

Methodology for food subsector modernization : the case of meat production in Belgium

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Summary

In this paper the authors present a methodology likely to explain and quantify the factors contributing to the dynamics of a particularly impenetrable subsector in Belgium : the butcher's meat. The results obtained can help the decision-makers to take measures in order to realize the restructuring of the Belgian slaughterhouses network. On a long-term basis it is possible to define a policy in order to stimulate some agro-alimentary activities by acting, not only on the slaughterhouses, but also, simultaneously, on all the deficient up- and downstream elements.

1. Introduction

In most countries the rationalization of the main parts of agro-industrial subsectors is, nowadays, more and more unavoidable. Nevertheless the problem is rather complex. Many elements of information are needed (economical, sanitary, political, juridical, sociological,...) and many professional skills are required.

Besides, the problem is not to study the settlement of new plants, but rather to consider the modernization of existing tools, inheritance of the past.

The rational approach of the problem, based on the optimization of the system and leading to the construction of processing units, having eliminated the present structures, must be rejected, because it is not operational.

Indeed, taking into account only purely theoretical considerations induces a complete spatial modification of the agro-industrial activities. This changes the relation within an agro-alimentary subsector thoroughly and is difficult to be accepted by the professionals and the political factors, from a human point of view (social cost, organization problems).

Nevertheless, the determination of the priorities needs an integration of the strengths and weaknesses of the different constituting parts of the agro-alimentary subsectors. It is difficult to realize this integration without using the methods of the quantitative geographical analysis. In fact, the purpose of this paper is to show that the researcher is able to deal with the problems linked with the modernization of an agro-alimentary subsector, by

using statistical methods. The methodology presented here has been applied to the meat subsector in Belgium, in order to find a strategy for the restructuring of slaughterhouses.

2. Method

An adapted methodology was immediately chosen, allowing a smooth restructuring of the subsector which is studied here. In fact, methods allowing a rationalization of the system by optimization have been abandoned for two main reasons. The first one is related to the social aspects mentioned above. The second one is the difficulty to define the function which must be optimized. The minimization of the transportation costs alone must be rejected in countries having good means of communication. The method proposed can be divided in three parts. The first one consists in defining the limits of the study, the second one deals with the integration of space in the economical analysis and the third one tries to find the equation measuring the level of activity of the processing units, according to elements situated upstream and downstream.

2.1. Limits of the study

In this paragraph we discuss the precautions which must lead the researcher for the choice of the population, the period and the variables. Ideally, studying the location of the activities of an agro-alimentary subsector needs the collection and treatment of data which are very precisely established in the space.

Nevertheless, it is true that choosing the smallest base unit leads to several technical

and statistical problems. The information relative to the subsector studied here, which is necessary to build a model, is not always available at the lowest level.

Besides, the collection, the encoding and the treatment of numerous observed variables can uselessly lengthen the preliminary step of the study. In fact, what seems to be important in the choice of the population is the area of action of the processing unit, so that most of the chosen base units have an activity for the link of the subsector which is considered.

A priori, the restructuring of a link of an agro-industrial subsector appears to be essentially a spatial problem and, in the limits of this study, the factor 'space' will be preferred to the factor 'time'. The data relative to the meat subsector studied here come from the most recent censuses available. Nevertheless, it is necessary to see if some special economical and political factors do not have effects on the values of some variables concerning the year of reference. The dependent variable which will be explained is the quantity of meat produced in the geographical areas during a year. The independent variables are the upstream and downstream variables. They are distinctly treated according to the different links of the subsector they characterize.

2.2. Insertion of space in the economical analysis

The establishment of the equation measuring the slaughter activity must integrate the space in the economical analysis. The integration of space is not only the introduction of a descriptive element, but an operational concept. Space is not economically neutral. It appears mainly as the environment where an action takes place, a structured environment, but which may see its structures thoroughly modified by a voluntarist policy of organization of the soil disposition, of improvement of the communication means, and of valorization of the natural resources (Lajugie et al., 1979).

The spatial theory and its economical consequences were first described by the works of two German economists : von Thünen, the pioneer, who tried to determine the best location for agricultural production, according to the different markets, and who published in 1826 his famous work : "Der isolierte Staat in Beziehung auf Landwirts-

chaft und national Ökonomie"; and Weber, who studied the rational location of raw material processing factories, in order to reduce useless transportation to consumption markets, and whose general theory is developed in his book : "Über den Standard der Industrien" published in 1879.

Several authors showed the weaknesses of Weber's theory (Claval, 1969; Ciceri et al., 1977, Lajugie et al., 1979;...) which, nevertheless, appeared to be fruitful by being often adapted and reviewed.

The gravity models have been established by analogy with Newton's gravitation law, by applying the newtonian logic to geography (Lange, 1982). The variables studied are considered as masses with forces, moving in a field of interrelations.

Many geographical works were based on the gravitation law and notably, at the beginning, by Reilly (1931), who, according to empirical researches about the commercial attraction areas of towns in the United States, formulated the gravitation law for the retail distribution, usually called "Reilly's law".

In fact, all gravitational models are based on two postulates : the first one implies that the strength of the interaction between two special units, in economical terms, is inversely linked with the distance separating them; the second one implies that the probability of settlement of a plant is changed (increased or decreased) when another plant is already in the neighbourhood (Ciceri et al., 1977). In order to insert space in the economical analysis, a peripherality index can be defined. It is also called the potential, accessibility or proximity index. It is appropriate to measure the reciprocal influence of each point of a given geographical area. The index is one of the results of the developments of the theory of mutual attraction in a spatial field. Different general formulations have been proposed (Harris, 1954; Nadasdi, 1971; Ciceri et al., 1977; Keeble et al., 1986, and others).

In the limits of this study, the formulation of Nadasdi is retained. It postulates a uniform distribution in the space, considering the base unit as a point :

$$P_i = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{x_j}{S_j d_{ij}^k} + \frac{x_i}{S_i}$$

where :

P_i is the peripherality index of the base unit;

k is a constant;

S_i is the area of the base unit i ;

S_j is the area of the base unit j ;

d_{ij} is the distance between the base units i and j ;

x_i is the measure of the weight of the variable in the base unit i ;

x_j is the measure of the weight of the variable in the base unit j .

The distance between each couple of points (i, j) is measured by the euclidian distance based on the "longitude - latitude" coordinates of the central points of the base units. In countries with well developed transportation infrastructures, the bird flight distance is an acceptable measure (Yates, 1963).

The problem is still to define a methodology in order to estimate the value of the constant k , which varies from 1 to 2 according to the specialists (Ciceri et al., 1977).

When the potential of a base unit is calculated, a high value of k favours the contribution of the base units which are just around. Inversely, a value near 1 is more neutral.

The variables may be transformed with the formula above for different values of k (for example : 1, 1.5 and 2). After that, the relation between the dependent variables retained and the transformed variables (independent variables), to which the variables before transformation are added (the variables before transformation correspond to $k = \infty$), can be studied.

The choice of the independent variables can be done by a forward selection, which requires a minimum of mathematical operations (Dagnelie, 1982). The significance levels of the t and F tests are fixed in order to reduce the number of variables appearing in the regression equation, and to facilitate the comparisons between the equations.

By comparing the different coefficients of determination (R^2) which are calculated, it is possible to make a choice within the transformed variables retained by favouring the equations for which R^2 is high.

2.3. Multivariate analysis

The multiple regression is used to define the equation which will later describe the spatial distribution of the processing units activities, according to the variables related to the studied subsector.

Globally, regression problems are double :

they concern the choice of the independent variables and the estimation of the parameters which come out of the model.

The choice of the independent variables is done with the help of the stepwise regression method, which proceeds by successive introduction of the different variables, but so that, before the introduction of a new variable, the significance of the already present variables in the equation is tested.

Practically, the results of the stepwise regression method are similar to those obtained by forward selection. Nevertheless, the stepwise method has the advantage to put out the variables which become useless or even harmful (Dagnelie, 1982). In order to be clear, the significance level of the t and F tests is defined to be equal to 0.05. Besides, the maximum of five variables have been selected.

The estimation of the parameters needs relatively complex operations, which are explained by different authors (Ciceri et al., 1977; Beguin, 1979; Dagnelie, 1982; ...).

In this study, only the estimation of the standard-errors of the partial regression coefficients and the determination coefficients R^2 are realized. The multiple regression, however, presents a major disadvantage : it gives equations established according to the observed values characterizing elements of which the level of activity has to be foreseen. By proceeding like this, the pre-existing situation is strengthened. In order to avoid this problem, the equations have been established, in a second time, by the "jackknife" method, which is discussed by several authors (Miller, 1974; Bissel and Fergusson, 1975; De Bast and Palm, 1987;...).

The model is calculated n times ($n =$ the number of base units), by suppressing each time the value of the dependent variable relative to one base unit. For a base unit considered, the estimated activity is given by the model established on the $n-1$ other units. By this means, the estimation relative to a base unit is, each time, independent of the value which is observed for this base unit.

The sum of the squares of the differences between the observed activities and the activities so estimated is then calculated and divided by $n-1$. This division gives the mean square, MS , which is then compared with the estimated variance of the activity in order to evaluate the part of the variance

which is explained by the "jackknife" model.
 $r^2_j = (\sigma^2_y - MS) / \sigma^2_y$

The parameter r^2_j is so called because of its analogy with the coefficient of determination.

3. Application to the meat subsector in Belgium

3.1. General remarks

The method described before has been applied to the meat subsector in Belgium in order to propose a reorganization of the slaughterhouses network. The base units considered are the 43 administrative geographical areas (1) (subdivisions of the 9 provinces) which constitute the country. The year of reference is 1985.

All the variables which have been used for the different types of analysis belong to the meat subsector.

The dependent variables have been defined from a practical point of view. Three types of slaughtering chains have been considered :

- the first one used for large animals (bovines and horses);
- the second one for veals;
- the third one for small cattle, essentially pigs.

The independent variables which have been taken into account in order to quantify and qualify the different parts of the meat subsector and which are situated before the slaughterhouse are numerous and come from the yearly agricultural and horticultural census of May, 15th.

Concerning the downstream parts of the subsector, less elements of information are available : the number of slaughterhouses which are authorized to export, and the variables relative to consumption.

3.2. Results

3.2.1. Integration of space

A priori, it seemed important to take space into account in a model measuring the slaughtering activity. Several transformations of the variables, which are able to insert the factor "space" in the economical analysis, were tried.

For different sets of independent variables, the best adequation between the variability of the dependent and the independent variable was sought by calculating the coefficients of determination of the regression equations.

As a whole, the results can lead to the conclusion that the methodic integration of space in the economical analysis does not, or weakly in some cases, improve the regression.

From a theoretical and rational point of view, the problem should essentially be a spatial one. However, according to the variables which play the most important role, it seems that the slaughtered quantities are relatively independent of space. The slaughtering activity, for the different types of animals, mainly depends on the specific characteristics of the constituting parts of the meat subsector measured within the districts. However, the geographical areas are not completely closed areas. There are exchanges of meat and living cattle among them, but the quantities which go in seem to balance those which go out. In fact, the approach adopted allows a first conclusion : the slaughtering activity seems to be essentially linked with the strong and weak aspects of the elements of the meat subsector within each geographical unit.

So, it already appears that it is not relevant to justify the establishment of a slaughterhouse in a determined place by considering upstream and downstream elements characterizing the neighbouring districts.

3.2.2. Multivariate analysis

3.2.2.1. Large animals slaughtering (y 1)

The general equation obtained with the stepwise regression method, for the quantities of meat from large animals slaughtered, is the following :

$$y_1 = 1345.864 + 238.558x_{33} - 459.870x_{47} \\ \quad \quad \quad (83.698) \quad \quad (132.351) \\ - 2034.926x_{55} + 0.005x_{81} + 1753.607x_{85} \\ \quad \quad \quad (966.611) \quad (0.001) \quad (303.907)$$

with

$$r^2 = 0.73;$$

x_{33} = number of veals sold at birth on the market;

x_{47} = number of lean large cattle, sold to a farmer for fattening;

x_{55} = number of lean large cattle, sold to important dealers, for fattening;

x_{81} = veal meat consumption;

x_{85} = number of slaughterhouses allowed to export.

The standard-errors of the regression coefficients are indicated between brackets.

The part of the total variance explained by

each independent variable (partial r^2) is particularly important for the downstream variables (respectively 0.41 for x_{85} and 0.19 for x_{81}). The variables relative to the purchases of the lean animals weakly contribute to the explanation of the variability (partial r^2 equal to 0.07 for x_{47} , 0.04 for x_{33} , and 0.03 for x_{55}). Consequently, it appears that it is important to see the signification of the appearance of the variable x_{85} , which constitutes the key element of the equation of regression.

First, because there is a lack of statistical information, this variable was chosen in order to take into account exports, which must be done by slaughterhouses that are allowed to do so.

The high explanatory power of the variable x_{85} can seem obvious: large cattle slaughtering is explained by the number of efficacious slaughterhouses. In fact, among the slaughterhouses which are allowed to export, important differences of activity can be observed. So, for example, in 1985, the district of Liège slaughtered 48 times more than Dinant, and Westrozebeke 61 times more than Maasmechelen. Consequently, the important role played by x_{85} in the equation of regression is less predictable than it seemed. Besides, x_{85} does not only reflect the number of exporting slaughterhouses.; Indeed, the slaughterhouses today in Belgium must often work for the exclusive needs of an important meat dealer, or are in the hands of a main user. In this context the variable x_{85} is useful to identify the important meat dealer, main operator of the meat subsector. Finally, when the regression is made without the variable x_{85} , it is substituted by the number of cut rooms which are allowed to export, which also reflects the importance of the knackers' activity.

The appearance of the variable x_{81} in the equation can seem curious, but this variable is linked with the variables relative to consumption in general and large cattle is principally slaughtered near the consumption centres. The explanation of the phenomenon lies in tradition and in the less integrated structure of the meat sector, where the standardization of the products is slower and more difficult than in other sectors.

In the past, only towns which were rich enough were able to afford the building of a slaughterhouse on their territory. The slaughtering of large cattle on farm being forbidden

and frigorific transportation non-existing, the main urban centres became the places where quantities offered concentrated and where slaughtering was done.

Nowadays, the inheritance of the past is still observable, because of the non-standardization of the product.

The dealers, who are mainly located in the consumption centres, wish to see the carcasses in order to appreciate their quality. So, the sales become easier when the slaughterhouse is located near the potential buyers. The variables x_{47} and x_{55} have a negative contribution. They are relative to lean cattle trading, the slaughtering of large animals being, logically, negatively influenced by the sales of lean cattle fattened elsewhere. The presence of x_{33} , which has a weak contribution, is more difficult to justify from an economical point of view.

3.2.2.2. Number of veals slaughtered (y_2)

The specificity and the concentration of veal slaughtering and, more widely, of the veal subsector, are remarkable in Belgium.

The result obtained from the independent variables,

$$y_2 = -582.959 + 2.954 x_{32} \quad (0.113)$$

with

$$r^2 = 0.94;$$

x_{32} = number of areas in cattle-sheds for veals early slaughtered,

shows the importance of the upstream variables in relation with the intensive fattening of veals, in order to explain the slaughtering activity. The narrow relation between veal slaughtering and the number of areas in cattle-sheds for veals early slaughtered raises another question. What are the main factors able to influence the whole system?

In fact, it seems difficult, according to the available information, to go further in the analysis and to identify the main actors of this subsector (the farmer, the slaughterhouse manager, the feed producer,...).

3.2.2.3. Small animals slaughtering (y_3)

The slaughtering of small cattle (mainly pigs, secondarily sheep) is the variable which most significantly influences the total quantities produced in the districts.

The multiple regression equation, coming from the 85 independent variables, is the following:

$$y_3 = 4690.398 - 12.271 x_6 + 0.138 x_{24} + 9569.454 x_{85}$$

(2.806) (0.034)

(1107.390)

with

$$r^2 = 0.80;$$

x_6 = number of bovidae owners;

x_{24} = number of fattening pigs;

x_{85} = number of slaughterhouses allowed to export.

The standard-errors of the coefficients of regression are between brackets. The equation is built on upstream independent variables relative to bovines and pigs and on the variable giving the number of slaughterhouses allowed to export.

Quantitatively, x_{85} plays the most important role : it contributes for 0.63 in the total variance.

The comments already made (large cattle slaughtering) concerning this variable are also appropriate here.

However, it is notable to see that the regression coefficient is higher in this case, the slaughtering of small cattle being quantitatively more important than the slaughtering of large cattle.

Besides, there is a link between the small cattle slaughtering and the specialization towards pork production. Consequently, it is not surprising to see the appearance, in the equation, of the variable x_{24} , which indicates the total of fattening pigs (partial $r^2 = 0.09$).

The appearance of the variable x_6 (partial $r^2 = 0.08$) is justified by statistical reasons.

3.3. Comments on the method and conclusions

The use of the multiple regression allows us to get general equations which are able to explain the slaughtering activity for the principal types of animals in 43 administrative circumscriptions in Belgium. The equations obtained have high coefficients of determination and, consequently, show the large explaining power of the independent variables kept. Among these ones, the role of the variable relative to the number of slaughterhouses allowed to export is remarkable. Except for the equation concerning the slaughtering of veals, it is the principal variable (the highest partial r^2).

In fact, the methodology used has two major disadvantages. The first one consists in the fact that, among the independent variables,

some elements, situated between production and consumption may disappear in the long term, according to the new trends in the meat subsector. These elements are the carcass disposal plants and the slaughterhouses. Using the multiple regression, the situation is fixed by a structural rigidity of the constituting parts of the meat subsector. The second one is that the equations established take the observed values into account in the districts of which the level of activity has to be foreseen. Proceeding like this means that the existing situation is accepted and strengthened.

Nevertheless, the equations obtained make possible the proposition of priorities to the decision makers, in order to modernize the slaughterhouses network in Belgium.

The application of the "jackknife" method gives estimations of the slaughtering activity which avoids the problems described above. This method allows a more fundamental questioning of the slaughterhouses network in Belgium. That will lead to important changes in the habits. That is no longer a modernization but a restructuring.

By considering only the extreme parts of the meat subsector and ignoring the inheritance of the past, the situation is analysed from a more rational point of view.

The results must not be considered *sensu stricto*. They permit to appreciate the appropriateness between the slaughtering activity and the strong and weak aspects of the meat subsector within the districts. So, a long term policy can be defined in order to stimulate agro-alimentary activities by dealing not only with slaughterhouses, but, in the same time, with all the weak up- and downstream elements. Globally, large differences are found in some districts, between the estimation and the slaughtering activity observed in 1985. Consequently, the stress must be laid, once again, on the importance of the subsector elements observed within the districts in order to estimate the quantities slaughtered.

The interest of this approach lies in the comparison between the three activity levels (observed, estimated without "jackknife" and estimated with "jackknife"). According to the results, the districts can be gathered in four groups.

The first group is composed of districts where the slaughtered quantities estimated are much less important than the observed

ones. In the beginning, the slaughtered quantities are not negligible. The estimation realized by taking exclusively the elements of the meat subsector into account weakens the role played by these districts. After that, by operating only on production and consumption characteristics and by ignoring the situation observed within the district of which the level of activity has to be foreseen, the quantities estimated are considerably lowered compared to the quantities observed. In fact, in those districts, other factors than those taken into account in the equation energize the slaughtering activity. It seems that the main factor is not in relation with the production and/or consumption characteristics.

For this kind of districts, the decision makers must be careful when they grant subsidies. Indeed, the slaughtering activity observed essentially lies on relatively subjective elements (dynamism of knackers, existence of some facilities,...) which may not last.

The second group is the opposite : the slaughtering activity observed is weaker than that estimated with the multiple regression without 'jackknife', the last one being weaker than the quantities estimated with the "jackknife" method. In this case, it seems that the strong points of the meat subsector are under-used compared with their potential. Consequently, the existing slaughterhouses in those districts have to be modernized. The third group consists of the districts where the quantities observed and estimated are similar. In this case, when the quantities are sufficient, these slaughterhouses may be equipped at first.

Finally, the fourth group gathers the districts for which the global level of activity is too low to face the development of the slaughtering activities. For these ones the problem of public service subsists. The service will not continue but we must admit that these units are not economically viable.

Note

1. On January 1st, 1986, there were, on the Belgian territory, 43 administrative geographical districts, which area went from 16, 138 ha (Brussels) to 201, 621 ha (Verriers). All these districts had a slaughtering activity. The number of slaughterhouses located in the same district went from one (Arlon, Brussels, Namur, Mouscron, Tournai)

to eleven (Alost and Turnhout). Important differences were observed between the quantities slaughtered in the 43 districts (the quantities slaughtered in the district of Courtrai were 163 times more important than the quantities slaughtered in the district of Virton).

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Résumé

Methodologie en vue de la modernisation d'une filière agro-alimentaire : le cas de la production de viande en Belgique

Dans cet article, les auteurs présentent une méthodologie susceptible d'expliquer et de quantifier les facteurs contribuant à dynamiser une filière particulièrement opaque en Belgique : la viande de boucherie.

Les résultats obtenus peuvent aider les décideurs à prendre des mesures en vue de réali-

ser la restructuration du réseau d'abattoirs en Belgique. A long terme, il est possible de définir une politique ayant pour but de stimuler les activités agro-alimentaires en agissant non seulement sur les abattoirs mais aussi, simultanément, sur tous les éléments déficients de l'amont et de l'aval.

Zusammenfassung

Methodologie für die Modernisierung eines Futtermittelnetzes : die Fleischproduktion in Belgien

In diesem Artikel sprechen die Autoren über eine Methodologie, die die Faktoren erklären und quantifizieren können, die zum Dynamisieren eines besonders unklaren Netzes in Belgien beitragen : des Schlachtfleisches.

Die erzielten Ergebnisse können den Politikern helfen, Maßnahmen zu ergreifen, um

die Umstrukturierung des Schlachthausnetzes in Belgien zu verwirklichen. Langfristig ist es möglich, eine Politik zu bestimmen, die das Futtermittelleben antreiben würde. Sie könnte nicht nur die Schlachthäuser beeinflussen, sondern auch alle schwachen Elemente des Netzes.

Samenvatting

Methodologie inzake de modernisering van de agrovoedingsbedrijfskolom : de vleesproductie in België

In dit artikel wordt een methode voorgesteld om de factoren die bijdragen tot een verhoogde dynamiek van de bijzonder ondoorzichtige bedrijfskolom slachtvee in België te verklaren en te kwantificeren.

De bekomen resultaten kunnen de beleidsmensen helpen bij het treffen van maatregelen met het oog op de herstructurering van

het slachthuisbestel in België. Er kan op lange termijn een beleid worden uitgestippeld met als doel de bedrijvigheid in de agro-voedingssector aan te wakkeren, waarbij niet alleen de slachthuizen worden betrokken, maar tegelijkertijd ook alle gebrekkig functionerende elementen in de toeleverings- en afnamesectoren worden aangepakt.