ECONOMY OF SCALE AND COST OF CHICKEN PRODUCTION IN THE MAIN PRODUCER REGIONS OF MINAS GERAIS STATE[1]

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ABSTRACT

In Minas Gerais, chicken production is concentrated in the regions of *Zona da Mata*, Midwest and *Triângulo Mineiro*, which account for 81% of the whole state. Ninety percent of this production comes from the integration system. At an economic level, the Brazilian chicken production has taken place from the 60s on, allowing the import of genetic material with high productivity and efficiency. Due to technology, it is necessary to study the economic aspects of the production in order to verify its efficiency and effectiveness. So, we tried to determine a production scale through which factors would be optimized. Also, the cost of production was studied, by using the production theory. The average total cost of production was lower in the *Zona da Mata*, followed by Midwest and *Triângulo Mineiro regions*. In the regions of *Zona da Mata* and *Triângulo Mineiro*, in stratum 1 the economies of scale take place, whereas in strata 2 and 3 diseconomies occur. In the Midwest, the contrary occurs, that is, diseconomies of scale in stratum 1, and economy in strata 2 and 3. In the region of *Zona da Mata*, the optimum scale occurs with a production of 26203.35 kg, which equals a hangar size of 1127 m^2, whereas in the Midwest and *Triângulo Mineiro* regions the optimum production scales

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reach 42888.08 kg and 34849 kg, respectively.

Key words: Economy of scale, production costs, chicken.

1. Introduction

The Brazilian sector of broiler chicken production shows a technology as developed as the one of other countries that stand out in the international scenario. In Brazil, the evaluation indexes of poultry production have been presenting high efficiency, which is a result of the integration system production.

Due to large production scale, agroindustries make the system more competitive, as they act throughout the productive chain (from the production of one-day old chicks to the commercialization of the chicken), they have the total control of the production, being less vulnerable to the sector's crises in the sector.

Because *Minas Gerais* State presents regions with different characteristics due to resource availability, it has differentiated chicken production systems, and the companies acting in each region determine these systems by means of input supply, technical assistance and rendering of other services. If there was a production structure and defined techniques it would become important to efficiently use the resources, in such a way to maximize their usefulness.

The studies concerning economy of scale and production costs guide the decision-making process, showing the participation of each variable in the productive process. These studies show the effectiveness of using several factors that indicate the optimum amounts to be used and the production scale.

In the case of economy of scale, one should worry about the factors that contribute more to the formation of the production cost. Previous studies show that the cost with feeding accounts for approximately 70% of the total cost of broiler chicken production and for 80% of the variable costs; so, the decisions about feeding largely affect the economic profitability of the activity (Moura, 1995).

Today, another decisive factor in chicken production is the investment capital for constructing the hangar and the acquisition of equipment, which has always been higher, due to the requirement pattern of the integrator companies*. Thus, questions are asked about what factors would be contributing for the reduction of costs and for the increase of competitiveness through adaptations in the production scale. The poultry size is expected to be compatible with the employment of the production factors in order to optimize their use.

Before this scenario and its importance in the production system, an important question is to identify the optimum relationship between the poultry size and its decisive variables. From the optimum size, it will be possible to analyze the existence or non-existence economy of scale in the producer regions of *Minas Gerais* State.

The general objective of this work is to determine the costs and to analyze the existence of economies of scale in broiler chicken production in the main producer regions of *Minas Gerais* State. Specifically, the objective is to determine the production cost of chicken in the different regions as well as to verify the occurrence or not of economies and/or diseconomies of scale.

2. Methodology

2.1. Theoretical model

The production cost is defined as the expenses with purchase and processing of the resources used in the productive process, added to the implicit costs, that is indirect costs (depreciation, interest, insurance, rent, etc.).

The production function shows the maximum amount of production that may be produced from any specialized set of input, according to existing technologies. It is a relationship between physical amounts, that is, the amount of production and the amount of resources necessary to

*These are firms that work in integration with producers. They organize and finance production, give technical assistance, process and commercialize products. By doing this, they gain market power, reduce costs and improve product finality.

obtain it.

The production function can be mathematically represented as follows:

$$Y = f(X_1, X_2, ..., X_n, K), \quad (1)$$

where Y = produced total amount; X_i = used amount of the i-th production factor (i = 1, 2,..., n); and K = size of the plant.

Isoquants, that is, curves in the space of the input showing all the possible combinations that are exactly enough to produce certain amount of the product, can be derived from the production function. Before several combinations of input, production economy seeks to determine or to identify that with which the maximum economic product is obtained. For the observation of this production level to be possible, it is necessary to know the concept of isocost or constant cost line. The isocost line shows the several combinations of input that have the same expenditure and may be algebraically represented as follows:

$$CT = \sum_{i=1}^{n} p_i X_i + f(K) \quad (i = 1, 2, ..., n) \quad (2)$$

where CT = total cost; p_i = price of the i-th input; X_i = amount of the i-th factor for each size of the plant; f(K) = total fixed cost for each dimension of the plant.

If the production function and the equation representative of the isocost condition were affected by the plant size given by K, the way to expansion (obtained by the tangency points among the different isoquant lines and isocost) would equally depend on this variable (Mello, 1995). The way to expansion can be represented by

$$C(X_1, X_2, ..., X_n, K) = 0. \quad (3)$$

In each one of the points on the way to expansion, it is possible to determine the optimum level for utilization of the productive factors, that

is the level of the economic efficiency that, when replaced in the production function, will determine the company's production level. If the prices of the factors are known, it is possible to calculate the fixed, variable and total costs in the long term, which are expressed as a function of the production level compatible with the dimension of the chosen plant, that is,

$$CTlp = f(Q, K) + f(K), \qquad (4)$$

where CTlp = total cost in the long term; f(Q, K) = function that defines the variable costs; and f(K) = fixed cost function.

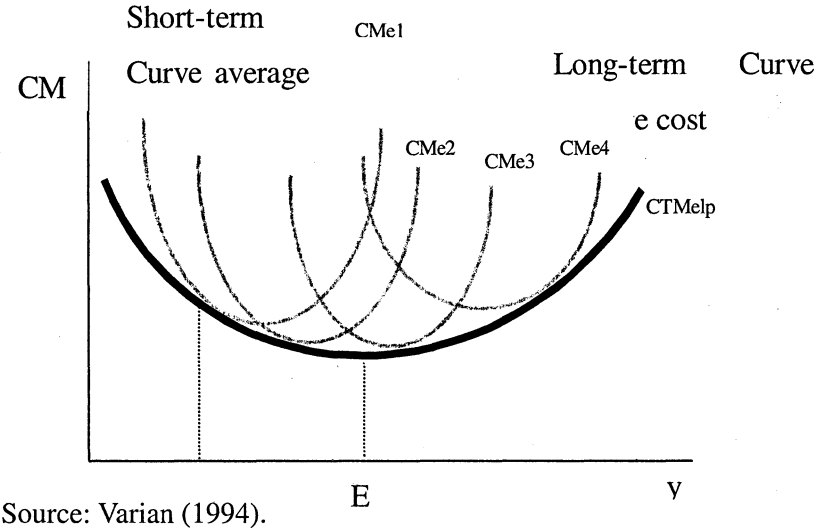
The total cost curve, in the long term, is the envelope of short-term curves. The average total cost (CTMe) is obtained through the division of the total cost by the produced amount. The production level that minimizes the average total cost represents the optimum level of scale (point E in Figure 1). Algebraically, the necessary condition for minimizing the total average cost function is that the first order derivative, in relation to the produced amount, equals zero, and the sufficient condition is that the second order derivative is greater than zero.

$$\frac{dCMe}{dQ} = 0 \qquad \text{e} \qquad \frac{d^2CMe}{d^2Q} > 0$$

The average total cost curve on the long term (CTMelp) shows the minimum cost of producing a given product level, by adjusting all the production factors. On the left side of point E (declining portion of the CTMelp curve), the plants would not be working with full capacity and to the right of the point E the plants would be "over crowded" (Figure1). Therefore, in both intervals one works with superior to optimum costs. This behavior represents the law of the revenues to the scale, so showing that the average cost declines as the size of the plant increases due to the company's economy of scale reaching an optimum size at "E", being all the economies reached. Beyond this point, the diseconomy of scale will occur.

The capitalist manager's objective is to reach a maximum economic efficiency, that is to maximize the profit or to minimize the cost of

determined product level, by using the production factors, the given technology.



Source: Varian (1994).

Figure 1 – Average total costs in the short and long term.

The maximum economic efficiency takes place when a combination of production factors, the given technology, reaches a maximum production level and with maximum profit. According to Gomes (1992), a way to measure the economic efficiency is to verify the existence (or not) of scale gains. According to Adam Smith (1776), there are two fundamental reasons for the economies of scale to occur: the division of work and its specialization as well as the technological development (Ferguson, 1986).

The term economy and diseconomy of scale refers to what happens with production when all the categories of input are proportionately increased. It is supposed that all the categories of input are duplicated; if the production duplicate, any economy or diseconomy of scale would exist; if the product increased more than twice, economy of scale would exist; otherwise the diseconomy of scale would occur. Generalizing, given a proportional change in the input, the quantitative effect of this change upon the product will define either the economy or diseconomy of scale

occurs.

In spite of the possibility of occurrence of diseconomies of scale, empiric studies conducted by several agricultural enterprises have revealed just a little evidence of the existence of diseconomies of scale in agriculture (Debertin, 1986).

The return to the scale (RE) is defined by the ratio between the average cost in the long term (CMelp) and the marginal cost in the long term (CMalp). This relationship is the inverse of the cost elasticity in relation to the production (Ec), that is

$$RE = \frac{CMelp}{CMalp} \quad \text{ou} \quad RE = \frac{1}{Ec} \qquad (5)$$

Thus, the return to the scale can be inferior, equal or superior to the unit, and the company will confront with returns to the decreasing, constant and growing scale, respectively.

The economies of scale are attributed to a fixed factor, at least, whose costs has its importance diluted by additional units of production. With the increase of the production, the unitary CTMe is expected to decline, thus reducing the participation of the unitary cost per produced unit.

2.2. The empirical model

In the determination of the cost, the arithmetic average of the strata and studied areas was used. The composition of the cost items was made in agreement with Canever (1997), except the costs with technical attendance and transport which are included in the chick and ration prices.

The fixed cost comprises the depreciation of the facilities, depreciation of the curtain, depreciation of the equipment, remuneration of the capital, expenses with maintenance and repairs and the hangar insurance. In turn, the variable cost is composed by the expenses with ration, chicks, bed, energy, labor, rat poison, disinfectant, CESSR* and administration.

* CESSR – Special contribution from the Rural Social Security.

A company that is expanding or contracting its operations needs to be able to foresee the way its costs will be modified due to the variation of the production level (Pindyck and Rubenfeld, 1994). The costs of certain activity can be represented by a function that relates the cost to the production level.

To estimate the average cost a quadratic function was used

$$CME_i = \alpha + \beta_1 Q_i + \beta_2 Q_i^2 + u_i,$$

where CME = the total average cost of the company i (i = 1, 2,..., n) in R$ per kilogram of chicken alive; Q = amount of chicken produced by the company i (i = 1, 2,..., n) where n = sample size; and u_i = random error.

The function of total average cost was adjusted by the method of the Ordinary Least Squares (OLS), based on the usual presuppositions on the random error and on the specifications of the model. In relation to the signs of the regression coefficients, it is expected that, in agreement with the theory, the linear coefficient is negative and the quadratic is positive.

2.3. Data source and sampling

In this study, the three main regions producing broiler chicken in *Minas Gerais* State were considered. Those are *Zona da Mata*, Midwest and *Triângulo Mineiro*, which participate with 81% of the state production, according to data of the Association of the Poultry Raisers of *Minas Gerais* (AVIMIG).

The data used in this work are primary and they were collected through questionnaire, by means of which the aspects of production structure, costs, technology, were researched besides the general aspects of the integration and production system.

To determine the sample, it was tried to identify the population of chicken producers in the regions to be studied. The lodging capacity was considered as reference for stratification. This population was obtained from several integrator companies and producer association companies

(Table 1). The research was carried out during the months of March and April 1997.

Table 1 – Population size and sample of broiler chicken producers per region and per stratum of lodging capacity, 1997

Strata	*Zona da Mata*		Midwest		*Triângulo Mineiro*		Total	
	Population	Sample	Pop.	Samp	Pop.	Samp.	Pop.	Sample
up to 1.200 m^2	354	29	88	6	67	7	509	42
1.200 a 2.400 m^2	112	10	44	4	103	9	259	23
> 2.400 m^2	11	2	47	2	45	3	103	7
Total	477	41	179	12	215	19	871	72

Source: Integrator companies and Associations of integrated producers. Elaborated by authors.

In order to determine the population's representative sample, the random sample formula, stratified with optimum allocation was used, being admitted a width of ± d, around the average (lodging capacity), and using a confidence interval of 95% that corresponds to two standard deviations in statistical terms (Kamel and Polasek, 1976). Then, we have

$$d = \frac{\sum \alpha_s \sigma_s}{\sqrt{N}} Z$$

where α_s = proportion of the properties in the stratum; σ_s = standard deviation in the stratum of the variable lodging capacity; d = amplitude (3.72% on the average of the lodging capacity); N = sample size; Z = significance level.

After finding the sample total size, the proportionality approach is adopted to find the sub-samples in the several strata (Table 1).

3. Results and Discussion

3.1. Production Cost

The importance of studying the production cost is due to two main objectives - helping the producer's decision-making process and evaluating the effects of governmental politics. For the producer, the detailed knowledge of the cost components helps the determination of the production system to be used, related to the use of several factors and taking into account its availability and price. Thus, the producer can alter its cost table, by rationalizing the use of factors to maximize profits. The government's intervention will occur by means of politics that target price and credit control, among others.

The objective of this analysis is to compare the costs of chicken production in the three studied regions, by identifying the factors that make them different. The costs were divided into fixed and variable ones. Tables 2 and 3 show the main items associated to these, as well as their values for the three studied regions.

3.1.1. Fixed cost

The fixed cost of the broiler chicken production involves the following items: depreciation of the facilities, the protection curtain and the equipment; capital return; maintenance expenses; repairs and the hangar insurance. In the case of the benefactresses, the fixed cost is affected by construction type, the time of use as well as the equipment. We can consider that the studied regions are distinguished by the time they act on the broiler chicken production through the integration system. The Midwest region is the most traditional of the State in broiler chicken production; that is why there is a great number of producers with an "older" structure of production, implying a lower value of the current capital invested in this region.

In the *Zona da Mata* region, before the integrated system appeared, the production of broiler chicken existed but in small scale. In the beginning

Table 2 - Cost of production for broiler chicken in the main producer regions in Minas Gerais State, R$/batch, 1997

Specifications	Zona da Mata (1)	Zona da Mata (2)	Zona da Mata (3)	Total
Fixed cost				
1. Facilities depreciation	137.47	286.60	391.27	186.23
2. Curtain depreciation	14.49	31.74	42.89	20.08
3. Equipment depreciation	132.63	180.88	440.48	167.79
4. Capital remuneration	148.99	368.11	442.65	216.76
5. Expenses with maintenance and repairs	13.14	35.04	32.86	19.44
6. Hangar insurance	4.60	12.26	11.50	6.80
Total fixed cost	451.32	914.63	1,361.65	617.10
Average fixed cost/kg	0.0232	0.0233	0.0223	0.0234
Variable cost				
1. Bedding	166.93	398.00	260.00	227.83
1. Chicks	1,690.00	3,568.30	5,607.50	2,339.22
2. Ration	9,240.29	19,259.38	28,620.87	12,629.37
3. Insecticides, raticides and antibiotics	0.93	3.93	0.00	1.61
4. Firewood	37.96	84.10	22.50	48.46
5. Gas	73.33	96.00	25000	87.47
6. Electrical energy	35.58	93.70	340.00	64.60
7. Disinfectant	13.37	30.70	9.50	17.69
8. Cleaning labor	87.76	117.50	215.00	101.22
9. Management labor	243.54	442.90	1,650.00	360.77
10. Loading labor	123.22	224.10	428.00	162.69
11. Transport (bed)	18.45	40.50	0.00	22.93
12. Administration	8.79	202.30	0.00	55.56
13. Association	23.51	50.62	76.95	32.73
14. Bonus	59.08	128.17	192.38	82.44
15. Social charges	1.03	27.00	0.00	7.32
16. CESSR	28.18	59.86	96.69	39.25
Variable total cost	11,852.35	24,827.06	37,769.39	16,281.16
Average variable cost/kg	0.6105	0.6326	0.6195	0.6196
TOTAL COST	12,303.67	25,741.69	39,131.04	16,898.26
AVERAGE TOTAL COST/kg	0.637			

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m². Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m². Stratum 3 - Includes the producers with lodging capacity of above 2400 m².

Table 2 - continue

Specifications	Midwest			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	188.24	280.42	168.67	215.70
2. Curtain depreciation	11.16	45.23	55.00	29.82
3. Equipment depreciation	75.12	173.56	185.37	126.31
4. Capital remuneration	126.01	240.28	150.45	168.17
5. Expenses with maintenance and repairs	9.85	19.42	6.67	12.51
6. Hangar insurance	3.44	6.80	2.33	4.38
Total fixed cost	413.82	765.71	568.49	556.89
Average fixed cost/kg	0.0219	0.0184	0.0084	0.0161
Variable cost				
1. Bedding	275.00	581.25	800.00	464.58
1. Chicks	1,967.32	4,613.75	7,650.00	3,796.58
2. Ration	9,256.90	19,851.19	32,430.60	16,650.62
3. Insecticides, raticides and antibiotics	9.87	37.50	15.00	19.94
4. Firewood	0.00	0.00	0.00	0.00
5. Gas	130.83	253.00	543.00	240.25
6. Electrical energy	96.67	130.00	210.00	126.67
7. Disinfectant	33.00	73.75	135.00	63.58
8. Cleaning labor	98.33	62.50	75.00	82.50
9. Management labor	283.78	525.00	758.00	443.22
10. Loading labor	168.33	385.0	605.00	313.33
11. Transport (bed)	0.00	10.00	125.00	24.17
12. Administration	0.00	56.00	312.00	70.67
13. Association	0.00	0.00	0.00	0.00
14. Bonus	0.00	0.00	0.00	0.00
15. Social charges	4.33	111.19	123.00	59.73
16. CESSR	42.67	55.77	99.59	56.52
Variable total cost	12,367.03	26,745.90	43,881.19	22,412.36
Average variable cost/kg	0.6556	0.6435	0.6484	0.6484
TOTAL COST	12,780.85	27,511.61	44,449.68	22,969.25
AVERAGE TOTAL COST/ kg				

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m². Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m². Stratum 3 - Includes the producers with lodging capacity of above 2400 m².

Table 2 - continue

Specifications	Triângulo Mineiro			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	251.70	269.99	959.08	372.05
2. Curtain depreciation	20.59	27.66	51.37	28.80
3. Equipment depreciation	139.15	188.89	451.56	212.04
4. Capital remuneration	372.99	497.55	1,162.34	556.63
5. Expenses with maintenance and repairs	40.84	48.86	115.06	56.36
6. Hangar insurance	14.29	17.10	40.27	19.72
Total fixed cost	839.56	1,050.05	2,779.68	1,245.60
Average fixed cost/kg	0.0356	0.0333	0.0496	0.0384
Variable cost				
1. Bedding	272.86	326.67	626.67	354.21
1. Chicks	2,18.5	3,611.94	7,425.08	3,921.86
2. Ration	9,501.87	15,900.75	30,637.63	15,870.14
3. Insecticides, raticides and antibiotics	2.57	0.00	0.00	0.95
4. Firewood	0.00	0.00	0.00	0.00
5. Gas	182.79	299.56	680.00	316.60
6. Electrical energy	90.71	144.67	268.67	144.36
7. Disinfectant	40.00	59.44	157.33	67.74
8. Cleaning labor	184.00	170.78	370.00	207.10
9. Management labor	465.43	424.89	1,082.67	543.68
10. Loading labor	221.71	294.79	651.44	324.18
11. Transport (bed)	0.00	16.67	0.00	7.89
12. Administration	51.71	183.11	323.33	156.84
13. Association	16.45	17.53	71.27	25.62
14. Bonus	0.00	0.00	0.00	0.00
15. Social charges	33.86	35.58	317.05	79.39
16. CESSR	41.74	43.67	36.64	41.85
Variable total cost	13,924.65	21,530.05	42,647.78	22,062.41
Average variable cost/kg	0.5901	0.6826	0.7619	0.6794
TOTAL COST	14,764.21	22,580.10	45,427.47	23,308.01
AVERAGE TOTAL COST/kg	0.6257	0.7159	0.8115	0.7178

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m^2. Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m^2. Stratum 3 - Includes the producers with lodging capacity of above 2400 m^2.

Table 2 - continue

Specifications	Total			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	167.76	279.02	571.02	240.18
2. Curtain depreciation	15.03	32.49	49.98	24.01
3. Equipment depreciation	125.50	182.74	372.34	167.79
4. Capital remuneration	183.04	396.53	667.60	298.35
5. Expenses with maintenance and repairs	17.28	37.73	60.60	28.03
6. Hangar insurance	6.05	13.21	21.21	9.81
Total fixed cost	514.66	941.72	1,742.75	768.17
Average fixed cost/kg	0.0257	0.0257	0.0287	0.0262
Variable cost				
1. Bedding	200.02	401.95	571.42	300.64
1. Chicks	1,917.77	3,767.19	6,970.03	2,999.75
2. Ration	9,286.26	18,048.05	30,573.69	14,154.78
3. Insecticides, raticides and antibiotics	2.48	8.23	4.28	4.49
4. Firewood	26.21	36.56	6.42	27.60
5. Gas	99.78	202.95	518.00	173.40
6. Electrical energy	53.49	119.95	272.28	96.00
7. Disinfectant	20.89	49.43	108.71	38.55
8. Cleaning labor	105.31	128.78	241.43	126.04
9. Management labor	286.27	450.13	1,152.00	422.78
10. Loading labor	146.08	279.74	574.33	230.41
11. Transport (bed)	12.74	25.86	35.71	19.17
12. Administration	14.69	169.35	227.71	84.80
13. Association	18.97	28.87	52.53	25.40
14. Bonus	40.80	55.73	54.96	46.94
15. Social charges	6.98	45.00	171.07	35.07
16. CESSR	32.51	52.81	71.78	42.82
Variable total cost	12,271.25	23,870.58	41,606.30	18,828.64
Average variable cost/kg	0.6125	0.6516	0.6849	0.6427
TOTAL COST	12,785.91	24,812.30	43,349.05	19,596.81
AVERAGE TOTAL COST/kg	0.6382	0.6773	0.7136	0.6689

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m^2. Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m^2. Stratum 3 - Includes the producers with lodging capacity of above 2400 m^2.

Table 3– Percent composition of the cost of broiler chicken production in the main producer regions of Minas Gerais State, 1997

Specifications	*Zona da Mata*			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	1.12	1.11	1.00	1.10
2. Curtain depreciation	0.12	0.12	0.11	0.12
3. Equipment depreciation	1.08	0.70	1.13	0.99
4. Capital remuneration	1.21	1.43	1.13	1.28
5. Expenses with maintenance and repairs	0.11	0.13	0.08	0.12
6. Hangar insurance	0.04	0.05	0.03	0.04
Total fixed cost	3.68	3.55	3.48	3.65
Variable cost				
1. Bedding	1.35	1.55	0.66	1.35
2. Chicks	13.73	13.86	14.33	13.84
3. Ration	75.09	74.82	73.14	74.74
4. Insecticides, raticides and antibiotics	0.01	0.01	0.00	0.01
5. Firewood	0.31	0.33	0.06	0.29
6. Gas	0.60	0.37	0.64	0.52
7. Electrical energy	0.29	0.36	0.87	0.38
8. Disinfectant	0.11	0.12	0.02	0.10
9. Cleaning labor	0.71	0.46	0.55	0.60
10. Management labor	1.98	1.72	4.22	2.14
11. Loading labor	1.00	0.87	1.09	0.96
12. Transport (bed)	0.15	0.16	0.00	0.14
13. Administration	007	0.79	0.00	0.33
14. Association	0.19	0.20	0.20	0.19
15. Bonus	0.48	0.50	0.49	0.49
16. Social charges	0.01	0.10	0.00	0.04
17. CESSR	0.23	0.23	0.25	0.23
Variable total cost	96.32	96.45	96.52	96.35
TOTAL COST	100.00	100.00	100.00	100.00

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m^2. Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m^2. Stratum 3 - Includes the producers with lodging capacity above 2400 m^2.

Table 3 - continue

Specifications	Midwest			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	1.47	1.02	0.38	0.94
2. Curtain depreciation	0.09	0.16	0.12	0.13
3. Equipment depreciation	0.59	0.63	0.42	0.55
4. Capital remuneration	0.99	0.87	0.34	0.73
5. Expenses with maintenance and repairs	0.08	0.07	0.01	0.05
6. Hangar insurance	0.02	0.03	0.01	0.02
Total fixed cost	3.24	2.78	1.28	2.42
Variable cost				
1. Bedding	2.15	2.11	1.80	2.02
2. Chicks	15.39	16.77	17.21	16.53
3. Ration	72.43	72.16	72.97	72.49
4. Insecticides, raticides and antibiotics	0.08	0.14	0.03	0.09
5. Firewood	0.00	0.00	0.00	0.00
6. Gas	1.02	0.92	1.22	1.04
7. Electrical energy	0.76	0.47	0.47	0.55
8. Disinfectant	0.26	0.27	0.30	0.28
9. Cleaning labor	0.77	0.23	0.17	0.36
10. Management labor	2.22	1.91	1.71	1.93
11. Loading labor	1.32	1.40	1.36	1.36
12. Transport (bed)	0.00	0.04	0.28	0.11
13. Administration	0.00	0.20	0.70	0.31
14. Association	0.00	0.00	0.00	0.00
15. Bonus	0.00	0.00	0.00	0.00
16. Social charges	0.03	0.40	0.28	0.26
17. CESSR	0.33	0.20	0.22	0.25
Variable total cost	96.76	97.22	98.72	97.58
TOTAL COST	100.00	100.00	100.00	100.00

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m². Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m². Stratum 3 - Includes the producers with lodging capacity above 2400 m².

Table 3 - continue

Specifications	Triângulo Mineiro			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	1.70	1.20	2.11	1.60
2. Curtain depreciation	0.14	0.12	0.11	0.12
3. Equipment depreciation	0.94	0.84	0.99	0.91
4. Capital remuneration	2.53	2.20	2.56	2.39
5. Expenses with maintenance and repairs	0.28	0.22	0.25	0.24
6. Hangar insurance	0.10	0.07	0.09	0.09
Total fixed cost	5.69	4.65	6.12	5.35
Variable cost				
1. Bedding	1.85	1.45	1.38	1.52
2. Chicks	19.09	16.00	16.34	16.83
3. Ration	64.36	70.42	67.44	68.09
4. Insecticides, raticides and antibiotics	0.02	0.00	0.00	0.00
5. Firewood	0.00	0.00	0.00	0.00
6. Gas	1.25	1.33	1.50	1.36
7. Electrical energy	0.61	0.64	0.59	0.62
8. Disinfectant	0.27	0.26	0.35	0.29
9. Cleaning labor	1.24	0.76	0.81	0.89
10. Management labor	3.15	1.88	2.38	2.33
11. Loading labor	1.50	1.31	1.43	1.39
12. Transport (bed)	0.00	0.07	0.00	0.03
13. Administration	0.35	0.81	0.71	0.67
14. Association	0.11	0.07	0.16	0.11
15. Bonus	0.00	0.00	0.00	0.00
16. Social charges	0.23	0.16	0.70	0.34
17. CESSR	0.28	0.19	0.09	0.18
Variable total cost	94.31	95.35	93.88	94.65
TOTAL COST	100.00	100.00	100.00	100.00

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m^2. Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m^2. Stratum 3 - Includes the producers with lodging capacity above 2400 m^2.

Table 3 - continue

Specifications	Total			
	(1)	(2)	(3)	Total
Fixed cost				
1. Facilities depreciation	1.31	1.12	1.32	1.23
2. Curtain depreciation	0.12	0.13	0.11	0.12
3. Equipment depreciation	0.98	0.74	0.86	0.86
4. Capital remuneration	1.43	1.60	1.54	1.52
5. Expenses with maintenance and repairs	0.14	0.15	0.14	0.14
6. Hangar insurance	0.05	0.05	0.05	0.05
Total fixed cost	4.03	3.79	4.02	3.92
Variable cost				
1. Bedding	1.56	1.62	1.32	1.53
2. Chicks	15.00	15.18	16.08	15.31
3. Ration	72.63	72.74	70.53	72.23
4. Insecticides, raticides and antibiotics	0.02	0.03	0.01	0.02
5. Firewood	0.20	0.15	0.02	0.14
6. Gas	0.78	0.82	1.19	0.88
7. Electrical energy	0.42	0.48	0.63	0.49
8. Disinfectant	0.16	0.20	0.25	0.20
9. Cleaning labor	0.82	0.52	0.56	0.64
10. Management labor	2.24	1.81	2.66	2.16
11. Loading labor	1.14	1.13	1.32	1.18
12. Transport (bed)	0.10	0.11	0.08	0.10
13. Administration	0.11	0.68	0.53	0.43
14. Association	0.15	0.12	0.12	0.13
15. Bonus	0.32	0.23	0.13	0.24
16. Social charges	0.06	0.18	0.39	0.18
17. CESSR	0.26	0.21	0.16	0.22
Variable total cost	95.97	96.21	95.98	96.08
TOTAL COST	100.00	100.00	100.00	100.00

Source: Data of the research.

Note: Stratum 1 - Includes the producers with lodging capacity of up to 1200 m^2. Stratum 2 - Includes the producers with lodging capacity varying from 1200 to 2400 m^2. Stratum 3 - Includes the producers with lodging capacity above 2400 m^2.

of the 80-ies, the region became consolidated as a great producer with the implantation of the integration system through PIF-PAF S.A. Industry and Trade. Given this characteristic, we can be affirmed that the facilities of broiler chicken production in this region are more modern and have higher current value.

Finally, we still have to mention the region of *Triângulo Mineiro*, where the broiler chicken production had larger expansion in the recent years, possessing a structure of modern production when referring to the hangar construction and the used equipment.

The fixed cost by lot of the three studied regions in absolute value is R$ 768.17, what corresponds to 3.92% of the total cost; in the regions of *Zona da Mata*, Midwest and *Triângulo Mineiro* these were R$ 617.10 (3.65%), R$ 556.89 (2.42%) and R$ 124560 (5.35%), respectively.

The current value affects all the items, mainly the remuneration of the capital, which in the region of the *Triângulo Mineiro* represents 44.68% of the total fixed cost while in *Zona da Mata* e Midwest represent 35.12 and 30.19%, respectively.

The Midwest region is the one that presents the lowest fixed cost because it possesses older facilities and equipment. It is worth emphasizing that this region is the only one presenting hangars with lodging capacity lower than 600 m^2, what also influences the value of the current capital.

The *Zona da Mata* region is an intermediate fixed cost in relation to the other two regions because it presents a larger concentration of producers in the stratum up to 1200 m^2, what influences the value of the capital invested in the activity.

As to the composition of the fixed cost, most of it is represented by the remuneration of the capital, constituting 38.83% of the total cost. The second important item is the depreciation of the facilities (31.3%) followed by the depreciation of the equipment (21.84%).

As expected, the average fixed cost tends to be reduced with the increase of the production scale. When variations are observed in the strata, the average cost is reduced when going from the stratum of lower lodging capacity to the higher one, except for the average *Triângulo Mineiro* region and that of the total.

In the *Zona da Mata* region, in stratum 1, the average fixed cost of produced chicken is R$ 0.0232, being reduced to R$ 0.0223 in stratum 3 what implies gains of scale.

The variation of the average fixed cost in Midwest region was more accentuated than in the other studied regions since it went from R$ 0.0219 in the smallest stratum of lodging capacity to R$ 0.0084 in the larger stratum. It is noticed that the variation was larger than the expected (160,71%), once in stratum 3 a higher capital value was expected, being observed a growing tendency of the fixed cost as the hangar constructed area was increased. This behavior is justified by the sample, which in stratum 3 of this region was represented by two producers who coincidentally have a structure of production with lower value.

In the *Triângulo Mineiro* region, the contrary to Midwest happened because, in stratum 3, the average fixed cost increases with the production scale, instead of reducing. The justification is also the sample, since in its stratum the producers are concentrated with a higher capital invested in the production infrastructure in relation to the average.

3.1.2. Variable cost

The components of this cost were determined based on the information about the demonstrative result given by the integrator company in the last lot of produced chicken and at the producer's expenses obtained by means of interview. The FUNRURAL expenses were not included, whose calculation took into account 2.3% of the gross margin received by the producer.

The variable total cost of the sample per lot was of R$ 18,828.64, which corresponds to 96.08% of the total cost. In the integrated production system, variable costs consist of the company cost that basically includes the ration and the chick, which represents 91.11% of this cost and 87.54% of the total cost. The other part is the producer's cost which involve the costs of the bedding material, labor, electric energy, gas or firewood used in heating the chicks, among others.

In absolute value, the *Zona da Mata* region presents the lowest

variable costs followed by the regions of *Triângulo Mineiro* and Midwest.

Some components of variable cost that make it different in the studied regions are analyzed as follows. The bed cost per lot is lower in *Zona da Mata* region (R$ 227,83) and higher in Midwest region (R$ 464,58), and this difference is due to the availability of the product in the region and to the form under which it is marketed. In the *Zona da Mata* region, trade of the bed is still accomplished without the middleman's presence. In the Midwest, where the rice straw is the only practically used, this trading is performed by brokers who buy it in *Uberlandia*, as well as make its processing (grinding) and distribute it to producers. The expense with labor is higher in *Triângulo Mineiro* region, followed by Midwest, while the lower expense occur in *Zona da Mata* region; this behavior is explained by the shortage of trained labor in these areas. Since there is a great portion of the family labor taking care of the poultry in *Zona da Mata*, this region presented lower cost. Other items, as electric energy and gas, also contributed to the differentiation of the total costs due to the illumination program and chick heating, which was adopted by several integrator companies.

The average variable cost per kilogram was 0,6196, 0,6484 and 0,6794 in the regions of the *Zona da Mata*, Midwest and *Triângulo Mineiro*, respectively.

The components of the variable cost have a logical behavior; as the production level is increased, the cost of each component also increases. Some items did not present such a behavior due to the way the data was obtained. An example is the social charge, which is not paid by all producers.

The average total cost follows the same tendency of the average variable cost.

3.2. Average total cost function and return to scale

For estimating the functions of the average total cost of broiler chicken production "dummies" variables were used for the differentiation of the studied areas. The quadratic functional form, which is representative

of the long-term average total cost, was used. This functional form was used by Mello (1995) in studying the milk production cost.

The function of the average total cost estimated for *Zona da Mata* region is represented in Table 4, where the independent or explanatory variable is the amount of chicken produced in tons. The estimated equation for the average total cost presented an determination coefficient (R^2) of 0.5712, showing that 57.12% of the production cost of broiler chicken are explained by the produced amount. The determination coefficient, adjusted for degrees of freedom was 0.5456.

Table 4 - Equation estimated from the average total cost of the broiler chicken production for *Zona da Mata* region -MG, 1997

Parameters	Variables	Estimates	Standard	t_c	$P(t > t_c)$
β_0	Constant	0.65217	0.0206	31.5426	0.0000
β_1	Q	-1.33E-06	1.26E-06	-1.0532	0.2960
β_2	Q^2	2.53E-11	1.62E-11	1.5601	0.1234
α_1	D_1	0.09259	0.0107	8.6508	0.0000
α_2	D_2	0.04324	0.0123	3.5128	0.0008

Determination coefficient	0.5712
Adjusted determination coefficient	0.5456
Observation numbers	72
Degrees of Freedom	67
F test	22.310*

Source: Research data.
* Significant at 1% probability.

The values of the determination coefficients and the adjusted determination coefficient are relatively low because the data are taken from the crossed section, where great variability occurs, and also because just one explanatory variable is used. However, the F test was significant at 1% probability.

The estimated function was concave upwards with decrease of the costs due to the increase of production, in which the economy of scale occurs passing through a minimum point with constant returns and later resulting in diseconomy of scale.

The Student t-test showed that the coefficients β_0, α_1 and α_2 are statistically different from zero at 1% probability. The coefficient β_2, referring to variable Q^2 is only significant at 12% probability, whereas the coefficient β_1 of the variable Q was not significant. This was the best model found for *Zona da Mata* region. The low statistical significance of the coefficients estimated for variable Q and Q^2 is a part due to the multicollinearity problem. According to Gujarati(1995) the existence of functional relationship between Q and Q^2 will make the linear correlation coefficient among them high, becoming difficult to estimate the parameters with greater accuracy (lower pattern error). Despite the low significance of the variables Q and Q^2 coefficients, these were maintained in the model, given their importance in the determination of the optimum production scale. Therefore the results should be considered with caution.

For the *Zona da Mata* region, the optimum production scale occurs when there are constant returns to scale, which is the minimum point of the average total cost curve and corresponds to the production of 26,304.35 kg of alive chicken per lot, at average total cost corresponding to R$ 0.6347. The number of chickens is 11,270 fowls, since the average weight observed per head was 2,333.87g. Considering the hangar density of 10 chicken/m^2, the hangar size is 1,127 m^2. Beyond this point is the diseconomy of scale. At the same time, below this point is the economy of scale, that is as the production grows the average total costs decrease. The diseconomy of scale occurs when the production is larger than the one of the minimum point, where the average total cost starts to grow.

According to Table 2, stratum 1, the long run average total cost, at

the *Zona da Mata* region, is below the optimum level, which indicates that there is economy of scale, so the production may increase, since at this level the factors are not being used with maximum efficiency. In strata 2 and 3 of the *Zona da Mata* region the diseconomies of scale occur since the production factors have been used beyond the limit of maximum efficiency.

The second estimated equation (Table 5) served as grounds for determination of the average total cost functions Midwest and *Triângulo Mineiro* regions, considered Triangle the "dummies" variables.

Table 5 - Estimated equation of average total cost of the broiler chicken production in the regions of Midwest and *Triângulo Mineiro*, MG, 1997

Parameters	Variables	Estimates	Standard	t	P > | t |
β_0	Constant	0.60452	0.0235	25.6343	0.0000
β_1	Q	0.00202	0.0015	1.3717	0.1750
β_2	Q^2	-2.13E-05	1.92E-05	-1.1094	0.2715
α_1	D_1	0.30360	0.0679	4.4711	0.0000
α_2	D_2	0.12133	0.0400	3.0330	0.0035
α_3	D_1Q	-0.01357	0.0037	-3.6550	0.0005
α_4	D_2Q	-0.00440	0.0024	-1.8149	0.0743
α_5	D_1Q^2	0.00018	4.49E-05	4.1584	0.0001
α_6	D_2Q^2	4.90E-05	3.20E-05	1.5312	0.1307

Determination coefficient	0.6945	
Adjusted determination coefficient	0.6557	
Observation numbers	72	
Degrees of Freedom	63	
F test	17.905	P(0.00000)

Source: Data of the research.

Combinations of "dummy" variables were used with the produced amount in order to determine the effect of the production scale per region.

The determination coefficient reached the value of 0.6945 so meaning that 69.45% of the variations in the dependent variable (average total cost) are explained by the explanatory variables.

The determination coefficient adjusted for freedom degrees was 0.6557.

Statistics t was significant for all the estimated coefficients, so indicating that they are different from zero, except for β_1 and β_2 that were significant at the probability levels of 17.50 and 27.15%. The F test was significant at 1% probability, demonstrating that independent variables explain a significant part of the variations in the average total cost.

For the Midwest and *Triângulo Mineiro* regions the equations of average total cost presented signs of coefficients according to the expected ones.

Test t, used to verify the inequality of the coefficients of the "dummy" variables, showed to be significant at 5% probability.

For the Midwest region the optimum scale of production was found to be 42,888.08 chicken kg per lot, so corresponding to an average total cost of R$ 0.6749. This production corresponds to 18,000 chickens, being 2,382.17 g the average weight for each finished chicken and given the lodging capacity of 1,800 m^2, and considering 10 chickens/m^2. In this region, stratum 1 has an average total cost above the optimum cost level, what indicates the occurrence of diseconomies of scale. In strata 2 and 3, the companies work with inferior to optimum average total cost, what shows the occurrence of scale of economies and that the production should be expanded.

The optimum scale of production found for *Triângulo Mineiro* region was 34,849 kg of chicken produced by batch, with an average total cost of R$ 0.7068. This production represents a flock of 14,925 chickens, given the average weight per fully grown chicken of 2,334.92 g, and given the lodging capacity of 1492 m^2 by considering 10 chickens/ m^2. In stratum 1 the economy of scale occurs because the average total cost is below the optimum one, what indicates that there was inefficiency

of the production and that the production should be expanded. In strata 2 and 3 the inverse behavior occur, since their average costs are above the optimum level due to the use of the production factors, what indicates that the production should be reduced.

4. Conclusions

In *Minas Gerais*, chicken production presents different technological characteristics per region due to the level of the integrator companies' demands.

The average total cost varies according to the type of resource used in each area. As example, we can mention the larger use of family labor in the *Zona da Mata* region, in the stratum with lower lodging capacity, where there are no social charges to reduce costs. In absolute values, the average total costs were R$0.6430, R$0.6645 and R$0.7178 for the regions of the *Zona da Mata*, Midwest and *Triângulo Mineiro* respectively.

In the regions of *Zona da Mata* and *Triângulo Mineiro*, for stratum 1, production should be expanded, since, in these areas, economies of scale occurs, while in the strata 2 and 3, it happens otherwise.

In the strata 2 and 3 of the Midwest region, economies of scale take place, so indicating that the production should be expanded; and in stratum 1 the production is in the region where the diseconomies of scale occur, which is a reason why the production level should be reduced.

For the regions of *Zona da Mata*, Midwest and *Triângulo Mineiro* the optimum scale of production was 26304.35 kg, 42888.08 kg and 34849 kg respectively.

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