The Effects of High Input Costs on Broiler Farm Productivity in Nigeria: A Dynamic Modelling Approach

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Introduction

Food systems in Sub Saharan Africa (SSA) have transformed rapidly over the last two decades driven in part by increased incomes, rapid urbanization, and a reduction in consumer transaction costs. As a result, diets have diversified from largely starchy staples to an increased consumption of animal proteins (Tschirley et al. 2015; Reardon et al. 2009). Given these expectations about the consumers, the future of Nigerian livestock value chains is moving towards rapid growth and continued structural change.

Although different types of meat remain relevant in Africa and Nigeria, no other production has skyrocketed at a faster rate than poultry. As poultry farms transition from isolated, backyard farming to large-scale farms they face a developing subsector with limited coordination mechanisms to help procure necessary inputs (feed and electricity) at efficient prices.

The purpose of this paper is to study the effect of inputs of production on the productivity and profitability of poultry farmers using a dynamic programing algorithm.

This article makes two key contributions to the Nigerian poultry literature:

1. **Estimate a dynamic model** on decision making, as opposed to the standard static regression.
2. Analyze the effect of **all of energy costs** in the analysis of profitability

The Nigerian Poultry Sector

The poultry value chain is comprised of maize farmers, maize wholesalers, and feed mills, followed by the middle-downstream nodes: poultry famers and retail outlets. Farmers sell maize to local traders and wholesalers who then sell it to feed mills. Poultry famers purchase maize and pre-made, packaged feed from millers and grow and sell broilers to different retail outlets.

In Nigeria, the poultry sector is considered a highly commercialized sub-sector of agriculture. The three main breeds of birds farmers in are sample use are Noiler, Arbor Acre Plus and Marshall.

In this paper, we focus on farmers that grow broilers. Feed costs are the primary expense, but as farms continue to grow, we expect energy costs to capture a larger share of the budget.

From our data, **we find that farmers get an average of 5 hours of electricity per day** from the grid and most of the cost of getting more electricity using alternative sources is underestimated.

Theoretical Framework

The farmer decides each period to feed the broilers, sell the batch and restock, or sell and exit the industry. Because of limited capacity, the farmer must sell the current batch of chickens for replacement to take place. The sale decision must be made within T periods because after that time the chickens become too old to be sold as live broilers.

The farmer receives the price $(p_t^B(w_t))$ for each fresh broiler sold as function of its weight (w_t). The farmer will stop the process at a time that maximizes the discounted expected sum of farm profits.

First let s_t, x_t, and r_t be choices of the farmer:

$$s_t = \begin{cases} 0, & \textit{Feed with no replacement} \\ 1, & \textit{Sell with replacement} \\ 1, & \textit{Sell without replacement} \end{cases}$$

The reward function resulting from one broiler $(q_t^B = 1)$ and depended on the combination of actions taken is:

$$\pi_t = \begin{cases} -c\left(1, p_t^f, a_t\right) - F(1, z_t), & s_t = 0 \\ p_t^B(w_t) - p_t^D - c\left(1, p_t^f, a_t = 1\right) - F(1, z_t), & s_t = 1 \\ p_t^B(w_t), & s_t = 2 \end{cases}$$

Where $c\left(q_t^B, p_t^f, a_t\right)$ is a cost function increasing in the quantity of birds and the price of feed (p_t^f). The cost function also depends on the age of the bird, a state variable defined as:

$$a_t = \{1, 2, 3, \ldots, n\}$$

$F(1, z_t)$ is the cost function associated with all sources of electricity as s function of the batch and z_t. We define z_t as a vector of energy prices such that $z_t = \{\alpha_t, \gamma_t, \delta_t\}$ where α_t corresponds to the price of electricity from the grid, γ_t is the price of fuel, and δ_t is the price of diesel. Prices are determined by a Markov probability process.

We solve this problem recursively using the dynamic program algorithm. To find the current period value function in an infinite horizon model, we assume a fixed terminal period T and start iterating backwards in time using Bellman's equation.

Data Sources

To parametrize the model we will be leveraging on two data sets:

1. Cross Sectional Data on Non-Household Farms:

- Data collection: Sept. 2017- Nov. 2017
- Listing of all non-household farms in the 11 Local Government Area (LGA) of Greater Ibadan
- Based on the Poultry Association of Nigeria classification: 236 farms are small, 203 medium, and 42 large

2. One Year Weekly Panel on 100 Random Farms:

- Data collection: June 2017-June 2018
- From the total sample of non-household farms, we randomly selected 100 farms
- Weekly data on input and output prices

Parametrization

Table 1: Parametrization of Sell-Feed Model

Parameter	Description	Base Value
β	Weekly discount rate	0.98
$w_t(a_t = 1)$	Initial weight of day old chick	1
$\overline{a_t}$	Maximum age of the bird (weeks)	14
$\tilde{v}$	One-time cost of vaccinating day-old chicks	100 NGN
$\overline{w_t}$	Maximum weight of the bird	2.65
s	Shape parameter of the logistic growth function	0.58

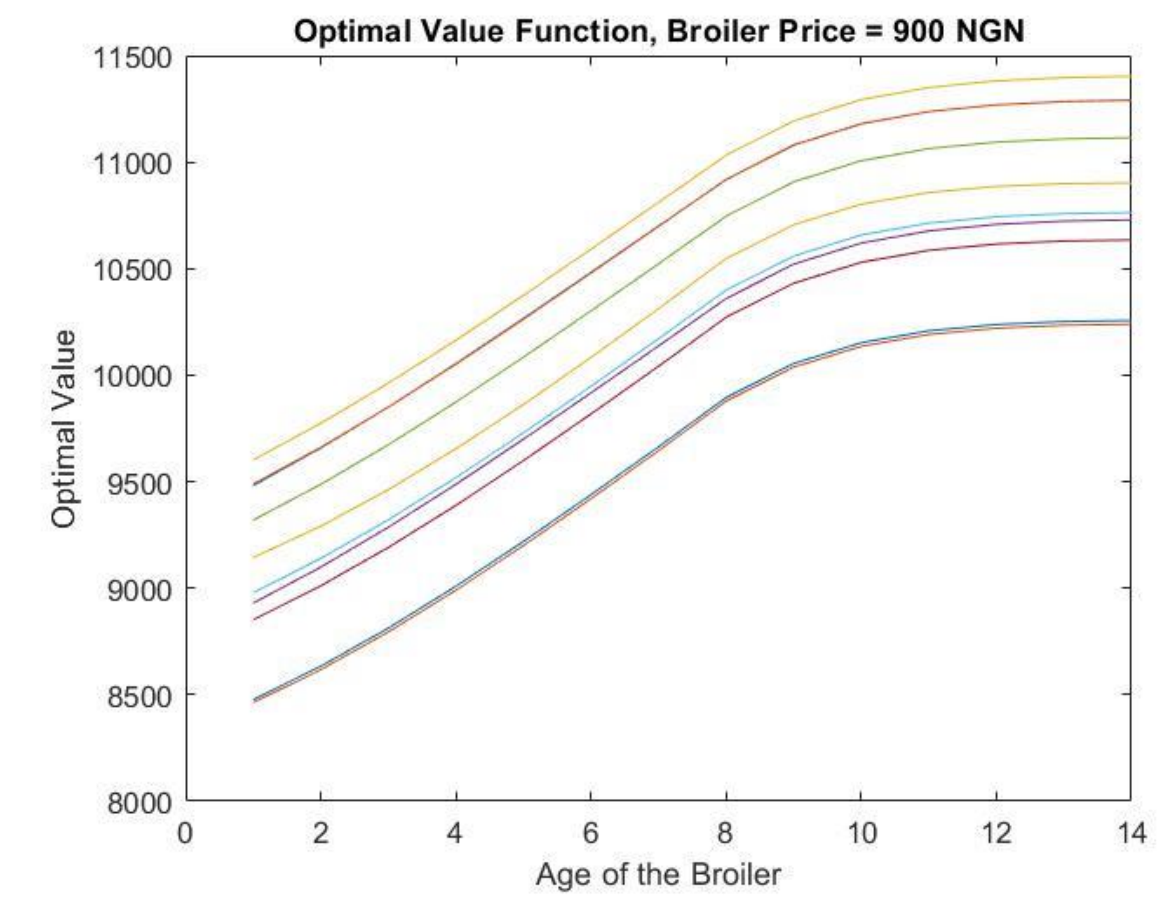
Table 2: Model Components

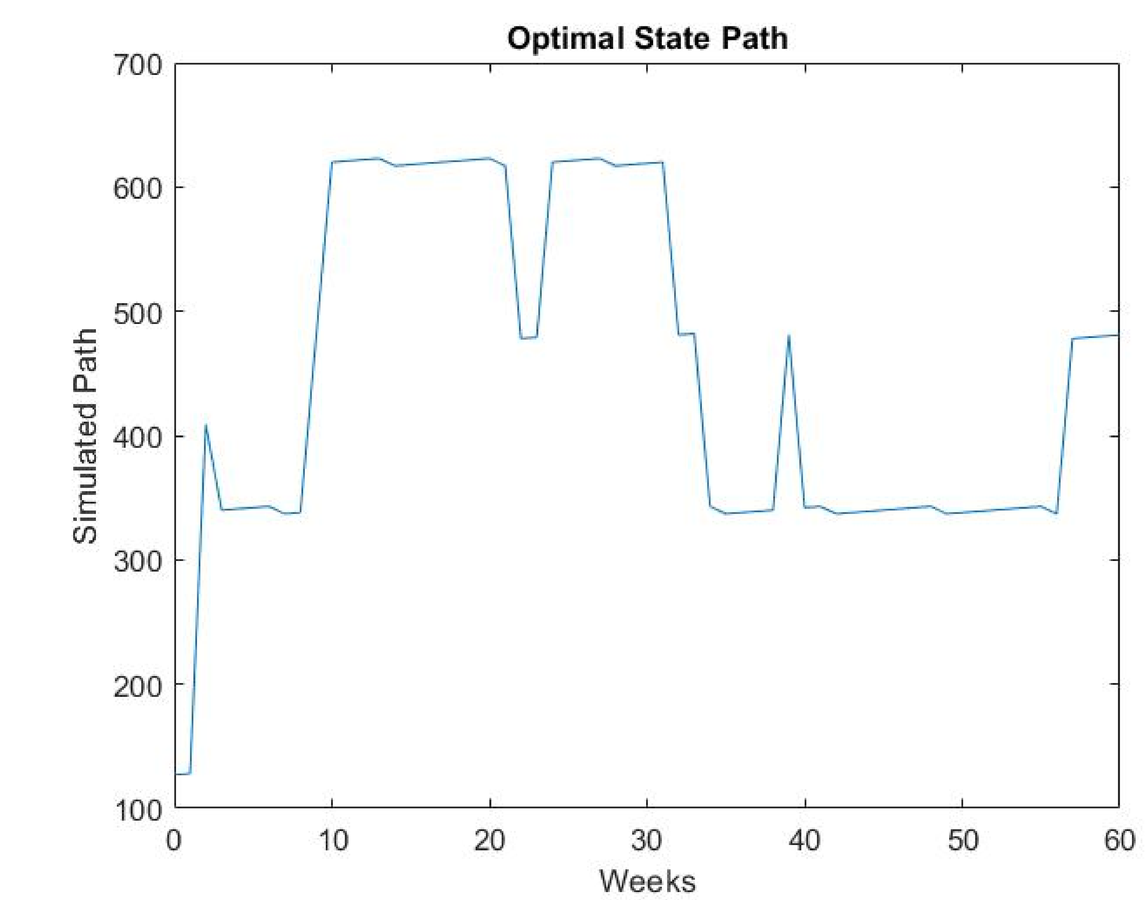
State Space	Age (Weeks)	$a_t = [1:14]$
	Feed Prices (NGN)	p^f =[116, 128, 130, 136, 140, 144, 160, 164, 170, 176, 200]
	Broiler Prices (NGN)	$p^B = [900,1000,1100,1200,1300]$
Action Space	Sell or Feed	"S"- Sell or "F"- Feed
Reward Function	If "S"	$f = p_t^B(w_t) - p_t^D - c\left(q^f(1),\ p_t^f\right) - v$
	If "F"	$f = -c\left(q^f(a_t),\ p_t^f\right)$
	If "S, Exit"	$p_t^B(w_t)$
State Transition Equations	Age	$a_{t+1} = \begin{cases} a_t + 1, & if\ \text{"F"} \\ 1, & if\ \text{"S"} \end{cases}$

Preliminary Results

- **Generally, it is optimal to sell the chicken when it is 7 weeks old**
- This time varies between 7-8 weeks depending on what price state we are in
- If broiler and feed prices are low, the farmer's optimal policy is to keep the chicken 8 weeks
  - If feed prices increase, farmers sell in week 7
  - This shift between 7-8 weeks disappears when broiler prices are high; then the farmer always sells in week 7

Optimal Value Path





Discussion

Our study has important implications for the Nigerian population. If farmers can invest in their poultry enterprise and expand their supply, this will make chicken more affordable and available to Nigerians.

The consumption of poultry is associated with many health benefits such as a reduction of cardiovascular disease, type 2 diabetes and a source of essential nutrients and protein (Marangoni et al. 2015). However, the improvement of the value chain and the potential health implications of expanding chicken production and consumption hinge on the stable supply of inputs such as electricity and feed.

As Nigeria moves towards development of strong production processes, reevaluation and research on the roles of various inputs across value chain becomes essential.