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Economic Assessment of Pig Meat Processing and Cutting Production by Simulation

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Abstract:
This paper presents the development and adoption of a discrete event simulation model of a pig meat-packing plant located in Navarre (Spain). The simulation model was developed to represent all the tasks and pig meat cuts production performed in the plant and implemented in ExtendSim™ 9.2. The development was incremental as the whole model was made of different sub-models focused in different products as for example ham, ribbon or sirloin. The main utility of the proposed model was the economic assessment of pig meat processing and cutting production. Pietrain breed presented more homogeneity and a better performance than Large White breed at equal price of the same products. In addition, even the ham is the most important cut, the loin and the bacon showed the best relative economic value with 52–53 % and 44–45 %, respectively, depending on the breed.

Keywords: meat plant operation, production planning, discrete event simulation

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1 Introduction

Increasing both productivity and reactivity has become a prime objective for managers of pig meat-packing plants and manufacturing systems in general [1]. Productivity implies paying very close attention to external variables such as clients, sales, etc. as well as to resources (carcasses, labour, etc.). Reactivity can lead to extreme flexibility in product planning, an excellent awareness of the expectations expressed by external factors (new products, likes, socio-economic context, etc.). Thus, simulation is becoming more and more an important tool [2, 3] with undoubted contribution to the progress of manufacturing systems [4, 5], mainly in meat processing and meat cuts production, in which product segmentation and waste reduction are relevant issues in the food engineering field. The simulation is the second most widely used technique in the field of operations management [3, 6, 7].

Different surveys of the current state of the art clearly reveal that discrete event simulation has been applied to various sectors, such as manufacturing, services, defence, healthcare and public services [2, 4, 7]. In particular, different simulation models for manufacturing system operation have been published [7] and few of them are related to the food industry as referred [5, 8]. That is also the case for the pig industry where most specialized software programs and decision support systems focus on herd management tools developed and introduced for on-farm use and less for slaughtering and meat processing plants [6, 9]. A surprising fact, taking into account that decisions at different levels are important for the pig industry viability and for meat-packing plants in particular. Then, there is a growing need to address the complexities of the whole pig enterprise and the difficulties of dealing with different layers of decision-making within a system [10–12]. Maybe the simplicity required in getting the big decisions right and making correctly the major tactical adjustments for the risk-averse primary sector [13] are the reasons.

Consequently, scarce examples exist about meat-packing processing plant models for decision support and even less for pigs [6]. The sole approach found in the literature is that of Ref. [14] who presented a set of Linear Programming (LP) models (not simulation) developed to schedule dynamically beef packing plant operations for a beef company. Proposed models were deterministic and developed ad hoc given the characteristics of that specific beef company with five different plants to coordinate. However, there is a general belief that discrete

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event simulation models are more suitable for modelling problems at an operational/tactical level and also to understand how systems behave, to explore the extension of the system operations and to compare their performance under different conditions [15]. Thus, the research questions addressed in this paper are as follows:

RQ1: Is it possible to build a complex discrete event simulation model for being used in practice by a meat-packing plant manager?

RQ2: Regarding the flexibility in production, is it possible to assess the economic interest of new meat cuts, not yet produced in a meat-packing plant?

RQ3: Regarding the productivity of a pig meat plant, which are the primary cuts concentrating the economic value of the carcass and a higher variability from a productive and commercial perspective?

RQ4: Are there carcasses fitting better for specific products? If so, what is the cost of opportunity of using the better one?

In this paper, the authors present the complete modelling update of a previous sample prototype presented in Ref. [6] in view of answering previous research questions. The simulation model represents typical tasks performed in a pig meat-packing plant processing pig carcasses in a two-sided conveyor belt and selling different meat cut products and by-products in fresh or frozen, to wholesalers and local butcheries. In addition, the authors illustrate the use of the model in a real company to explore the impact of weight carcass in specific products comparing two breeds. The analysis is focused first in an economic assessment valuing the cost–benefit of the different alternatives for a family's end-products as the plant receives time-to-time demands of different products they do not produce usually and their meet problems to assess a convenient sale price. Hence, the goal of the model is twofold: the capability to compare different production plans of end-products for primary cuts in a working week and, even more important, a better selection of breeds for a specific production planning.

2 Material and methods

The company "Carnicas Iruña SA" (former Carnicas Iruña-Velasco) settled in Orcoyen (Navarre, Spain) provided the data, collaboration and support for this project. The original framework was a collaborative project understood as a joint collaboration between the University of Lleida and Carnicas Iruña to improve the knowledge in this kind of processes. The meat-packing plant is embedded in a pig supply chain (PSC) [16] where different long-term agreements with pig producers and abattoirs are settled to assure the procurement of carcasses (body of the animal eviscerated) to process.

2.1 The pig meat-packing plant

The processing capacity of Carnicas Iruña is limited by the receiving room for carcasses and ranges between 800 and 900 carcasses as maximum per day. Three trucks a day coming from two different abattoirs serve the plant. Each abattoir slaughters approximately a half of the stock. Carnicas Iruña belongs to two pig producers' companies procuring the pigs sent to the abattoir and later processed. There are two breeds fattened: Pietrain and White breed (Large White). The Pietrain animals are produced by farms owned by the same company owning the pig meat-packing plant. Carnicas Iruña coordinates the deliveries of pigs from fattening farms and manage the relationship with the abattoir. Time to time, depending on needs and capacity, purchases to external providers of fattened Large White pigs may occur to fulfil the working capacity of the plant. After the slaughtering, the same day abattoirs send the carcasses' information of slaughtered pigs to the plant and so, Carnicas Iruña can set the production planning for the following day according to pending or already received orders. The plant has only one cutting line capable of operating at a speed of 150 or 120 carcasses per hour. Mandatory stops for personnel are scheduled every 2 h. In a first stage of the cutting line, primary cuts are produced leading to a second stage where each primary cut is processed and first commercial cuts are obtained. These cuttings are done along a processing line with two sides (conveyor belts), each one devoted for each semi-carcass. Depending on the product, offline cuts may be required involving additional personnel, variable workload and time incurring in additional cost. Even though, this cost is convenient whenever the disaggregation plan extracts the maximum value of the carcass, i. e. leading to the right (best valuable) products.

2.2 The general purpose simulation software

The simulation model was implemented in ExtendSim 9.2, an interactive general purpose simulation tool [17, 18] with 2D and 3D animation capabilities. The simulation environment provides the tools for all levels of modellers to create accurate, credible and usable models in an efficient way. Thus, ExtendSim facilitated every phase of the simulation project, from creating, debugging, verifying, and validating the model, to the construction of a user interface. This way, developers and target users could collaborate in the conceptual development of the model and later in the analysis of the system. A model is created by adding blocks to a worksheet, connecting them. Each block has its own functionality, dialogue, help, icon and connections. Each instance of a block in the model has its own data. The logical entity that moves through the system is referred to as an item. The items carry properties or attributes with them as they progress from one block to the next. These items are represented using data structures allowing large numbers to exist simultaneously within a model. An additional advantage for developers is the programming language to create reusable modelling blocks beyond the standard libraries provided by ExtendSim. Hierarchical blocks are the blocks of blocks and they help to organize the model with sub-models making it more readable. For instance, each primary cut or product can be encapsulated as a sub-model into a hierarchical block.

2.3 Development methodology

The development methodology employed to develop the simulation model involved modelling and prototyping. The modelling is aimed at representing a simplification of the pig meat-packing plant as a system helping to focus on meat processing and cutting, eliminating ambiguities and improving accuracy. The prototyping is based on a top-down approach and assists developers to ensure that the resulting model represents the real system with enough detail accepted by clients. Therefore, it is very important to involve the client in all the steps of modelling and prototyping. In view of the development of the model and a likely adoption by the company, a project team was created. This team consisted of the following:

- University team: joined the expertise in operational research methods, data analysis and knowledge of the pig sector.
- Quality department team: two employees at the company are in charge of the quality control in the plant.
- Plant manager: eased the development of the model and the implementation of the solution. He is the contact person among all the players in the project.
- Company manager: control decisions and has the overview of the whole PSC.

The university team managed the de implementation of the simulation model by using Scrum [19] as an agile framework for designing and incremental prototyping assisted by the plant manager. After a couple of visits and based on the description of the process given by the plant manager, assisted by the quality department team and supervised by the company manager, a conceptual model was developed by the university team for approval.

A first prototype was implemented following the conceptual model. The implementation of the simulation model was incremental involving successive refinements and checking the rationale of the model. Animation features of ExtendSim were used in different meetings to assess how close was the model to the real behaviour of the plant. This way, all participants in the project were involved preserving the commitment of all parties. The operation of the cutting line including employees was modelled first and primary cuts were the outputs. Then, after the validation of this part, different hierarchical models to represent each family of product derived from the primary cuts were modelled and secondary cuts were the output. The secondary cuts were derived from primary cuts and most of them were produced actually offline. Afterwards, all the parts implemented as hierarchical blocks were assembled in one simulation model representing the plant. Each hierarchical model was tested individually by the plant manager. The plant manager and the University team corroborated along different visits and inspections the correspondence between the conceptual model and real operations in Carnicas Iruña. After that, a version of the model was built assembling all the parts to represent all the packing plant productivity. This stage ends up once both parts accepted the preliminary version of the simulation model.

3 Brief overview of the simulation model

The discrete event simulation model represents carcasses arriving at the system as items that flow through the different blocks of the model. As the simulation progresses, initial items are split into other items as a result of cutting operations done by employees. There is a logical correspondence with the blocks represented in the model and the real operations performed in the meat-packing plant (Figure 1). For instance, Figure 1 shows the first three tasks in the plant as connected blocks before carcasses reach the cutting line represented by a two-sided conveyor belt. The first block represents the unloading and sorting of carcasses at the receiving area. The following two blocks represent some preparation of the carcass: to cut off completely the carcass in two semi-carcasses, to saw the rib for a later easier processing in the line with just knives, to remove the sternum bone and give a helping cut in the upper part of the leg ham to ease a later separation from the rest of the mid carcass. As result of this procedure, small cuts of lean, skin, fat and bones are obtained. These subproducts are also obtained along the cutting line and offline with a significant commercial value at the end of the cutting process.

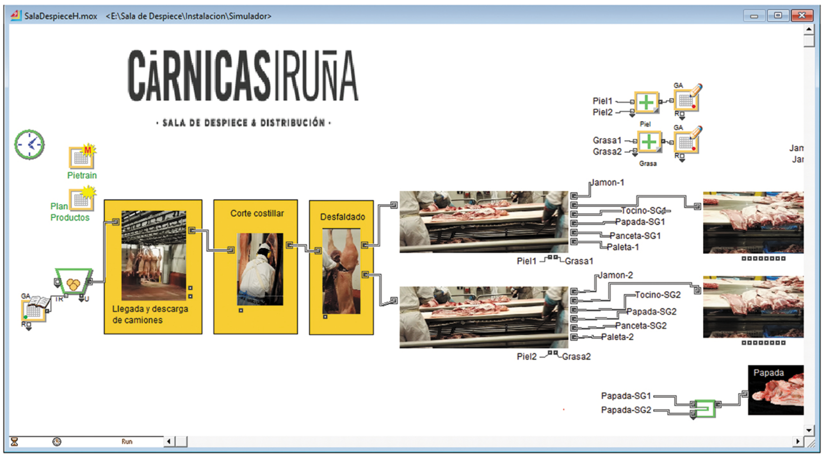

Figure 1: Overview of the model representing the processing of Pietrain carcasses.

There are five primary cuts for each mid carcass processed in one conveyor belt of the cutting line: shoulder blade, cutlet, bacon, lard and ham (Figure 2). Then, an original primary cut can produce different secondary cuts according to a cutting tree pre-stated by the packing plant. In this sense, the simulation model relies on carcass cuts (primary cuts) and their disaggregation in secondary cuts leading each cut to different meat products. It is important to mention the variety of cut products depending on the regional area or country. In particular, meat cuts presented in this work not only represent the Spanish market preferences but also some specific French and Italian cuts. In general, all end-products and by-products have a different commercial value. The commercial value varies over time and even from order to order, customer to customer. It is a task of the sales' department to agree the final value with clients when placing orders.

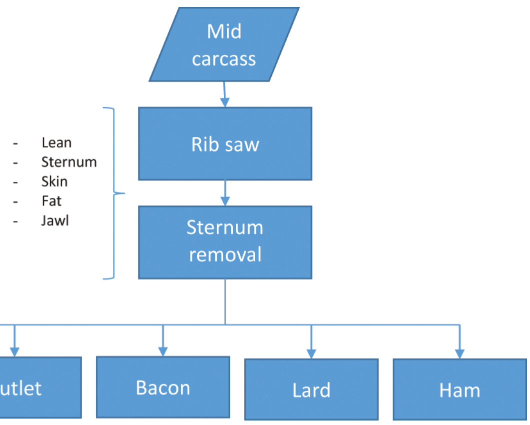

Figure 2: Meat cutting tree for primary cuts (shoulder, cutlet, bacon, lard and ham) and by-products (lean cuts, sternum, skin cuts, fat and jowl).

Jowl is removed during the first stage of processing primary cuts and considered a subproduct like heads or hands. Once primary cuts are produced on the cutting line, some of them can be marketed as such, like ham, lard or shoulder blade. However, it is more likely to go on processing further and getting additional and more elaborated/processed products. For instance, Figure 3 presents the products' family or secondary cuts for ham, i. e. the different products can be obtained from the primary cut corresponding to a leg ham. First of all, a ham can be with skin or skinless. The latter is mainly used for York ham production. It is the result of removing skin, tail, ankle bone, foot and minor cuts of lean and fat to shape the ham. Further products are obtained with additional processing of the York ham (Figure 3): Ham 3D (boneless ham), Ham 4D (boneless and sinew removal), Ham 5D (like a leaner 4D) and Ham 6D (like a ham 5D without the aponeurosis). Ham with skin (and foot) is the raw to produce cured ham products very appreciated in Spain and little by little abroad.

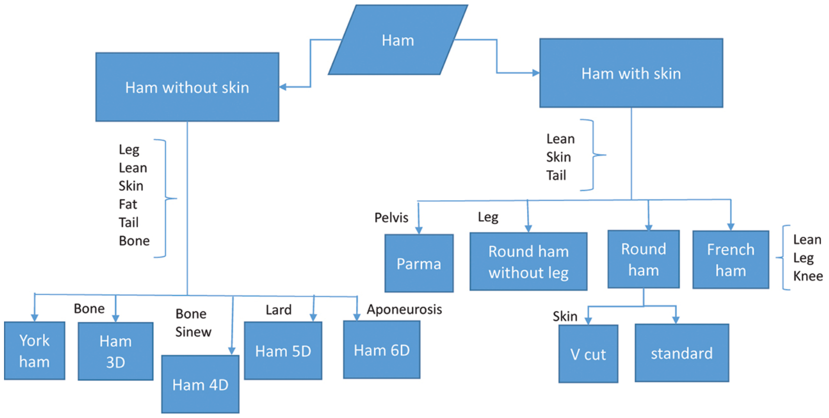

Figure 3: Cutting tree for leg ham products' family.

Information for each piece of meat susceptible of being cut (items in the simulation model) down flowing in the model has to include attributes like weight, lean, bone, fat and skin. Once a meat cut has been processed, each resulting cut is represented by a new item defined with the same attributes referred before but updating the corresponding values. In order to consider different kind of carcass, a sampling by genotype (only Pietrain and Large White breeds are processed by Carnicas Iruña) and weight (three categories: low <80 kg, regular [80, 90] and heavier >90 kg) were performed. Normal distribution was considered for weight attributes with mean and standard error calculated from corresponding samples.

Table 1 shows an example of one sample of ten Pietrain pigs. The sample is classified of heavier weight category (i. e. 95.8 kg > 90 kg) and used to estimate the normal distribution for this genotype × weight category. Gender was recorded but not considered in the simulation. Main results of the carcass composition of primary cuts for a sample of low weight are shown in Table 2. Figures in Table 2 are the base to randomly derive primary cut attributes. Similarly, each family's products in the cut tree were sampled in similar terms to simulate them properly. It should be noted that several products or by-products come directly from the abattoir without any processing on plant like heads, blood or liver.

Table 1: Sample example of a low weight range from Pietrain pigs (averaged carcass weight > 90 kg).

High weight range			
#	**Weight**	**Gender***	**%Lean**
217	95.9	M	65.9
220	105.4	M	63.6
221	106.2	M	65.5
222	95.0	M	65.7
223	95.0	M	68.2
226	92.2	M	68.0
230	95.6	F	64.1
237	90.1	F	64.7
239	94.0	F	67.6
249	90.2	F	66.0

*M: male; F: female.

Table 2: Carcass partition for a sample of ten carcasses Pietrain of low range weight (averaged carcass weight of 78.4 kg < 80 kg).

Cut	Weight (total sampled)	Percent
Ham	255.2	32.4
Shoulder blade	110.3	14.0
Jowl	24.9	3.2
Lard	47.5	6.0
Bacon	121.5	15.4
Loin	169.3	21.5
Skin	5.0	0.6
Lean 1st	0.6	0.1
Fat	0.25	0.0
Heads	42.6	5.4
Hands and feet	7.6	1.0
Sternum	2.9	0.4

4 Results and discussion

4.1 Validation and product segmentation

Before the model was validated on field conditions, a verification was performed by the University team. Then, for verification purpose, the model was compared with analytical results as recommended by Refs. [3, 20], running the model in a deterministic mode and later with the random capabilities for each carcass type. In all the cases, observed means for different cuts were consistent with the fixed values derived from the deterministic run. The simulation model was not verified with all possible parameters (i. e. end-products), only those compatible with current cutting tree in Carnicas Iruña were set. In addition, verification process was automatized by developing specific measures keeping track of main variables for each meat cut like total meat weight and bone percent.

Later on, in order to validate the model and assess the suitability of the proposed simulation model, a comparison was established between simulated results performed with random variability of variables and correlations (i. e. generating random values for each random variable present in the model) and the observed results on plant reflecting the real systems. The comparison was performed for each primary cut and derived products (see Figure 4). For this purpose, a group of parameters satisfying the needs of the model was set by the quality department team (based on sampling different carcasses), the model was run by the university team and results presented and discussed with the plant and company managers who gave their approval.

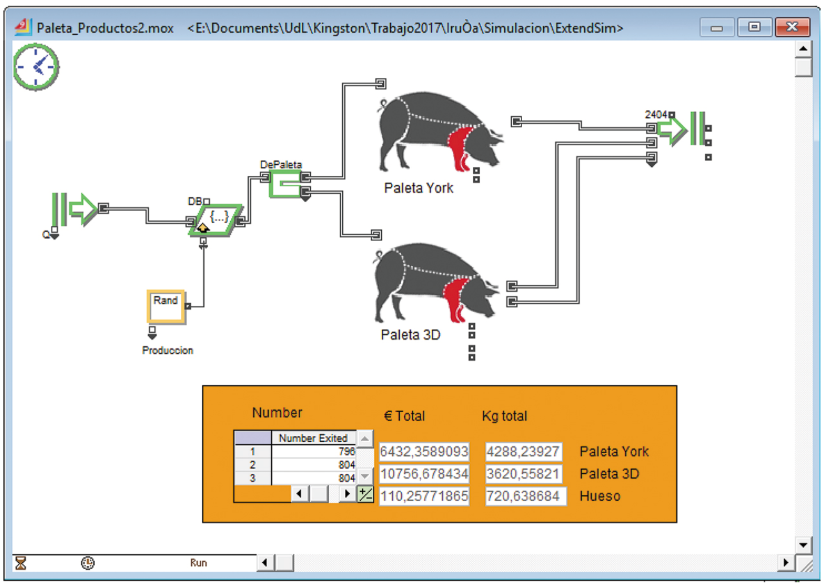

Figure 4: Comparison between incomes of two products: York shoulder and Shoulder 3D (Shoulder is *paleta* in Spanish).

For instance, the shoulder and their family's products are those derived from the shoulder primary cut (depicted in Figure 2) and also other subproducts associated to them (e. g. lean, bone, skin, fat, etc.). The manager of the plant can explore as shown in Figure 4 the more suitable segmentation of products derived from shoulders. S/he can explore the range of prices for each product and subproduct that can make more interesting to produce one product or the other one. In addition, s/he has a tool to get the shadow price for a product in case an interested costumer requests information about a specific product. For instance, we can see the income of York shoulder is 6,432/796 = 8.08€/product unit, while the result for Shoulder 3D is (10,757 + 110)/804 = 13.52€/product unit. The income is greater in the latter than in the former; however, Shoulder 3D has to be processed offline with additional labour. In Carnicas Iruña, this labour cost is fixed per kg (0.1€/kg). Then, the real opportunity cost of Shoulder 3D over York shoulder is not (13.52–8.08) = 5.44€/product unit but 5.44–(4,341·0.1)/804 = 4.90€/product unit being, more or less. Therefore, the commercial department knows what is the margin of 0.455€/kg of Shoulder 3D over York shoulder when negotiating with clients.

4.2 Application comparing carcasses types

As every product and family's products were represented by a hierarchical block, the link of all of them in an ExtendSim sheet allowed the representation of the full operation of the plant. Labour is represented in the simulation model by the number of employees involved in each part of the cutting process. However, the original interest of the company was not focused on labour cost aspects. Modelling offline labour was simple since hired personnel was paid per kilogram of products regardless the time invested in the operation. Hence, the full model was used to compare the two breeds or genotypes processed by the plant. There was the interest in determining key performance indexes for both genotypes and see which of them were more profitable and should be powered.

It was agreed to simulate the workload of a week representing 5 working days processing 4,300 carcasses in total. Two different types of carcass were considered: Pietrain and Large White breeds with a medium weight range (i. e. regular between 80 and 90 kg). These parameters are feasible as the meat-packing plant can place these orders to the abattoir. In addition, a production planning had to be agreed as there are a number of different products that can be obtained from a primary cut and not all of them ordered weekly. This plan of end-products is presented in Table 3. The selection of a primary cut to provide a specific secondary cut to fulfil the production planning was assigned randomly according to a uniform distribution.

Table 3: Production plan to be satisfied during a week processing 4,300 carcasses. Figures represent percent of each product within a family of products.

Family's products	Products within a family	Percent within family (%)
Ham	Round Ham without foot	10
	Ham 4D	55
	Ham 6D	15
	Ham *Loines*	10
	Ham *Parma*	10
Shoulder	Shoulder *York*	15
	Shoulder 3D	50
	Shoulder 4D	35
Bacon	Bacon	60
	Cutter	40
Loin	Loin + sirloin	80
	Rib	20

Each end-product obtained from the cutting process was valued with corresponding selling price provided by the meat-packing plant. All end-products and by-products were valued and the total income for the week was reported by the model. The total number of kg was processed too. A total of 20 runs were performed and mean, standard deviation, standard error and confidence interval of 95 % were calculated for each breed.

In addition, a t-test comparing means of both types of carcasses was performed. The test confirmed the different outcome from both breeds given a higher productivity in kg and income to the Pietrain breed, but just a 0.17 % in kg or a 0.81 % in €. This narrow margin produced significant differences regarding production, either in total number of kg or euros of income as the t-test confirmed ($p > 0.0001$). In Table 4, it is observed how Pietrain has a lower standard error regarding Large White and, therefore, being more homogeneous. Homogeneity in carcass weight is a quality appreciated by meat-packing plants as it facilitates cutting tasks [12]. However, the own production of all of this kind of animals may explain this observation against the purchase of some Large White animals to third parties.

Table 4: Mean values and standard error (SE) for kg and income in euros of 4,300 carcasses of Pietrain (80 kg < carcass weight < 90 kg).

	kg		Income	
	Mean	**SE**	**Mean**	**SE**
Pietrain	265,417	71.77	478,782	167.99
Large W	264,966	102.83	474,927	209.51

The simulation model allowed to inspect the results by different products. Hence, it was compared the percent of each product over the total production either in kg and euros, and the relative difference between both percentages as shown in Table 5. Regarding the weight, ham represents at least the double of the contribution of any other primary cut, being the loin, shoulder and bacon the second, third and fourth ones in both genetics. The same order of importance is observed regarding the contribution of each part to the total income of the carcass, but all these cuts appear more valuable and they increase the economic importance in euros comparing to the production of kg. However, it is interesting to observe the important relative gain of bacon (from 12 % to 19 % in Pietrain or from 12 % to 18 % in Large White) and loin (from 19 % to 27 % in Pietrain or from 18 % to 26 % in Large White) when the contributions in kg are compared with the corresponding contributions in Euros representing 52 % and 44 %, respectively, in Pietrain and a 53 % and 45 % in Large White for bacon and loin, respectively. Results are slightly better for Pietrain, but with similar trend and value in Large White when we consider the same selling price for meat cuts of both breeds.

Table 5: Percent of each product families with respect to the total amount of euros (€) and kg per breed (80 kg < carcass weight < 90 kg).

	Pietrain			Large White		
	€ (%)	**kg (%)**	**Inc. (%)**	**€ (%)**	**kg (%)**	**Inc. (%)**
Ham	43	38	14	39	34	15
Shoulder	22	19	17	22	18	17
Bacon	19	12	52	18	12	53
Jowl	3	3	−16	3	3	−16
Lard	2	3	−43	2	3	−43
Loin	27	19	44	26	18	45
Heads	3	10	−69	3	10	−69
Feet	2	2	5	2	2	5
By-products	23	32	−28	25	34	−26

Inc.: Relative variation between percent in euros and kg per each product.

Another analysis was performed to check the variability of the different products produced during the simulated week by calculating the coefficient of variation (CV). These results are shown in Table 6. It is observed as the most valuable cuts observed previously like ham and loin have a high CV, but this is true also for all the commercial valuable cuts produced (ham, shoulder, bacon and loin). In general, the CV is similar per product between breeds, but it is slightly greater in Large White breed than in Pietrain (0.20 vs. 0.16). This difference can be explained because the model is representing the better homogeneity of Pietrain animals produced by vertically integrated farmers into the same PSC than the Large White carcasses purchased to third-party producers and exhibiting more weight variability.

Table 6: Coefficient of variation (CV) of incomes per product depending on breed produced during 1 week (4,300 carcasses of a weight between 80 and 90 kg).

	Pietrain	**Large W**
Round Ham without foot	3.68	2.78
Ham 4D	1.06	0.91
Ham 6D	2.01	2.14
Ham *Loines*	2.65	3.13

Ham *Parma*	3.22	3.12
Shoulder *York*	2.04	2.47
Shoulder 3D	1.34	0.75
Shoulder 4D	1.52	1.12
Bacon	1.29	1.93
Cutter	0.07	0.06
Jowl	0.06	0.05
Lard	0.06	0.05
Loin	2.81	2.81
Sirloin	2.81	2.81
Rib	2.81	2.81
Heads	0.06	0.04
Feet	0.06	0.04
Fat	0.53	0.65
Tails	0.40	0.38
Bones	0.37	0.37
Total	0.16	0.20

4.3 Lessons learnt by the company

After the first results were presented to the company and before they adopted the model for regular use, several lessons were derived:

– The importance of a good sampling policy of carcasses arriving to be manufactured. As much accurate is the cutting tree, much more accurate are the results the simulation model offers.

– Samples of carcasses from pigs bought to third parties appear to be less homogeneous than those produced by suppliers belonging to the same PSC.

– The opportunity to develop a cost–benefit analysis for new products not produced in the plant but susceptible of being marketed abroad gives information about the commercial interest of producing them or not, as it had happened with French ham or Parma.

– A discovery of the company was the model representing a support tool to control inventory as many times by-products inventoried in kg like lard, bones or lean meat was difficult to control or detect mistakes.

The main interest in the simulation model is to explore beforehand situations not known previously that may happen when trying to open new markets with new products. A real situation experienced by the meat plant was related to hams marketed in Spain and those ordered by French costumers. Both countries have different likes and so the diversity of products makes difficult sometimes to assess the commercial interest for the company to produce one specific product for a new market or limit the presence to the national market. In addition, the value of the different costs affecting the manufacturing of one cut or a different one is not always evident and so, the simulation model helps to make a reliable estimation.

5 Conclusion

Increasing both productivity and reactivity has become a prime objective for the managers of many manufacturing systems like meat-packing plants. The simulation model described here represents a practical approach for comparing different production plans of a pig meat-packing plant. Economic assessment under different carcass disaggregation plans either to evaluate productivity or to react/face new products demanded by clients is feasible with the model.

A discrete event simulation model of a pig meat-packing plant has been introduced in view of answering several research questions. With the assistance of a Spanish company, we can conclude:

RQ1: The discrete event simulation model is being used in practice by a meat-packing plant company using a spreadsheet software as interface with ExtendSim. The discrete event simulation is more flexible and accurate than deterministic or stationary approaches, essentially because it better captures the dynamics of the plant production and the cutting operation process. The use of a visual simulation tool like ExtendSim is essential to interact with the client company during the development of the model.

RQ2: The simulation model allows the plant manager to compare different products of the same family assessing a reasonable price to produce one or the other.

RQ3: The primary cuts with more economic value are ham, loin, shoulder and bacon being ham more than the double percent of the second most important cut. However, the relative economic impact is higher in loin and bacon of 52–53 % and 44–45 % depending on the breed, respectively.

RQ4: Pietrain breed showed a better performance in the packing plant and exhibited less variability in a weight range in part because Large White animals proceed from third-party suppliers.

Moreover, different advantages are drawn with respect to previously published models for similar purposes in other fields like a greater understanding of the system, the reduction of operating costs by a better control of products to serve and personnel, a risk reduction in failing to fulfil orders, lead time reduction, reduction of capital costs and faster configuration changes in production planning. The simulation model considered only variations in carcass weight and breeds but can explore alternative products from the same primary cut and can be easily adapted to different meat-packing plants, thanks to their modularity.

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