Dirk STRIJKER*

CENTRES OF GRAVITY ON THE MOVE: AGRICULTURE

Abstract: The determination of centres of gravity is a well-known geographical technique to summarise the spatial distribution of activities. In this paper the spatial development between 1950 and 2001 of the centres of gravity of agricultural production in a regionalised European Union is shown and analysed. The underlying dataset covers the surface of the EU-9 for 9 arable productions and 4 types of animal. It will be shown that the centres of gravity have moved considerably, for different productions in different directions. Important changes in the agricultural policy can be recognised in the patterns.
Key words: regions, agriculture, European Union, centre of gravity, production, land use, dynamics.

1. INTRODUCTION

Agriculture is probably the best documented and investigated economic sector in Europe. An important reason is that there is a long tradition of public intervention in agriculture, leading to demand for undisputable information. The availability of detailed information necessitates the use of global indicators to summarise the spatial distribution of activities. In this paper the spatial dynamic of EU-agriculture is visualised by means of the centre of gravity. Centre of gravity is a well-known concept in geography. It gives insight into the global spatial development of phenomena such as population (cf. Terlouw, 1996), and employment (cf. Brugnoli and Fachin, 2001).

* Dirk STRIJKER, Faculty of Spatial Sciences, Groningen University, P.O.-Box 800, 9700 AV, Groningen, the Netherlands, e-mail: D.STRIJKER@RUG.NL
2. CENTRE OF GRAVITY

The concept of centre of gravity is widely used in geography, and is in fact no more than the average location of an activity, weighted with the size of the activity. It is one, and certainly not the only or the final way to describe the spatial distribution of activities. Other quantitative measures, such as the spatial coefficient of Gini, and different types of Moran's I (see Sohn 2004 for an overview) highlight also aspects of the spatial distribution and its dynamics. The power of the concept of gravity lies in the visualisation of developments. At the same time it is an average, and it can be applied to summarise the long-term spatial development in a graphical form (see also Elhorst and Strijker, 2003).

Centre of gravity has also a non-scientific application. With the concept it is possible to 'determine' the centre of a geographical entity (a country, the EU, 'Europe') for instance political or tourist purposes (the centre of gravity of the landmass of the EU-15 is situated in Vironval in Belgium, and is marked there with a tourist monument). In this paper the concept is not used for such purposes, but for the visualisation of the long-term movement of agricultural production in the European Union of 9 countries (the situation of 1973–1981). The centres of gravity of several agricultural productions and land uses are summarised here in figures 1–11. These figures show that their average location has moved between 1950, the first year of observation, and 2001, the last year.

3. DATA

For the period after the development of the Common Agricultural Policy of the EU, especially after 1975, Eurostat publishes coherent regional data on agricultural resources, land use, production, employment, and income (Cronos and New Cronos; see Eurostat, 2004). For earlier years one often has to rely on the statistics of individual member countries, and unity of definition and comparability is then questionable. In the 1970s Eurostat started a pilot project in which basic data on agriculture at the regional level were gathered for the countries of the EU-9, for the period back to 1950 (De Boer and Jacobs). In this paper the two sources are combined.

The analysis is directed at the territory of the then EU-9. In this project the EU-9 is subdivided in 86 regions. For some countries data are available at the Nuts 1 level (Denmark, former West Germany, Luxembourg, Ireland), for some at the Nuts 2 level (Belgium, the Netherlands, France, Italy), while for one
country data are available at an intermediate level (United Kingdom\textsuperscript{1}).\textsuperscript{2} In the analysis data are used on the physical agricultural production (*1000 tons) and the planted area (*1000 ha) of 9 arable crops, the numbers (*1000) of 5 types of animals, and the total agricultural area (*1000 ha). The data are aggregated to four years averages for 1950 (= 1950–1953), 1960, 1970, 1980, 1983, 1986, 1989, 1993, 1997, 2001 (= 2001–2004). The definitions of crops and animals in both sources are equal.

The result is a unique dataset, because it covers the core of the European Union over a period of half a century. It is inevitable that our dataset is not entirely complete. In case of missing or not yet published data, three or two years’ averages or eventually single years were accepted. In certain cases gaps had to be filled with data from national sources, taking into account that eventually slight differences in definitions are introduced in that way. The problems are concentrated in the data for fodder maize, chicken, and sheep, and more general in the most recent data (2001–2004). For oats and rye data are only available until 1970–1973.

In order to get an unbiased picture of the dynamics of the spatial structure, one has to decide how to deal with the remaining holes in data series. There are different options available, interpolation between earlier and later years, and estimates related to the average development in the country, or in the entire EU-9. It appeared that the first option, interpolation, yields by far the most reliable results. This implies that region-specific circumstances play an important role in the intertemporal development of acreages and production.

4. SPACE\textsuperscript{3}

There are many ways to transform a location on a map into digital data. In an earlier project simple longitude-latitude coordinates were used to describe the different locations (Elhorst and Strijker, 2003). As those coordinates give a distorted picture for regions close to the poles, it is preferable to use a projection of the map. Two projections can be considered in this case, the equidistant and the equivalent (equal-area) projections. Both have their pros and cons, because the project is about spatial movements, but also about (agricultural and total) areas. All in all we prefer in this case the equivalent projection (Albers equal area projection) is preferable in this case.

\textsuperscript{1}North (UKC+UKD1), North West (UKD2-5), South East (UKI-J+YKH2-3), UKE, UKF, UKG, UKK-N
\textsuperscript{2}Nuts: Nomenclature of Statistical Territorial Units. For details see Regulation (EC) No. 1059/2003 of May 26th.
\textsuperscript{3}Maps were produced in ArcGIS (ESRI).
5. THE CENTRE OF THE AGRICULTURAL AREA

The 'unweighted' centre of gravity for our regional division for the EU-9 countries (regional centre weighted with the total agricultural area (− TAA)) is located in Champagne-Ardenne (east of Paris) (figure 1). The line in the figure shows the path of the centres of gravity in a number of years between 1950 and 2001.

![Map showing the spatial development of the centre of gravity, regions weighted with the total agricultural area (1950–2001)](image)

Fig. 1. The spatial development of the centre of gravity, regions weighted with the total agricultural area (1950–2001)

Figure 1 shows that the 'unweighted' centre moved slowly to the northwest, with an average speed of about 2 kilometres per year. This implies that the total agricultural area of the north-westerly regions of the EU-9 increased relatively, compared to that of the south-easterly regions. A closer look at the data revealed that there is a general decrease of the TAA since 1950 in nearly all regions, but
that the decrease was much faster in the south (southern France, Italy) than in the north. In the Netherlands, the UK and Ireland the decrease is 10–15%, in the south often 30% or more.

6. AGRICULTURAL PRODUCTS AND ANIMALS

The centre of gravity for agricultural products can be shown in two ways: the locations weighted with the land use (hereafter: acreage), or weighted with the physical production (hereafter: production) for that product. The global movements of the points of gravity for the nine arable crops (acreage) and four types of animals are shown in figure 2. The arrows show the path from 1950 onwards. For example, in 1950 the average location of the land used for the production of corn was situated near La Spezia, in Italy. In the course of time it moved gradually in northwest direction. In 2001 it is situated near Dijon, in France. So, in half a century the production of corn moved nearly 400 kilometre to the northwest.

In the entire period 1950–2001 for some crops (tobacco, corn, wheat, potatoes) the points of gravity have moved several hundreds of kilometres, for other crops the change is much smaller. The movements are in quite different directions, depending on crop-specific developments in for instance the technique of production and the agricultural policy (see hereafter). In some cases the distance between 1950 and 2001 is impressive (the centre of gravity for tobacco moves some 500 km to the south), in many cases the average relocation is limited. From figure 2 it is clear that the centre of gravity for most crops is situated quite far to the north (‘near Belgium’). In general the centre of gravity is situated north of the unweighted centre: the north-westerly regions have a relatively higher share in the EU-9 agricultural activities – their production yields more weight or animals per unit of agricultural land.
Fig. 2. The global movements of the points of gravity for seven arable crops (Acreage) and four types of animals (1950–2001)
Fig. 3. Centre of gravity for corn production and acreage

Fig. 4. Centre of gravity for oats production and acreage

Fig. 5. Centre of gravity for potatoes production and acreage

Fig. 6. Centre of gravity for sugar-beets production and acreage
Fig. 7. Centre of gravity for tobacco production and acreage

Fig. 8. Centre of gravity for wheat production and acreage

Fig. 9. Centre of gravity for cows numbers
In figures 3–8 the intertemporal movement of the centres of gravity for both acreage and production for some arable crops is presented. In most cases the centres of gravity for acreage and production move in the same direction, but they do not coincide completely. There is a tendency (wheat, corn, potatoes) that the centre of gravity of production lies north of that of acreage and that in the course of the time the centres are also moving in that direction. This implies that the higher yielding regions are situated in the north and that there is a gradual further relocation into that direction. There are also exceptions: for sugar-beets and tobacco production and acreage are almost at the same place. In figures 9–11 comparable pictures for three types of animals are presented (cattle, dairy cows and pigs). The centre of gravity of all of them is moving north.

![Fig. 10. Centre of gravity for pigs numbers](image)

![Fig. 11. Centre of gravity for cattle numbers](image)

7. AGRICULTURAL AND POLICY BACKGROUND

Of course there are many different forces working behind the pattern that we have seen above. Two can be mentioned here: policy and physical-technical circumstances. In the traditional agricultural policy of the EU some landmarks can be traced (see Tracy, 1989; Meester, Strijker and de Groot, 2004 for overviews of the policy-development). In the 1960s the policy was developed, but it came into full being from 1970 onwards. The influence of the policy is traceable
in 1970; from 1960 onwards the pattern takes another direction for barley, potatoes, pigs, dairy-cows and cattle. In most cases the direction 1950–1960 is south bounded, after 1970 the development goes into the opposite direction. In that period national policy measures are replaced by EU-measures, and the markets become more integrated. In the case of potatoes, and to a lesser extent also pigs, the common market implied the end of all kinds of protective border measures without the introduction of new agricultural policy measures. Acreage and production of potatoes move in northern direction since that time, pigs to the northwest.

In 1973 three new member states entered the EU (Denmark, UK and Ireland). Especially for the last two the entrance implied an important increase in the prices for agricultural products. The full effect is traceable in 1980; especially the direction of the centre of gravity for wheat shows a reaction to the northwest. The higher prices for wheat in for instance the UK after the accession resulted in an increase and intensification of wheat production.

For dairy farming 1984 is an important year because then the super levy was introduced. The effect of it can be expected in 1986. It seems indeed that after 1986 the centre of gravity takes a new direction: to the northwest, but the distance, some 35 km in 10 years, is not impressive. We should bear in mind that it is not the number of dairy-cows that in limited by the quota-system, but their production. A fixed national quota, and a fast increasing production per dairy-cow, resulted in a relative decrease of the number of dairy-cows. For arable crops the period after 1990 is really important because then the influence of the MacSharry and subsequent reforms (from price support to income support) was felt. For barley there seems indeed to be a spatial reaction: the development to the southeast comes to a standstill.

On the physical-technical side there also are some landmarks. One is the deteriorating position of oats, due to the switch from pulling horses to tractors. From figure 4 it is clear that the production of oats survived best in the easterly part of the EU-9. Contrary to that is the development for corn. Due to technical improvements the crop gradually could be grown in colder climate zones.

A last feature to be mentioned here has a mixed character. The production of pigs (and poultry) rapidly moved to the northwest, due to the availability of cheap (imported from overseas, non-cereal) feedstuffs, giving regions close to the deep-sea harbours a comparative advantage (see Meester, Strijker and de Groot, 2002). The feedstuff aspect was primarily caused by the agricultural (trade) policy, but the development was speeded-up by technical developments in milling, feed management and technical equipments (stables). We also can see a redirection in the most recent years: the policy measures to curb the serious environmental problems of intensive livestock husbandry, and also changes in the structure of the prices of animal feed, have put pressure on the production in the before mentioned harbour regions (in the south of the Netherlands, in north and west Belgium and in the adjacent regions in Germany).
8. DISCUSSION AND CONCLUSIONS

Although the results reveal remarkable spatial developments in the regional agricultural production in the EU-9, some of the results are difficult to interpret. For instance the patterns for sheep, for corn around 1990, and for a number of products in 2001 is doubtful. Probably this is caused by weaknesses in the data. Although the bulk of the data is reliable – published data with clear definitions – there also are less reliable data included. In some cases missing data have been reconstructed by interpolation, and data for one year, or two-years averages are included. Especially for the most recent period this plays a role. Another weakness to mention is that in the course of time important administrative regional re-divisions occurred. In most cases the data for the new regions can be reconstructed from the former ones, but especially in England there have been many, and more fundamental re-divisions. It can be expected that there the reconstruction of data has given less reliable results.

The spatial development of the centres of gravity is typically a data reducing method. It is an average, in which many details, such as variance, are hidden or neglected. The strength of the method lies in its explorative character. Broad developments are revealed which are normally difficult to trace from detailed data sets, but additional, more detailed and quantitative analysis is necessary to create a more complete picture.

The foregoing analysis shows that the notion of centre of gravity can help to trace global spatial developments from detailed data. The main findings are that the average location of the agricultural area of the regions of the EU-9 is slowly but steadily moving to the north. The average locations of many arable and animal productions is situated north of the centre of gravity of the agricultural area. The centre of gravity of many productions moves further to the north(west): the share of the north-westerly part of the EU is increasing. An important exception is tobacco. The decline of the production of tobacco in Germany, Belgium and France has driven the average location far to the south(east). As a result, the influence of some policy measures can be traced. The development of the common market for agricultural products and the coming into being of the Common Agricultural Policy in the 1960s, and the accession of Denmark, Ireland and the UK are visible in some cases. In some specific cases technical and physical developments play a clear role behind the spatial pattern of the centres of gravity.
REFERENCES


