Optimizing Harvest Dates in Philippine Commercial Poultry Farming

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Abstract—**This paper examined how the cleaning period in commercial and contract poultry raising can be improved such that the poultry collected at the end of the growing cycle can be sold at a higher market price. A dynamic programming model was formulated that is able to alter the dates of the harvest and position them to periods with high market price for poultry. The recommended plan improved total profit for the studied case in the Philippines by about 20.92%.**

***Index Terms*— dynamic programming, poultry farming, workforce sizing**

I. INTRODUCTION

Poultry farming is defined as raising poultry animals, such as chickens, turkeys, ducks, geese, commercially or domestically for the purpose of farming meat or eggs for consumption [1]. The term "poultry" refers to a category of domesticated birds typically bred for the purpose of collecting their eggs, meat or feathers. Several techniques in poultry farming are being practiced depending on breed, farm size, season, among many other factors.

Villanueva Poultry Farm located in San Ildefonso, Bulacan in the country of the Philippines uses commercial growing and contract growing techniques in raising poultry, particularly, chickens. These techniques are somewhat similar in procedure and are common in farms aiming to collect volumes of poultry products. Chickens are housed in a special temperature-controlled building where they are raised, fed and given medications to avoid contracting diseases and promote gains in weight. The difference between these two techniques is in the acquisition of the chicks to be raised. In commercial growing, the farm takes care of the acquisition of the chicks to be raised, and usually all of the feeds, and the medicines to be given, and later on, of finding the buyers of its poultry; in contract growing, all of these are provided for by an integrator, commonly large poultry companies.

Growing cycle starts from the delivery of the chicks to the farm up to the harvesting day. The time required to raise the chicks until they are ready to be harvested is approximately constant at 42 days for every growing cycle, based on historical data. When ready to be harvested (usually, when the chickens reach a live weight base of 1.5 kilograms), the integrator collects the chickens and immediately moves them to their dressing and processing plants and labeled and sold later as their own products. The sole buyer in contract growing is the integrator. In this case, profit is only dependent on the average weight of the chicken and not on the state of the market. The grower's fee to be received by the farm depends on the scheme agreed upon with the integrator. Contract growing has an advantage during lean seasons (when prices are also low) but a disadvantage during peak seasons (when prices are also high) due to the fixed grower's fee per chicken. Costs shouldered by the raiser in contract growing include building rent, and other operational expenses such as electricity, water consumption, and labor.

Subsequent to every growing cycle are cleaning periods wherein the farm spends approximately two weeks to prepare the site for the next growing cycle. Possible traces of contamination are cleared to avoid exposure to chicks that are more vulnerable to diseases than adult chickens. The farms' floor layout may also be rearranged to make it appropriate for the start of the brooding period.

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The Villanueva Poultry Farm (later on referred to as the “Farm”) uses both commercial and contract growing procedures to take advantage of the price stability under contract growing and the price increases under commercial growing at the same time. The same feeding specifications and supplement schedules are followed for both commercial growing and for contract growing. Market prices of poultry can differ substantially per period within the year. While selling during a period with high market price is desired, the farm sells during the period when the harvest falls to immediately start the next growing period. In the case presented in this paper, both techniques are considered in the cost evaluation.

II. STATEMENT OF THE PROBLEM

The growing and cleaning cycles repeat successively several times in a year, with the harvest occurring at the immediately after the growing period has ended. Because of the fluctuations in the market selling price of chicken under commercial growing, a poultry raiser always runs the risk of achieving lower profit when harvest falls during the period with low market price. Since the growing period cannot be altered at this point, this paper examines how the cleaning cycle can be improved (shortened or lengthened) such that the harvest by the end of the growing cycle falls in a high price period.

III. OBJECTIVES OF THE STUDY

This paper aims to draw a schedule for the cleaning period which can move the growing cycles backward or forward within the year, thus altering the date of the harvest period at the end of each cycle. The constructed schedule shall give optimum profitability for the farm.

IV. ASSUMPTIONS

For this paper, the following assumptions were made:

1. The growing cycle is assumed to be constant at 42 days.
2. Workers share the same amount of work during the cleaning period. Furthermore, the share of work of each worker is proportional to the number of workers during the cycle.
3. Each worker must be individual equipped with machines.

V. MODEL FORMULATION

A. Determination of Relevant Parameters and Variables

The following cash flows were determined relevant in the farm throughout the growing-cleaning cycles for both commercial and contract growing. Data gathered from the most recent cycle of the farm were used.

R_T = Revenues from Contract Growing
R_M = Revenues from Commercial Growing
C_T = Costs incurred in Commercial Growing only
C_M = Costs incurred in Contract Growing only
C_{TM} = Costs incurred in both Commercial and Contract Growing

Hence, total profit can be computed as

$$P_r = R_T + R_M - C_T - C_M - C_{TM} \tag{1}$$

Each of these revenues and costs terms were evaluated for the case of Villanueva Poultry Farm and the figures presented are in Philippine Peso (PhP) currency. Obtaining the expressions for each parameter in (1) are illustrated in the succeeding sections.

B. Revenues from Contract Growing

It is important to note that revenues from Contract Growing depend on the agreement or scheme established by the integrator and the farm. The components common in the revenues of Villanueva Poultry Farm from contract growing are given in Table I.

Table I Components of R_T

R_T Components	**Value**
Chick-in Quantity	17,000
Recovery Percentage	95%
Average Harvest Weight	1.6 kg
Feed Conversion Ratio (FCR)	1.921
Per Head Medicine Purchases	(Php 1.00)
Computed Monthly Feed Cost (CMFC)	Php 11,500.00
Per Head Medicine Rebate	Php 1.00
Grower's Fee (at Php 6.75 / head in this scheme)	Php 109,012.00
Mortality Incentive (at Php 3.25 / head in this scheme)	52,487.50
Uniformity Bonus	8,054.50
Feed Rebate	22,091.50
MedVac Purchases	(17,000.00)
Miscellaneous	(5,000.00)
Medicine Rebates	16,150.00
R_T	**Php 185, 796.00**

C. Revenues from Commercial Growing

The revenue from commercial growing is simply the total average live weight per growing cycle multiplied by the per-kilogram price of poultry as shown in Table II.

Table II Components of R_M

R_M **Components**	**Value**
Chick-in Quantity	5,000
Recovery Percentage	95%
Average Harvest Weight	1.6 kg

Define P_i as the market price of chicken harvested from growing cycle i. Total revenues from commercial growing can then be computed as follows:

$$R_T = (\text{Chick - in quantity}) \times (\text{Recovery percentage}) \times (\text{Average harvest weight}) \times P_i \quad (2)$$

$$R_T = 5000 \times 0.95 \times 1.6 \times P_i = 7600 \times P_i \quad (3)$$

Using the average farm gate price data from 1978 to 2006 acquired from the Bureau of Animal Industry in the Philippines [7], the forecast poultry prices for 2008 in Philippine pesos are given in Table III.

Table III Forecast Prices in PhP for 2008

Month	Calendar Day	P_i
January	1 – 31	67.97
February	32 – 59	63.25
March	60 – 90	60.09
April	91 – 120	65.10
May	121 – 151	72.60
June	152 – 181	70.34
July	182 – 212	71.03
August	213 – 243	67.92
September	244 – 273	64.72
October	274 – 304	65.30
November	305 – 334	65.40
December	335 – 365	71.31

D. Costs from Contract Growing

While the integrator supplies the chicks and feeds under contract growing, no costs are incurred by the farm in contract growing.

E. Costs from Commercial Growing

The costs incurred in commercial growing only (per grow) are given in Table IV.

Table IV Components of C_M

C_M **Components**	**Value**
Chick Purchases (5000 *PhP 25.00)	PhP 125,000.00
Feed Purchases (60 *5 * PhP 930.00)	279,000.00
MedVac Purchases	5,000.00
C_M	**PhP 409,000.00**

F. Common Costs

The costs common to both commercial and contract growing are building rent, permanent labor, electricity and water, and the costs to decrease cleaning time per grow.

Define a_i is the the number of additional workers hired (equal to the number of additional equipment rented)

Table V Components of C_{TM}

C_{TM} **Components**	**Value**
Building Rent	PhP 53,000.00
Labor (permanent)	10,000.00
Electricity & Water	12,000.00
Additional costs to decrease cleaning time	
Labor (Php 200.00/day/worker)	200 * a_i
Equipment rent (Php 2000/day)	2,000 * a_i
Total common costs	**75,000 + 2200 * a_i**

At present, two workers (each with separate piece of equipment) are hired to clean and prepare the farm for the next batch of chicks to be raised in-house. The figures in Table VI were computed as the number of days required to clean the site for every additional worker hired (an additional piece of equipment has to be rented for every additional worker hired).

Table VI Computed Length of Cleaning Cycle

Number of additional machines/workers	Number of days required to clean the site
0	14
1	10
2	7
3	6
4	5
5	4

Management suggests the hiring more than 5 workers is unrealistic considering the limitations with regard to accessibility and availability of machines to rent and/or workers to hire. Furthermore, the last day for the growing cycle is set by management to December 8 (or the 342nd calendar day) to give time for the year-end business activities of the farm.

G. Profit from Growing Cycle

Table VII Summary of Cashflows

R_T	PhP 185,796.00
R_M	7600 P_i
C_T	0
C_M	(409,000.00)
C_{TM}	(75,000 + 2,200a_i)

Given the cash flows in the preceding sections, summarized in Table VII, the total profit for a given growing cycle is expressed in (4) as a function of P_i and a_i using (1).

$$\text{Pr}_i = 7600P_i - 2200a_i - 298204 \qquad (4)$$

VI. THE DYNAMIC PROGRAMMING MODEL

Determining the optimal schedule requires optimizing (4) obtained in section V. Since the duration of the cleaning cycle dictates the harvest date and therefore P_i, while this duration is dependent on a_i, optimizing Pr_i is not an easy task. To optimize Pr_i, a dynamic programming (DP) model was formulated

The components of the DP model were defined as follows:

1. Stage i represented the ith growing cycle within the year (i = 1, 2, …, 6)
2. The alternatives, x_i were the number of workers hired (or machines rented) at the end of the ith growing cycle
3. The states are the number of workers hired (or machines rented) at the end of the (i+1)th growing cycle

The recursive function for the dynamic programming model was formulated as follows:

$$f_i(x_i) = \begin{cases} 7600 * P_i - 298204 - (2{,}200 * \lceil 28/(x_i+2) \rceil * x_i) & \text{for } i = 6 \\ 7600 * P_i - 298204 - (2{,}200 * \lceil 28/(x_i+2) \rceil * x_i) + f_{i+1}(x_{i+1}) & \text{for } i < 6 \end{cases} \qquad (5)$$

The term a_i was defined as equal to $\lceil 28 / (x_i + 2) \rceil * x_i$ in the recursive function. The ceiling function denoted by $\lceil 28 / (x_i + 2) \rceil$ is defined as the smallest integer not less than or equal to (28 / (x_i + 2)). This expression denotes the equivalent number of cleaning days if x_i additional workers are hired. Data from past cleaning activities indicate that if 2 workers (no additional worker) are present, it would take 14 days to finish the process.

VII. RESULTS AND DISCUSSIONS

Fig. 1 to Fig. 6 presents the backward pass calculations for the DP model:

x_6	$f_6(x_6)$ = 7600 * Pi - 298204 - (2200 $\lceil 28 / (x_6 + 2) \rceil$ * x_6)	Optimum Solution	
		$f_6(x_6)$	x_7*
0	198836	198836	0
1	176836	176836	1
2	212952	**212952**	2
3	204152	204152	3
4	199752	199752	4
5	199752	199752	5

Fig. 1 DP Calculations in Stage 6

x_5	$f_5(x_5)$ = 7600 * Pi - 298204 - (2200 $\lceil 28 / (x5 + 2) \rceil$ * x5) + $f_6(x_6)$						Optimum Solution	
	x_6=0	x_6=1	x_6=2	x_6=3	x_6=4	x_6=5	$f_5(x_5)$	x_6*
0	392504	374912	411028	402228	397828	397828	**411028**	2
1	374912	352912	389028	380228	375828	375828	389028	2
2	366112	344112	380228	371428	367028	367028	380228	2
3	357312	335312	371428	362628	358228	358228	371428	2
4	352912	330912	367028	358228	353828	353828	367028	2
5	352912	330912	367028	358228	353828	353828	367028	2

Fig. 2 DP Calculations in Stage 5

x_4	f4(x4) = 7600 * Pi -298204 - (2200 $\lceil 28 / (x4 + 2) \rceil$ * x4) + f5(x5)						Optimum Solution	
	x_5=0	x_5=1	x_5=2	x_5=3	x_5=4	x_5=5	$f_4(x_4)$	x_5*
0	629016	607016	598216	589416	585016	585016	**629016**	0
1	607016	585016	576216	567416	563016	563016	607016	0
2	598216	576216	567416	558616	554216	554216	598216	0
3	589416	567416	558616	549816	545416	545416	589416	0
4	585016	563016	554216	545416	541016	541016	585016	0
5	585016	563016	554216	545416	541016	541016	585016	0

Fig. 3 DP Calculations in Stage 4

x_3	$f_3(x_3)$ = 7600 * Pi - 298204 - (2200 $\lceil 28 / (x_3 + 2) \rceil$ * x_3) + $f_4(x_4)$						Optimum Solution	
	x_4=0	x_4=1	x_4=2	x_4=3	x_4=4	x_4=5	$f_3(x_3)$	x_4*
0	865396	843396	834596	825796	821396	821396	**865396**	0
1	843396	821396	812596	803796	799396	799396	843396	0
2	834596	812596	803796	800240	795840	795840	834596	0
3	825796	803796	800240	791440	787040	787040	825796	0
4	821396	799396	795840	787040	782640	782640	821396	0
5	821396	799396	795840	787040	782640	782640	**821396**	0

Fig. 4 DP Calculations in Stage 3

x_2	$f_2(x_2)$ = 7600 * Pi - 173204 - (2200 $\lceil 28 / (x_2 + 2) \rceil$ * x_2) + $f_3(x_3)$						Optimum Solution	
	x_3=0	x_3=1	x_3=2	x_3=3	x_3=4	x_3=5	$f_2(x_2)$	x_3*
0	1061952	1039952	1031152	1022352	1017952	1074952	**1074952**	5
1	1039952	1017952	1066152	1057352	1052952	1052952	1066152	2
2	1031152	1066152	1057352	1048552	1044152	1044152	1066152	1
3	1022352	1057352	1048552	1039752	1035352	1035352	1057352	1
4	1017952	1052952	1044152	1035352	1030952	1030952	1052952	1
5	1074952	1052952	1044152	1035352	1030952	1030952	**1074952**	0

Fig. 5 DP Calculations in Stage 2

x_1	$f_1(x_1) = 7600 * Pi - 173204 - (2200 \lceil 28 / (x_1 + 2) \rceil * x_1) + f_2^*(x_2)$						Optimum Solution	
	$x_2=0$	$x_2=1$	$x_2=2$	$x_2=3$	$x_2=4$	$x_2=5$	$f_1^*(x_1)$	x_2^*
0	1233432	1224632	1224632	1215832	1211432	1233432	**1233432**	0,5
1	1211432	1202632	1202632	1193832	1189432	1211432	1211432	0,5
2	1202632	1193832	1193832	1185032	1180632	1202632	1202632	0,5
3	1193832	1185032	1185032	1176232	1171832	1193832	1193832	0,5
4	1189432	1180632	1180632	1171832	1167432	1189432	1189432	0,5
5	1189432	1180632	1180632	1171832	1167432	1189432	1189432	0,5

Fig. 6 DP Calculations in Stage 1

The DP model produced two optimal sets of decisions as summarized in Table VIII.

Table VIII Optimal Decision at Each Growing Cycle

Cycle	Alternative 1	Alternative 2
1	Do not hire any additional worker.	Do not hire any additional worker.
2	Do not hire any additional worker.	Hire 5 additional workers.
3	Hire 5 additional workers.	Do not hire any additional worker.
4	Do not hire any additional worker.	Do not hire any additional worker.
5	Do not hire any additional worker.	Do not hire any additional worker.
6	Hire 2 additional workers.	Hire 2 additional workers.

If the recommended number of workers is hired for each growing cycle, the expected harvest dates are summarized in Table IX.

Table IX Harvest Schedule

	Alternative 1	Alternative 2
Stage 1	Harvest at day 65 (March 6)	Harvest at day 65 (March 6)
Stage 2	Harvest at day 121 (May 1)	Harvest at day 121 (May 1)
Stage 3	Harvest at day 177 (June 26)	Harvest at day 167 (June 16)
Stage 4	Harvest at day 223 (August 11)	Harvest at day 223 (August 11)
Stage 5	Harvest at day 279 (October 6)	Harvest at day 279 (October 6)
Stage 6	Harvest at day 335 (December 1)	Harvest at day 335 (December 1)

The optimal decisions at each stage are shown graphically in Fig. 7. The numbers in the arrows represent the number of days between harvest dates, while the figures inside the circles represent the additional number of workers to be hired. The illustration diverged at growing cycle 2 indicating alternative optimal decisions (in cycles 2 and 3). From growing cycle 4 onwards, the optimal decisions are the same for both alternatives.

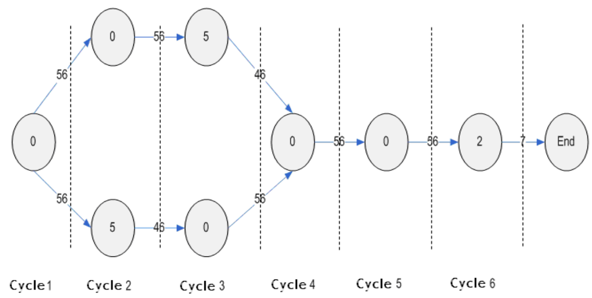

Fig. 7 Scheduling of Hiring Workers at Each Growing Cycle

It is important to note that both alternatives resulted to a maximum profit of PhP 1,233,432.00, an improvement of about 20.92% in profit from the current system whose average profit is PhP 1,020,000.00 per year (or PhP 170,000.00 per grow).

The optimal decisions identified here involve shortening and lengthening the cleaning period of the farm. The following measures can be observed in altering the duration of the cleaning cycle.

To *shorten the duration of the cleaning cycle*, the following methods are suggested:

1. Since harvesting is done for a number of days, cleaning may be started gradually even before all chickens are harvested. However, this can't be done for the following reasons:
   A. Hiring additional workers is required if workers are still attending on the harvesting of the chickens that are still present.
   B. Cleaning involves dirt removal on floors using power sprayers. If the floors are wet, harvesting may be difficult or slower than when it is dry.

2. Much of the cleaning is done on the floors. The floors can be covered by old newspapers or rubber mats that can be disposed of and replaced after the growing cycle.

To *lengthen the cleaning cycle* on the other hand, the following alternatives can be followed:

1. Reward workers by giving them days off or paid or non-paid leaves.
2. Reallocate or reassign workers temporarily to other areas until they are needed again during the cleaning cycle.

The DP model presented here was proven to be an effective tool in planning poultry farm scheduling. From the case studied, 20.92% improvement in profit was realized which accounts not only to higher profit from the opportunity to sell poultry at a higher market price, as well as to the savings from efficient acquisition of labor and equipment.

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