

USE OF INTERACTIVE PERFORMANCE OPTIMIZATION FOR IDENTIFYING THE IDEAL PROFILE OF SWINE FINISHING PRODUCERS

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ABSTRACT: The present research aimed to develop a modeling capable of identifying the ideal profile of swine finishing producers using the interactive performance optimization, which began by verifying qualitative the criteria considered most relevant to the decision-making, generating a closed structured diagnosis that covers the socioeconomic aspects about the activity, until the design of a mathematical model able to translate the data obtained in quantitative information. For the verification, it was proposed a practical study for a universe of 120 members of a cooperative in the state of Rio Grande do Sul, Brazil. The results showed that, from the application and the definition of the ideal profile, it was possible to verify that 82 producers are in the group of those who have obtained a "Good" performance, and to 44 the result is in the range between 86% to 90% from the ideal, which means that most have short or medium-term conditions to evolve their status for the considered "Very Good", where only 12.5% of the producers are currently.

KEYWORDS: swine production, performance optimization, competitiveness, agribusiness.

USO DA OTIMIZAÇÃO DE DESEMPENHO INTERATIVA NA IDENTIFICAÇÃO DO PERFIL IDEAL DE PRODUTORES TERMINADORES DE SUÍNOS

RESUMO: A presente pesquisa teve por objetivo desenvolver uma modelagem capaz de identificar o perfil ideal de produtores terminadores de suínos utilizando a otimização de desempenho interativa, que se iniciou através da verificação qualitativa dos critérios considerados de maior relevância para o contexto decisório, gerando um diagnóstico contendo perguntas estruturadas fechadas que abrangem aspectos socioeconômicos acerca da atividade, até se chegar à concepção do modelo matemático capaz de traduzir os dados obtidos em informações quantitativas. Para a verificação, foi proposto um estudo prático para um universo de 120 produtores associados a uma cooperativa localizada no Rio Grande do Sul. Os resultados mostraram que, a partir da definição do perfil ideal, foi possível verificar que 82 produtores estão no grupo dos que obtiveram um desempenho "Bom"; sendo que, para 44, o resultado se encontra na faixa entre 86% e 90% do ideal, o que significa que a maioria possui condições a curto ou médio prazos de evoluir seu *status* para o considerado "Muito Bom", onde apenas 12,5% dos produtores se encontram atualmente.

PALAVRAS-CHAVE: suinocultura, otimização de desempenho, competitividade, agronegócio.

INTRODUCTION

Pig farming is an important segment of the national agribusiness being regarded as one of the main responsible for the economic performance of the primary sector in Brazil in the international scenario due to technological and organizational advances involving activities related to breeding,

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nutritional status, health management, genetic quality and productivity of the squad (BAPTISTA et al., 2011; ABCS, 2011; COELHO et al., 2011; EMBRAPA, 2013).

Despite of this progress, discrepancies are still observed in the way that the control of productivity on farms which can result in management prognoses flawed regarding the performance of each one of the producers, resulting in a scenario of high unpredictability at the moment of the prediction realization about the future behavior of the market for pig production industries and cooperatives (BEATTIE et al., 2000; SILVA et al., 2008).

Therefore, the importance of the interactive optimization role for the management context of enterprise operations allow an increase in the level of competitiveness in the market (KAPLAN & NORTON, 2008; PORTER, 2009; NEUENFELDT JÚNIOR et al., 2014), as well as a convergent way to the increase of earnings of farming activities according to special emphasis given the proposal described by DILL et al. (2010) when dealt with the implementation of strategies to optimize the portfolio products as changes seasonality and climate of a region, KING et al. (2010) about the ways in which the economic dynamics and management are interrelated in the sector, and ZARÓD (2011) for the dynamic optimization of production-related factors in *agribusiness*.

Consistent to the foregoing the present research aimed to develop a model capable of identifying the ideal profile of pig's finishing producers using the interactive performance optimization.

In relation to the technical professional framework the correct management of pig farming allows an increase in the level of competitiveness between cooperative industries located in the same region, in order to obtain incremental productivity gains. As for the academic sphere it is expected that the article fills a gap recurring to searches involving performance measurement of activities related to agribusiness management.

MATERIAL AND METHODS

The development of the research is grounded through the completion of ten methodological steps (Figure 1), assuming the bibliographical survey initially based on the studies of BEATTIE et al. (2000), EMBRAPA (2003), GIVANT & MIRANDA (2004), EMBRAPA (2006), GONÇALVES & PALMEIRA (2006), DILL et al. (2010), KING et al. (2010), ABCS (2011), FERREIRA (2012) and EMBRAPA (2013).

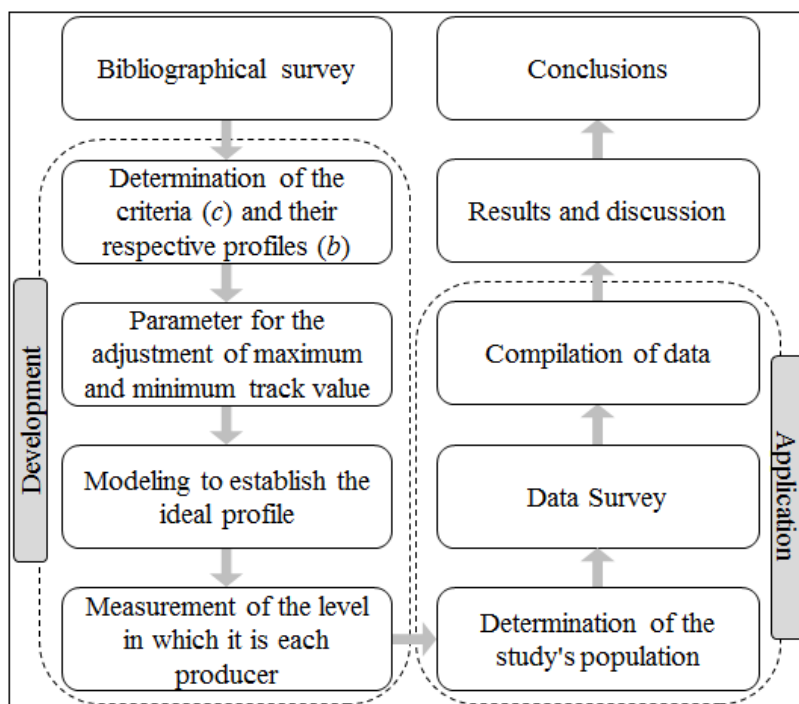


FIGURE 1. Verification of the structure's problems.

Being tied to a vertical organizational structure favored for its vast Brazilian territory the swine industry has been directly linked to production capacity of its main inputs as corn, soybean and the technology used in the creation which entails the possibility of falling operating costs compared to the international competition (BEATTIE et al., 2000; EMBRAPA, 2013).

Criteria (c) determination was established in 18 points which were divided into three groups (Social / Economic, Facilities / Equipment and Bio-security / Logistics) in order to facilitate the verification where each consists of a series of profiles (b) (Table 1) in such a way there is the possibility of individually list all producers (p) in at least one of these.

It is a particular highlight issues the main activities ($c = 1$) and secondary ($c = 2$) it was found that all producers are involved in the execution of more than one productive activity beyond swine industry. Thus, when a swine producer is characterized as the main, this profile was automatically excluded from the selection of the secondary activity.

TABLE 1. Criteria and profiles selected.

Criterion (c)	Profiles (b)
Social / Economic	
Main activity (1)	Another (1); Poultry (2); Dairy cattle (3); Swine (4)
Secondary activity (2)	Another (1); Tobacco growing (2); Dairy cattle (3); Swine (4)
Age group (3)	51 to 60 years (1); Above 60 (2); 21 to 30 (3); 31 to 40 (4); 41 to 50 (5)
Education (4)	Junior High School incomplete (1); Junior High School complete (2); High School incomplete (3); High School complete (4); Superior incomplete (5); Superior complete (6)
Type of manpower (5)	Hired (1); Family (2)
Quantity of manpower (6)	1 (1); 2 (2); 3 (3); 4 (4); Above 5 (5)
Ancestry (7)	Portuguese (1); German (2); Polish (3); Italian (4); Other (5)
Facility / Equipment	
Number of pigs housed (8)	Up to 499 (1); 500-999 (2); Above 1000 (3)
Number of sheds (9)	1 (1); 2 (2); Over 3 (3)
Solar orientation (10)	Another (1); North / South (2); East / West (3)
Coverage (11)	Cement or similar tile (1); Conventional tile (2)
Floor (12)	Massive Floor (1); Leaked floor (2)
Ration distribution (13)	Manual (1); Automated-manual (2); Automated (3)
Type of water drinker (14)	Pacifier (1); water drinker (2)
Bio-security / Logistics	
Herd density (15)	Above 4 herds (1); 2 to 3 (2); 1 (3)
Distance Farm-road (16)	Shorter than 0.5 km (1); From 0.5 to 1 km (2); Over 1 km (3)
Quality of Insulation (17)	Without bio-security (1); with bio-security (2)
Distance Farm to the cold storage (18)	More than 80 km (1); 60 to 80 km (2); 40 to 60 km (3); 20 to 40 km (4); Up to 20 km (5)

The quantitative guided optimization aimed to be able to describe the data collected in logical mathematics information, in order to make feasible the process of comparison of the production of each swine producer, for which later became feasible identifying the ideal profile.

To this, the checking counts with five numeric data treatment steps beginning by defining the function of maximizing the global index (IG_{cb}), described to this modeling as shown in Equation 1, determined by the value which refers directly to the ideal profile definition (b) of the producer for each criterion (c),

$$\max_{1 \leq b \leq n} IG_{cb}, s. a: \begin{cases} IG_{cb} = \frac{Py_{cb}}{3} \\ IG_{cmin} \leq IG_{cb} \leq IG_{cmax} \end{cases} \quad (1)$$

where,

Z_{cb} is the feed conversion ratio (kg animal/ kg feed),

$\forall Z_{cb} \in \{0; \infty\}$,

M_{cb} the mortality rate (absolute numbers),

$\forall M_{cb} \in \{0; \infty\}$, D_{cb} the average daily gain index (kg animal / days) (D_{cb}),

$\forall D_{cb} \in \{0; \infty\}$ and $\gamma_{cb} = \{Z_{cb}, M_{cb}, D_{cb}\}$: generic variable indices used for modeling purposes of calculation, expressed in the case of normalized proportionately ($P\gamma_{cb}$), as measurement scales are different which makes it infeasible to compare the values without prior standardization in favor of the same unit of measure. It is necessary to determine the values that served as a parameter for a needed standard scale, making use of the determination by the two limits researchers, referred to as maximum in proportion, and

$P\gamma_{cmax} = 100\%$ and minimum $P\gamma_{cmin} = 65\%$.

The index Z_{cb} is proposed concerning the search for results that establish the best outcome (Z_{cmin}) for feed conversion ct_p concerning to producers being both essential to find the average value that can express the best relationship between the function of the variable amount of feed (kg feed) (r_p) consumed in relation to the live weight of the pig (kg animal) (w_{an}) obtained for each of the live animals (an) passed along to the cooperative to slaughter (YAGUE, 2008; IRGANG, 2011), resulting in the expression described by [eq. (2)]:

$$\min_{1 \leq b \leq n} Z_{cb} = ct_p, s. a: \begin{cases} p \subset b = \{1, 2, \dots, k\} \\ Z_{cb} > 0 \\ ct_p = \left[\frac{\sum_{an=1}^n w_{an}}{r} \right]_p \begin{cases} r_p > 0 \\ w_{an} > 0 \end{cases} \\ Z_{cmin} = ct_{min} \square \end{cases} \quad (2)$$

For the second index called mortality (M_{cb}), it must also find the minimum value (M_{cmin}) that can express the best relationship established in mortality parameter (ms_p), calculated through the number of animals housed for animal husbandry (d_p) with the mortality total (f_p) during the growth and termination period, based on SOTO et al. (2008) and calculated using the [eq. (3)]:

$$\min_{1 \leq b \leq n} M_{cb} = ms_p, s. a: \begin{cases} p \subset b = \{1, 2, \dots, k\} \\ M_{cb} > 0 \\ ms_p = \left(\frac{f}{d} \right)_p \begin{cases} f_p > 0 \\ d_p > 0 \end{cases} \\ M_{cmin} = ms_{min} \square \end{cases} \quad (3)$$

Finally, the third index, as determined by Average Daily Gain (ADG) available by indicator D_{cb} , aims to find the highest value (D_{cmax}) regarding to the gain estimates md_p checked for each producer, in accordance with the established maximizing for Equation 4, to j_{an} relative to the total weight of each animal at slaughter (Kg animal) and g_p the number of housed days, according to AMARAL & MORES (2008) and EMBRAPA (2013).

$$\max_{1 \leq b \leq n} D_{cb} = md_p, s. a: \begin{cases} p \subset b = \{1, 2, \dots, k\} \\ D_{cb} > 0 \\ md_p = \left[\frac{\sum_{an=1}^n (j)_{an}}{g} \right]_p \begin{cases} j_{an} > 0 \\ g_p > 0 \end{cases} \\ D_{cmax} = md_{max} \square \end{cases} \quad (4)$$

Regarding to the relative percentage values $P\gamma_{cb}$ of each producer for the three selected indexes, feed conversion (Z_{cb}), mortality (M_{cb}) and Average Daily Gain (D_{cb}), that its calculation is directly linked to the minimum and maximum estimates parameterized previously in relation to the proportional $P\gamma_{cmax}$ and $P\gamma_{cmin}$, as shown in the proposed calculus by the [eq. (5)]:

$$PY_{cb} \propto \gamma_{cb} \rightarrow \begin{cases} PY_{cmax} = \{Z_{cmin}, M_{cmin}, D_{cmax}\} * 100 \\ PY_{cmin} = \{Z_{cmax}, M_{cmax}, D_{cmin}\} * 100 \\ PY_{cb} = (Y_{cmax} - \gamma_{cb}) * 100 \end{cases} \quad (5)$$

Therefore, it becomes feasible to measure the overall index IG_{cb} of the ordained profiles, in descending order, as to their level of importance obtaining individual types of producers that refer to a configuration considered optimal for the problem ($OrIG_{cb}$) regarding the differences ΔIG_{cb} for profiles located between the maximum IG_{cmin} and the minimum IG_{cmax} overall, from the descriptions proposed in the eqs. (6) and (7):

$$OrIG_{cb} = \lim_{b \rightarrow k} IG_{cb} \quad (6)$$

$$OrIG_{cb} = \begin{cases} IG_{cb} = IG_{cmin}, OrIG_{cmin} \\ IG_{cmin} \leq IG_{cb} \leq IG_{cmax}, OrIG_{cb} \propto \Delta = IG_{cmax} - IG_{cb} \\ IG_{cb} = IG_{cmax}, OrIG_{cmax} \end{cases} \quad (7)$$

Through the ideal propositions established, it can perform the grouping in order to identify, in a unified way, the characteristics that best refer the considered ideal profile (AIG) through the set $AIG = \{OrIG_{1max}, OrIG_{2max}, \dots, OrIG_{nmax}\}$. Yet in order to provide an additional verification tool, it is proposed the development of the indicator which can refer the situation of the producers in relation to the profiles determined as ideal in pig farms (IG_p), in order to enable the separate measurement of the situation of these with the system to which they are inserted, following the definitions proposed by the Equation 8 in relation to the stipulated criteria,

$$IG_p = \frac{PZ_p + PM_p + PD_p}{3} \quad (8)$$

where,

the result of the comparison returns a value in percentage units so that the more the IG_p approach the PY_{cmax} , the better the producer's situation, besides allowing the measurement of the global *status* of it in relation to other cooperatives.

In order to visualize more clearly the context of the situation, it is proposed the use of a range of fractional values of five parts: the worst, referred to as "Fair", is found in a distribution from $PY_{cmin} = 65\%$ to 70%, the "Intermediate" comprises the values in between 71% and 80%, "Good" from 81% to 90%, "Very Good" from 91% to 99% and finally with $PY_{cmax} = 100\%$ has the profile referred as "Ideal", according to the demand for clarification identified by the researches authors.

For the practical application of the development of interactive optimization, the research was conducted by the data obtained in a cooperative which covers 47 municipalities in the Vale do Taquari region, located in the state of Rio Grande do Sul, comprising the research the universe of 120 producers between February and March 2012, in the termination phase (100 days of animal production), where the average weight of the piglets in the termination shed was 25.27 kg and 112.2 kg for slaughter.

Data were collected from two sources: the first relating the use of a diagnosis with structured closed questions generated by prescribed criteria, and the second was referring to all the productive results provided by the cooperative for the year 2011. Finally, this set of information was compiled by using spreadsheets provided by *software Microsoft Excel*®.

RESULTS AND DISCUSSION

Placed in the context of the 120 producers, the cooperative divides these into seven regions, existing for each one a technician dedicated exclusively for its service. Regarding to the general

characteristics of the producers it is possible to say that 96% are male, and 64% of the totals are primarily involved with activities directly linked to swine, fact considered normal by noting that many of the properties have conditions to engage in different activities.

As for education, only 6.7% of the respondents have degree in graduate courses, while 58.3% are in or not completing primary education and, finally, 35% are finishing or have already completed high school. For the age group, 56.7% of the producers were in an age from 41 to 60 years old, and the sum of the values that are at the extremes of the curve (21 to 30 and over 61 years old) fills only 42.5% of the adopted universe.

Following the population characteristic predisposed, Table 2 shows the consolidated results for determining the ideal profile of the pig farmers by maximizing the overall index (IG_{cmax}) of each criterion, considering the minimum and maximum parameters: feed conversion ($Z_{cmax} = 2.16$ and $Z_{cmin} = 2.43$), mortality ($M_{cmax} = 0.72$ and $M_{cmin} = 3.61$) and ADG ($D_{cmin} = 0.81$ and $D_{cmax} = 0.96$), identified in the course of the data collection stage.

TABLE 2. Profile set as ideal for each criterion.

Criterion	Profile	Global Index		Mortality rate	Average Daily Gain
		Food conversion Index	Index	Index	Index
<i>c</i>	<i>AIG</i>	IG_{cmax}	PM_{cmax}	PZ_{cmax}	PD_{cmax}
Social / Economic					
Main activity (1)	Pig Industry	99.17%	100.00%	97.50%	100.00%
Secondary activity (2)	Cattle Industry	99.84%	99.52%	100.00%	100.00%
Age range (3)	31 to 40 years old	98.64%	98.43%	97.50%	100.00%
Educational level (4)	High school graduate	99.48%	98.43%	100.00%	100.00%
Type of manpower (5)	Familiar	100.00%	100.00%	100.00%	100.00%
Quantity of manpower (6)	2	99.18%	99.88%	100.00%	97.67%
Ancestry (7)	Italian	98.29%	99.88%	95.00%	100.00%
Facility / Equipment					
Number of pigs housed (8)	500 a 999	99.96%	99.88%	100.00%	100.00%
Number of sheds (9)	1	99.17%	100.00%	97.50%	100.00%
Solar orientation (10)	North / South	100.00%	100.00%	100.00%	100.00%
Coverage (11)	Fiber cement tile	99.6%	99.88%	100.00%	100.00%
Floor (12)	Leaked floor	100.00%	100.00%	100.00%	100.00%
Feed Distribution (13)	Automated	100.00%	100.00%	100.00%	100.00%
Type of water drinker (14)	Pacifier	99.18%	99.88%	100.00%	97.67%
Bio-security/ Logistics					
Herd density (15)	2 to 3 pig herds	99.84%	99.52%	100.00%	100.00%
Distance farm-highway (16)	Less than 0,5 km	100.00%	96.12%	91.25%	100.00%
Insulation Quality (17)	With bio-security	99.84%	99.52%	100.00%	100.00%
Distance farm - cold storage(18)	20 a 40 km	99.17%	100.00%	97.50%	100.00%

First of all, it was found that only four of the criteria (*c*) calculated in IG_{cmax} peaked 100% proposed for the application, family manpower ($c = 5$), north / south orientation ($c = 10$), leaked floor ($c = 12$) and distribution of automated feed ($c = 13$), a fact derived only from partial homogeneity of the results for the ideal profile for the three indexes, since its composition is proposed by the average of these. Notably, it can be seen that the results of the ADG index are equivalent to 100%, and in only two points ($PD_{6max} = 97.67\%$ and $PD_{14max} = 97.67\%$) this pattern is not perpetuated.

According to the proposed model, it can be noted as the ideal profile of the swine producer, the ones engaged in pig farming as main activity whose have an advantage of 1.49% over the second place (dairy cattle farmer) because it is believed that they are more committed to producing this type of meat towards the other, which becomes a significant competitive advantage. The dairy cattle comes as the second which, coincidentally, achieved the best result as a secondary activity, thus representing the best relationship when the arrangement of these to the same farm.

Based on the calculated results, in terms of the producers' age, it was noticed a relative higher production values for those who declared the range between 31 to 40 years old when contact with production becomes more intensive and direct. Education has become a global superiority relative to those who finished high school ($IG_{4max} = 99.48\%$), because it is believed that they were able to correlate effectively studies up to this level and the development of their skills.

Two people are the ideal number involved, as cited in a figure that usually involves responsible for the property and another member who as noted on the best results, it is someone directly connected to the family, a fact that complements the argument that this type of manpower is more appropriate together with the fact that from 1992 to 2013 there is a gradual shortage of this type of worker in agribusiness as shown in the data by FEE (2013) for the state of Rio Grande do Sul.

For structural issues it was observed that the leaked floor has an advantage over the massive one of 1.70%, and the roof with cement tile type took advantage of 3.60% over the clay tile although most of the nationwide, almost entirely, the clay tile has advantages to fiber cement ("asbestos") due to the physical characteristics of the products (thermal conductivity, thermal delay and damping) (ABCS, 2011; SARUBBI, 2012). The isolation was a favorable trend for producers using bio-security facilities accessed by a building containing office, dressing room, and pharmacy, in attention to the rules that prevent access and movement of people and vehicles to the farm according to the recommended by EMBRAPA (2003).

For the two criteria involving measurements of distances, on the first proposal, the relationship between the highway and the farm ($c = 16$), was obtained the optimal outcome for the lowest proposal (Less than 0.5 km), as the easiest especially for the arrival of inputs which enables the reduction of freight costs for charging to the property and facilitate the access of rural technicians responsible for monitoring the activities progress. For the distance between the farm to the slaughterhouse ($c = 18$), it was noted that the ideal outcome is proposed for intermediate distances (20-40 km) seen the best conditions in which are the roads used to transport the production of producers who are featured in this range.

As to items related to bio-security it was found that the most appropriate feeding is performed automatically ($IG_{13max} = 100\%$), as well, in accordance to ORRICO et al. (2010) and ABCS (2011), is assessed that the producer can control more effectively the way feeding is being conducted on animals regardless to the type of feed.

For the water drinker there was a slight predominance of system that uses a pacifier type ($IG_{14max} = 99.18\%$) in relation to the feeder ($IG_{142} = 99.17\%$), which is consistent with recommendations cited by OLIVEIRA (2002) in concern the most rational use of water resources for swine. To verify the ideal profile by the results obtained to the context of pig farming area surveyed it allowed to check the following situation in which are each of the 120 clients studied. Therefore, the article's focus is not individually specify the status of each proposal but was to see the general results as the previously defined methodology scale.

Thus, it was found that 82 producers are in the group of those who obtained "Good" performance, and for 44 the result is in the range of 86% to 90% of the ideal, which means that most of them have conditions in the short or medium-term to improve their status for the considered "Very Good", where only 12.5% of the producers are presently, as the highest percentage was found $IG_{79} = 98\%$, being 3% above the second placed ($IG_8 = 95\%$). Finally, the arithmetic mean result for the population subject to verification is equal to 85%, equivalent to a level of performance considered "Good" level.

CONCLUSIONS

In relation to the aim of the research to develop a model able to identify the ideal profile of pig farmers using the interactive performance optimization, it is considered that the application has been shown suitable to determine the optimal eighteen profiles depending on the characteristics

presented for finishing pig farming producers, where were reached a set of points that were determined as a guidance standard on the search for the optimization of the farms which are in a lower standard level.

It was evident that the application of the tool to other universes refer, as the system characteristics adopted in other ideal profiles, a fact that is consistent with the proposal of the study to make the model applicable to any settings in pig farming. Finally, for future prospects, it is believed that the development of specific software for this purpose shall refer to improvements in the condition of exploring the situation of the producer in relation to the context.

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