expected to have positive values indicating substitutability. The cross price elasticities of feed, vaccines are supposed to have negative values indicating complementarity. It is anticipated that layer production in the poultry industry would exhibit positive economies of scale.

### **Method of Data Collection**

Annual data on expenditures on feed, veterinary services, labor, institutional credit in the form of loans obtained from the banks and number of layers produced



annually from 1988-1999 were compiled from Delawin Farms, Farm Vivian, Vidas Farms, Sydals Farms, Mackba Farms, Dufie Farms, Alpine Farms, and Darko Farms. The first six farms are situated in the Accra/ Tema metropolis, the seventh is located at Nsawam, and the last at Kumasi. These farms are classified as intensive large-scale poultry farms because their production process being mechanized and have a capacity of over ten thousand birds. A set back in the data collection is that many farms were unwilling to enter into their archives to provide data except those mentioned above.

#### **Description of Variables and Sources of Data**

The total cost of production is calculated from the equation below.

$$C = P_{IC} X_{IC} + P_L X_L + P_V X_V + P_F X_F \quad (1.2)$$

where  $P_{IC}$  = the yearly price of institutional credit,

$P_L$  = the yearly price of labor,

$P_F$  = the yearly price of feed,

$P_V$  = the yearly price of vaccines

$X_{IC}$  = the yearly amount of credit taken,

$X_L$  = the yearly number of employees,

$X_V$  = the yearly quantity of vaccines consumed and

$X_F$  = the yearly number of bags of feed consumed.

The capital used is defined as the annual loan acquired from the banks. The price of capital is the interest rate on loan quoted by the banks as agricultural lending rate which is obtained from Quarterly Digest of Statistic by finding the average between the high and low.

The yearly total cost of labor is computed as the sum of total salaries and wages paid in the production of the output. To estimate the yearly price of labor, the average monthly earnings from the Quarterly Digest of Statistics are multiplied by twelve and this was used as a proxy.

The annual cost on vaccines is computed as the expenditure on all the major vaccines used. These vaccines are Marex used for a one day old layer bird, Hitcher B.1 is administered when bird is two weeks old, Gumboro for a three week old bird, Lasota is applied in the sixth week, Fowl Pox is given in the ninth week, and finally Newcavac is administered when bird is sixteen weeks old. The yearly price of vaccine per dose used was obtained from the Veterinary Services Department of the Ministry of Food and Agriculture.

The yearly total cost on feed is calculated as the product of the price of a fifty-kilogram bag and number of bags consumed. The yearly price of a fifty-kilogram bag

was accessed from the Ghana Co-operative Poultry Farmers Association.

Individual data from all these poultry firms are pooled to obtain a pooled cross-section time-series data which is used for estimation. The total cost for the industry is obtained by summing up the cost of individual inputs of all the firms for each year.

## CHAPTER FIVE

## RESULTS AND DISCUSSION OF ANALYTICAL MODEL

This Chapter presents and discusses the results of the elasticities of the inputs demand and the economies of scale of layer production in the Ghanaian Poultry Industry during the period 1988-1999. The system of equations used for the estimation are explicitly given as:

$$\begin{aligned} LTC = & C(1) + C(3)*U + C(4)*V + C(5)*W \\ & + C(6)*LQT + C(7)*((0.5)*(LQT^2)) + C(22)*((0.5)*(U^2)) \\ & + C(23)*U *V + C(24)*U *W + C(33)*((0.5)*(V ^2)) + C(34)*V *W \\ & + C(44)*((0.5)*(W ^2)) + C(46)*LQT*U + C(47)*LQT*V + C(48)*LQT*..... \end{aligned} \quad (5.1)$$

$$SL = C(3) + C(22)*U + C(23)*V + C(24)*W + C(46)*LQT..... \quad (5.2)$$

$$SV = C(4) + C(23)*U + C(33)*V + C(34)*W + C(47)*LQT..... \quad (5.3)$$

$$SF = C(5) + C(24)*U + C(34)*V + C(44)*W + C(48)*LQT$$

Where,

LTC is the natural logarithm of total cost,

SL the shares of labor,

SV the shares of vaccines,

SF the shares of feed.

U is the price ratio between labor and institutional credit,

V is the price ratio between vaccines and institutional credit and

W the price ratio between feed and institutional credit respectively.

C(i) is the coefficient of the ith parameter.

### **Empirical Econometric Results**

The unrestricted model with 15 degrees of freedom estimated after 25 iterations gives 10 significant coefficients out of the 15 coefficients at the 95 percent level of significance (Appendix 1).

Homotheticity is tested by imposing three restrictions on the model that is by dropping the coefficients C(46), C(47) and C(48). The degrees of freedom are 12 and all the coefficients are significant at the 99 and 95 percent levels of significance. The Chi-square value from the Wald test is significant at the 99 percent level of significance. The calculated Chi-square is greater than the critical Chi-square hence a rejection of the null hypothesis of homotheticity (Appendix 2).

The rejection of the homothetic model implies the rejection of the nested model therefore homogeneity, unitary elasticity and Cobb-Douglas models are also rejected at the 99 percent level of significance (Appendices 3 & 4). All of the restricted models are rejected at the 99 percent level of significance.

A summary of the estimated parameters along with their calculated chi-square and their respective critical chi-square for unrestricted and restricted models are presented in Table 5.1 below.

**Table 5.1 A Summary of Test Statistics for Model Selection (1988-1999)**

Coefficient	Unrestricted	Homotheticity	Homogenous	Unitary Elastic
$\beta_0$	-223.0480*	-372.5472*	-38.31577*	-20.95751*
$\beta_{F,S}$	-1.141808			
$\beta_L$	0.967126*	1.269226*	1.253976*	0.722875*
$\beta_V$	-4.189959*	-5.641706*	-4.268080*	0.594802*
$\beta_F$	4.364641*	5.107874*	4.411586*	0.929127*
$\beta_Q$	36.31555*	59.47583*	2.107219*	1.999217*
$\gamma_{QQ}$	-3.111515*	-4.921807*		
$\gamma_{LL}$	-0.049833*	-0.082635*	-0.106419*	-0.072688*
$\gamma_{LV}$	0.066338*	0.075941*	0.056772	
$\gamma_{LF}$	-0.037176	-0.059881*	-0.023152	
$\gamma_{VV}$	-0.840571*	-0.919570*	-0.597665*	0.177333*
$\gamma_{VF}$	0.662128*	0.689474*	0.558653*	
$\gamma_{FF}$	-0.571605*	-0.553930*	-0.523795*	-0.095447
$\gamma_{QL}$	-0.012564			
$\gamma_{QV}$	-0.090686			
$\gamma_{QF}$	0.049320			
Number of Restrictions	0	3	4	7
Critical $X^2$	-	11.34	13.28	18.48
Calculated $X^2$	-	12.71379	36.60911	141.6666

Source: Author's Computation

The coefficients with \* are significant at 95 percent level of confidence and the critical value for  $x^2$  is 99 percent level.

It is clear that a model, which allows non-

homotheticity, non-homogeneity, non-unitary elasticities of substitutions, and non Cobb-Douglas model is required to adequately represent the production of layers by the Ghanaian Poultry Industry. This indicates that a model that

has no restrictions on the production function best represents the poultry industry in Ghana.

The computed White Heteroskedasticity Chi-square statistic rejects the null hypothesis of Heteroskedasticity in favour of homoskedasticity at both 99 and 95 percent levels of significance. The calculated Chi-square is greater than the critical Chi-square with 15 degrees of freedom (Appendix 5).

The F-statistic from the Breusch-Godfrey Serial Correlation Lagrange Multiplier Test suggests that the model does not exhibit autocorrelation as the calculated F-value is significant at the 95 percent level (Appendix 6).

The results of the estimated Allen Partial Elasticities of Substitution obtained from the coefficients of the unrestricted model in Table 5.1 and the cost shares in Appendix 7 are presented in Table 5.2 below.

**Table 5.2 Results of Estimates of Allen Partial Elasticity of Factor Substitution**

	Institutional credit	Labor	Vaccine	Feed
Institutional credit	-4.92	3.17	2.38	0.40
Labor		-54.50	1.57	0.65
Vaccine			-8.97	1.73
Feed				-5.63

Source: Author's Computation \*The unfilled spaces are due to elasticities of substitution being symmetric. The own elasticity of substitution has little economic meaning except that it is used in computing own price elasticity of demand.

Symmetry requires that the matrix of the share elasticities must be symmetric, which condition is met. Linear homogeneity is an imposed constraint and thus this condition is satisfied. Additional regularity conditions that the cost function must satisfy in order to correspond to a well-behaved production structure are positivity and concavity in factor prices. The positivity condition is satisfied if the fitted cost shares for each observation are positive. This condition is not met at every data point as both positive and negative values are obtained.

Concavity requires that the principal minors of the Hessian matrix of the second-order partial derivatives be negative definite (i.e., alternate in sign starting with negative) or the symmetric matrix of the Allen Partial Elasticities of Substitution (AES) must be negative definite. A necessary condition for the matrix to be negative semi-definite is that all the own AES be negative. This condition is satisfied because the AES is symmetric and negative semi-definite as shown in Table 5.2. This shows that the derived demand curves will be downward sloping.

The estimates of the Allen Partial Elasticities of Substitution along with the cost shares are used to obtain own and cross price elasticities of input demand and the results presented in Table 5.3 below.

**Table 5.3 Results of Price Elasticities of Input Demand**

	Price of Institutional credit	Price of Labor	Price of Vaccine	Price of Feed
Institutional credit	-1.16	0.13	0.02	0.15
Labor	0.75	-2.34	0.54	0.24
Vaccine	0.56	0.07	-3.93	0.65
Feed	0.10	0.03	0.60	-2.13

Source: Author's Computation. The elasticities are computed using the mean share values

Own price elasticities of demand from Table 5.3 show the expected negative sign, and in each case demand is shown to be relatively highly elastic with respect to the input's own price.

The results of the study suggest that over the study period 1988-1999, firstly, a 10 percent increase/decrease in the price of vaccines, *ceteris paribus*, stimulates a 39.3 percent decrease/increase in the quantity demand.

Similarly a 10 percent increase/decrease in the price of labor leads to a 23.4 percent fall/rise in the quantity demand.

Furthermore, a 10 percent increase/decrease in the price of institutional credit precipitates/stimulates an 11.6 percent quantity demand of institutional credit from banks.

Finally, a 10 percent increase/decrease in the price of feed leads to a fall/rise in the quantity demand by 21.3 percent.

Given that the inputs are price elastic coupled with the phenomenal increases in the prices of inputs, especially vaccines and feed instead of producers operating at an optimum, they rather tend to operate under capacity. This explains why local production of poultry meat is not meeting the local market demand.

The results of estimates of scale elasticities, which indicate economies of scale using the coefficients of the unrestricted model, are given in Table 5.4 below.

**Table 5.4 Results of Scale Elasticities**

Year	Scale Elasticities
1988	-1.965
1989	-2.123
1990	-0.656
1991	1.965
1992	1.085
1993	-4.076
1994	2.508
1995	3.749
1996	5.168
1997	4.465
1998	5.938
1999	5.983

Source: Author's Computation

The accepted model rejecting the homotheticity then shows that as scale is changed the relative shares of the inputs in the production process are also changed.

A positive value of scale elasticity indicates economies of scale and a negative value indicates diseconomies of scale. The interpretation of scale economies for the translog function is in terms of total

cost changes as output is varied. It is observed from Table 5.4 that from 1988 to 1990 and 1993 the scale elasticities are negative, which means diseconomies of scale for the poultry industry. It can be conjectured that the rise in total cost is more than proportionate relative to the rise in output. In other words the industry is not operating on the downward sloping portion of the long run average cost curve rather the upper part of the curve where average cost increases with increase in output. The years 1991, 1992 and from 1994 to 1999, scale elasticity values are positive for each year. This indicates positive economies of scale with a decrease in average variable cost with increase in output when varied and the industry is operating on the flat and downward sloping part of the long run average cost curve.

The implication of this is that the industry is on average, operating in an environment where there are cost advantages to increasing the scale of the business.

It is therefore reasonable to state that over the twelve-year period, the poultry industry experienced eight years of positive economies of scale. This observation is made taking cognisance of the facts that removal of subsidies and the nominal exchange rate depreciations tended to stimulate phenomenal increases in the price of inputs especially vaccines and feed which are generally imported.

The obvious explanation to these positive economies of scale is the purchase of inputs in bulk from the manufacturers and also the introduction of high-tech into the operations of the poultry industry, which in no doubt are cost advantages. These obviously led to minimisation of costs with rather marginal increases in output although not commensurate enough to meet the market demand.

The diseconomies of scale may be mainly due to obsolete technology.

The increasing values of scale elasticity over the period indicate that scope for making economies of scale has been increasing over the period this study.

## CHAPTER SIX

### SUMMARY, CONCLUSION AND RECOMMENDATION

The purpose of this study has been to find out why local production of poultry does not meet the local demand. This was done by determining the responsiveness of poultry inputs in the production of live layer birds to price and also the economies of scale of layer production in the Ghanaian Poultry Industry using econometric analysis. This has been done with the use of a translog cost function. First, the cost equation and the cost shares were jointly estimated for efficient estimates, using one of the maximum likelihood estimators known as seemingly unrelated regression. These estimates were then used to compute Allen Partial Elasticities of Substitution, which were then employed for the computations of own price elasticities, cross price elasticities of demand and finally scale economies. The price elasticities were then used to estimate the changes in expenditures of the inputs. A summary of the results of the analysis as well as conclusions and recommendations for considerations by policy makers are presented below.

### **Summary**

The results show that the production structure of the poultry firms in Ghana analyzed, over the period 1988 to 1999 appear to be best represented by a production function which does not assume homotheticity, homogeneity, unitary elasticity or Cobb-Douglas but rather a Constant Elasticity of Substitution production function. The matrix of the share elasticities is symmetric. Inputs were found to be highly elastic which means that when their price rise the quantity demanded drastically fell. The relatively high price elasticities of the inputs led to decreases in the expenditures of the inputs indicating non-optimum production by poultry firms.

For three continues years running specifically from 1988 to 1990, there were diseconomies of scale in the industry but economies of scale started setting in from 1991 to 1999 with the exception of 1993 where diseconomies of scale was again exhibited. This positive economies of scale indicates that the industry is operating on the flat and downward sloping part of the long run average cost curve. This indicates cost advantages to the industry, which increases the scale of the business. Scope for making positive economies of scale has been increasing over this period.

**Policy recommendation**

From the empirical results obtained, it is first of all recommended that, domestic macroeconomic balance must be achieved so as to reduce drastically the rate of nominal exchange rate depreciation as complete liberalisation of the poultry inputs market per se, in the face of flexible foreign exchange rate regime characterised by daily or weekly significant nominal exchange rate depreciations is not expedient, since the bulk of poultry inputs are imported.

Next, appropriate channels for input distribution must be sought so that supply and distribution of inputs would be improved by fostering support among all relevant stakeholders. Specifically, it is imperative that financial institutions are made to help importers/suppliers to procure inputs in bulk so that some more economies of scales could be achieved. The distribution of poultry pharmaceuticals must be carefully monitored to ensure the prompt delivery at places where they are needed. In other to reduce the high cost of vaccines/drugs, Government must encourage more private participation in their delivery.

Thirdly, given the role institutional credit plays in agricultural development in Ghana, an Agricultural Development Fund must be set up. This fund must be given to

banks as well as agricultural mortgages and leasing companies which should in turn lend it for agricultural purposes. The fund must also ensure that institutions guaranteeing agricultural credit have the necessary resources to do so. Government must develop the financial institutions and provide specialised financials to poultry firms.

Fourthly, market-based input and output pricing policies must be put in place, which would be expected to influence the pricing of agricultural technology.

Finally the production of locally made vaccines and good quality feed at low cost using local materials would go a long way to help the poultry industry. For this policy to be realised, it is imperative to financially resource Research Organisations and adequately remunerate their scientific staff to take up the task of researching and coming out with the standard vaccines/drugs and good quality feed.

## APPENDIX 1

Results for unrestrained model but with symmetry

Estimation Method: Iterative Seemingly Unrelated Regression

Sample: 1988 1999

Convergence achieved after 25 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-223.0480	85.97734	-2.594265	0.0140
C(3)	0.967126	0.342652	2.822473	0.0080
C(4)	-4.189959	2.359052	-1.776120	0.0849
C(5)	4.364641	1.140955	3.825428	0.0006
C(6)	36.31555	14.21874	2.554062	0.0154
C(7)	-3.111515	1.188683	-2.617615	0.0133
C(22)	-0.049833	0.015785	-3.156999	0.0034
C(23)	0.066338	0.032629	2.033108	0.0501
C(24)	-0.037176	0.025004	-1.486813	0.1466
C(33)	-0.840571	0.243058	-3.458322	0.0015
C(34)	0.662128	0.113797	5.818487	0.0000
C(44)	-0.571605	0.082412	-6.935979	0.0000
C(46)	-0.012564	0.014275	-0.880133	0.3852
C(47)	-0.090686	0.113309	-0.800337	0.4292
C(48)	0.049320	0.052215	0.944563	0.3517
Determinant residual covariance			4.74E-08	

Equation:  $LTC=C(1)+C(3)*U+C(4)*V+C(5)*W+C(6)*LQT$   
 $+C(7)*((0.5)*(LQT^2))+C(22)*((0.5)*(U^2))+C(23)*U*V+C(24)*U*$   
 $+C(33)*((0.5)*(V^2))+C(34)*V*W+C(44)*((0.5)*(W^2))+C(46)*LQT*U$   
 $+C(47)*LQT*V+C(48)*LQT*W$

Observations: 12

R-squared	-0.005704	Mean dependent var	9.816145
S.D. dependent var	2.495149	Sum squared resid	68.87407
Durbin-Watson stat	1.852883		

Equation:  $SL=C(3)+C(22)*U+C(23)*V+C(24)*W+C(46)*LQT$ 

Observations: 12

R-squared	0.025194	Mean dependent var	0.040284
Adjusted R-squared	-0.531837	S.D. dependent var	0.039076
S.E. of regression	0.048363	Sum squared resid	0.016373
Durbin-Watson stat	1.127279		

Equation:  $SV=C(4)+C(23)*U+C(33)*V+C(34)*W+C(47)*LQT$ 

Observations: 12

R-squared	0.546513	Mean dependent var	0.344786
Adjusted R-squared	0.287377	S.D. dependent var	0.483292
S.E. of regression	0.407980	Sum squared resid	1.165135
Durbin-Watson stat	1.470962		

Equation:  $SF=C(5)+C(24)*U+C(34)*V+C(44)*W+C(48)*LQT$ 

Observations: 12

R-squared	0.741830	Mean dependent var	0.378480
Adjusted R-squared	0.594304	S.D. dependent var	0.289656
S.E. of regression	0.184495	Sum squared resid	0.238268
Durbin-Watson stat	1.370470		



## APPENDIX 2

Results when c(46), (47), (48) are dropped to test homotheticity

Estimation Method: Iterative Seemingly Unrelated Regression

Sample: 1988 1999

Convergence achieved after 35 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-372.5472	66.62768	-5.591478	0.0000
C(3)	1.269226	0.286064	4.436856	0.0001
C(4)	-5.641706	1.090467	-5.173661	0.0000
C(5)	5.107874	0.764444	6.681812	0.0000
C(6)	59.47583	11.53507	5.156088	0.0000
C(7)	-4.921807	1.000549	-4.919106	0.0000
C(22)	-0.082635	0.016051	-5.148189	0.0000
C(23)	0.075941	0.031422	2.416800	0.0209
C(24)	-0.059881	0.026655	-2.246541	0.0309
C(33)	-0.919570	0.190277	-4.832810	0.0000
C(34)	0.689474	0.096071	7.176739	0.0000
C(44)	-0.553930	0.075319	-7.354430	0.0000

Determinant residual covariance 8.88E-08

Equation: LTC=C(1)+C(3)\*U+C(4)\*V+C(5)\*W+C(6)\*LQT

+C(7)\*((0.5)\*(LQT^2))+C(22)\*((0.5)\*(U^2))+C(23)\*U\*V+C(24)\*U\*W

+C(33)\*((0.5)\*(V^2))+C(34)\*V\*W+C(44)\*((0.5)\*(W^2))

Observations: 12

R-squared	-0.668765	Mean dependent var	9.816145
S.D. dependent var	2.495149	Sum squared resid	114.2827
Durbin-Watson stat	2.266097		

Equation: SL=C(3)+C(22)\*U+C(23)\*V+C(24)\*W

Observations: 12

R-squared	-0.298820	Mean dependent var	0.040284
Adjusted R-squared	-0.785878	S.D. dependent var	0.039076
S.E. of regression	0.052219	Sum squared resid	0.021815
Durbin-Watson stat	1.225278		

Equation: SV=C(4)+C(23)\*U+C(33)\*V+C(34)\*W

Observations: 12

R-squared	0.521613	Mean dependent var	0.344786
Adjusted R-squared	0.342218	S.D. dependent var	0.483292
S.E. of regression	0.391968	Sum squared resid	1.229110
Durbin-Watson stat	1.472920		

Equation: SF=C(5)+C(24)\*U+C(34)\*V+C(44)\*W

Observations: 12

R-squared	0.722206	Mean dependent var	0.378480
Adjusted R-squared	0.618033	S.D. dependent var	0.289656
S.E. of regression	0.179018	Sum squared resid	0.256379
Durbin-Watson stat	1.319500		

Wald Test:

Null Hypothesis: C(46)=0

C(47)=0

C(48)=0

Chi-square	12.71379	Probability	0.005298
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## APPENDIX 3

Results when c(7), (46), (47), (48) are dropped to test homogeneity

Estimation Method: Iterative Seemingly Unrelated Regression

Sample: 1988 1999

Convergence achieved after 25 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-38.31577	6.542823	-5.856153	0.0000
C(3)	1.253976	0.346815	3.615695	0.0009
C(4)	-4.268080	1.073943	-3.974213	0.0003
C(5)	4.411586	0.733448	6.014858	0.0000
C(6)	2.107219	0.521535	4.040414	0.0003
C(22)	-0.106419	0.024471	-4.348846	0.0001
C(23)	0.056772	0.034160	1.661920	0.1050
C(24)	-0.023152	0.030271	-0.764826	0.4492
C(33)	-0.597665	0.183174	-3.262830	0.0024
C(34)	0.558653	0.093137	5.998190	0.0000
C(44)	-0.523795	0.074380	-7.042158	0.0000

Determinant residual covariance 2.50E-07

Equation: LTC=C(1)+C(3)\*U+C(4)\*V+C(5)\*W+C(6)\*LQT  
 $+C(22)*((0.5)*(U^2))+C(23)*U*V+C(24)*U*W+C(33)*((0.5)*(V^2))$   
 $+C(34)*V*W+C(44)*((0.5)*(W^2))$

Observations: 12

R-squared	-1.196980	Mean dependent var	9.816145
Adjusted R-squared	-23.166779	S.D. dependent var	2.495149
S.E. of regression	12.26608	Sum squared resid	150.4567

Durbin-Watson stat 0.765281

Equation: SL=C(3)+C(22)\*U+C(23)\*V+C(24)\*W

Observations: 12

R-squared	-0.451914	Mean dependent var	0.040284
Adjusted R-squared	-0.996382	S.D. dependent var	0.039076
S.E. of regression	0.055211	Sum squared resid	0.024386

Durbin-Watson stat 0.988583

Equation: SV=C(4)+C(23)\*U+C(33)\*V+C(34)\*W

Observations: 12

R-squared	0.346503	Mean dependent var	0.344786
Adjusted R-squared	0.101442	S.D. dependent var	0.483292
S.E. of regression	0.458123	Sum squared resid	1.679015

Durbin-Watson stat 0.859220

Equation: SF=C(5)+C(24)\*U+C(34)\*V+C(44)\*W

Observations: 12

R-squared	0.627175	Mean dependent var	0.378480
Adjusted R-squared	0.487366	S.D. dependent var	0.289656
S.E. of regression	0.207390	Sum squared resid	0.344083

Durbin-Watson stat 0.832771

Wald Test:

Null Hypothesis: C(7)=0

C(46)=0

C(48)=0

C(47)=0

Chi-square	36.60911	Probability	0.000000
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## APPENDIX 4

Results when c(23), (24), (34) are dropped to test unitary elasticity

Estimation Method: Iterative Seemingly Unrelated Regression

Sample: 1988 1999

Convergence achieved after 85 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	50.30572	77.49714	0.649130	0.5204
C(3)	-0.342016	0.185155	-1.847192	0.0730
C(4)	6.297324	1.806190	3.486523	0.0013
C(5)	-1.204873	0.899543	-1.339428	0.1888
C(6)	-5.063512	12.97722	-0.390185	0.6987
C(7)	0.234031	1.086180	0.215463	0.8306
C(22)	0.051869	0.019606	2.645531	0.0120
C(33)	0.402317	0.062769	6.409495	0.0000
C(44)	-0.237552	0.056451	-4.208126	0.0002
C(46)	-0.008703	0.009762	-0.891494	0.3786
C(47)	-0.448664	0.147932	-3.032913	0.0045
C(48)	0.246141	0.077516	3.175341	0.0031
Determinant residual covariance			3.16E-07	
Equation: LTC=C(1)+C(3)*U+C(4)*V+C(5)*W+C(6)*LQT				
+C(7)*((0.5)*(LQT^2))+C(22)*((0.5)*(U^2))+C(33)*((0.5)*(V^2))				
+C(44)*((0.5)*(W^2))+C(46)*LQT*U+C(47)*LQT*V+C(48)*LQT*W				
Observations: 12				
R-squared	-0.115789	Mean dependent var	9.816145	
S.D. dependent var	2.495149	Sum squared resid	76.41307	
Durbin-Watson stat	1.306384			
Equation: SL=C(3)+C(22)*U+C(46)*LQT				
Observations: 12				
R-squared	0.198189	Mean dependent var	0.040284	
Adjusted R-squared	0.020008	S.D. dependent var	0.039076	
S.E. of regression	0.038683	Sum squared resid	0.013467	
Durbin-Watson stat	1.256407			
Equation: SV=C(4)+C(33)*V+C(47)*LQT				
Observations: 12				
R-squared	-0.279461	Mean dependent var	0.344786	
Adjusted R-squared	-0.563786	S.D. dependent var	0.483292	
S.E. of regression	0.604363	Sum squared resid	3.287291	
Durbin-Watson stat	1.028838			
Equation: SF=C(5)+C(44)*W+C(48)*LQT				
Observations: 12				
R-squared	0.061753	Mean dependent var	0.378480	
Adjusted R-squared	-0.146747	S.D. dependent var	0.289656	
S.E. of regression	0.310182	Sum squared resid	0.865916	
Durbin-Watson stat	1.052648			
Wald Test:				
Null Hypothesis: C(23)=0				
C(24)=0				
C(34)=0				
Chi-square	101.4393	Probability	0.000000	

**APPENDIX 5**

White Heteroskedasticity Test:

F-statistic	0.427170	Probability	0.848147
Obs*R-squared	7.893599	Probability	0.544904

Test Equation:

LS // Dependent Variable is RESID<sup>2</sup>

Sample: 1988 1999

Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.854895	4.017816	0.461668	0.6897
RESID2	-29.02330	137.9134	-0.210446	0.8528
RESID2 <sup>2</sup>	-4088.752	6695.950	-0.610631	0.6036
RESID2*RESID3	-87.24477	3309.126	-0.026365	0.9814
RESID2*RESID4	2662.817	6886.905	0.386649	0.7363
RESID3	0.502698	37.73479	0.013322	0.9906
RESID3 <sup>2</sup>	-39.94736	258.2160	-0.154705	0.8913
RESID3*RESID4	-98.83246	1018.410	-0.097046	0.9315
RESID4	-12.30790	54.91006	-0.224146	0.8435
RESID4 <sup>2</sup>	-402.2686	1927.796	-0.208668	0.8540
R-squared	0.657800	Mean dependent var		1.877013
Adjusted R-squared	-0.882100	S.D. dependent var		3.490075
S.E. of regression	4.788022	Akaike info criterion		3.007142
Sum squared resid	45.85032	Schwarz criterion		3.411231
Log likelihood	-25.07011	F-statistic		0.427170
Durbin-Watson stat	3.232687	Prob(F-statistic)		0.848147

**APPENDIX 6**

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.204441	Probability	0.308747
Obs*R-squared	1.761643	Probability	0.184420

Test Equation:

LS // Dependent Variable is RESID

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID6	17.22307	34.04801	0.505847	0.6285
RESID7	2.977373	7.667754	0.388298	0.7093
RESID8	1.602716	15.00747	0.106795	0.9179
C	-0.027257	0.478959	-0.056909	0.9562
RESID(-1)	-0.452279	0.412110	-1.097470	0.3087
R-squared	0.146804	Mean dependent var	-7.40E-17	
Adjusted R-squared	-0.340737	S.D. dependent var	1.430961	
S.E. of regression	1.656913	Akaike info criterion	1.304250	
Sum squared resid	19.21753	Schwarz criterion	1.506294	
Log likelihood	-19.85276	F-statistic	0.301110	
Durbin-Watson stat	2.089931	Prob(F-statistic)	0.868448	

## APPENDIX 7

**TOTAL COST, COST SHARES AND PRICES OF FINANCIAL SERVICES, LABOR, VACCINES AND FED**

YEAR	Total Cost of Inputs	Share of Financial Services	Share of Labor	Share of Vaccines	Share of Feed	Price of Financial Services	Price of Labor	Price of Vaccines	Price of Feed	Output
1988	250174.1304	0.000320	7.68E-05	0.998664	0.000939	28.875	165660	3.5	5800	50459
1989	649261.8536	0.000123	4.97E-05	0.999346	0.0004814	30	291084	3.666667	6000	47844
1990	797641.688	0.000251	7.85E-05	0.999218	0.000453	30	360672	3.833333	6400	76593
1991	754832.0058	0.000529	6.69E-05	0.998761	0.000642	34.67	422544	3.833333	7200	178510
1992	1085.4956	0.515893	0.078672	0.002575	0.402860	29.25	376898.8	3.833333	7800	134373
1993	382.44825	0.282391	0.130476	0.013877	0.573257	33.19	414896.3	7.833333	8000	25100
1994	6099.32146	0.261832	0.031791	0.002828	0.703550	33.21	452893.8	11.33333	9000	206435
1995	5975.62666	0.371108	0.060260	0.012662	0.555970	39.96	490891.3	12	16000	310853
1996	7963.8235	0.321579	0.054758	0.017991	0.60567163	47	528888.7	18.5	17400	486090
1997	9597.9638	0.345177	0.046381	0.020394	0.588048	41.67	566886.2	20.66667	22000	387076
1998	14279.0999	0.473792	0.04101	0.025919	0.459279	40.66	604883.7	22.66667	30000	622394
1999	14175.1017	0.264407	0.039792	0.045193	0.650607	35.401	642881.2	30	32000	625300

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