

Spatial developments of EU agriculture in the post-war period: The case of wheat and tobacco

J. Paul Elhorst and Dirk Strijker*

Abstract

This article analyses the intertemporal development of the regional and spatial distribution of agricultural production in the territory of the EC-9. The analysis is based on a unique set of data: the analysed territory has been divided into 88 regions and data from these regions over a period of more than 40 years (1950/53-1993/96) are used. Different methods are applied to analyse the developments: maps and the skewness of distribution (coefficient of Gini) are combined with rank correlation (coefficient of Spearman), the calculation of the centre of gravity, and spatial autocorrelation (Moran's I). These methods are applied to two crops, wheat and tobacco. The results of the analyses of wheat cultivation indicate that the regional concentration has remained more or less unchanged, while the spatial concentration has decreased considerably. The centre of gravity has moved 600 km to the north-west. The research results for tobacco cultivation show an increasing regional concentration, combined with a stable or decreasing spatial concentration. The centre of gravity has moved 600 km to the south-east.

Keywords: *agricultural production, land use, regional concentration, spatial analysis, European Union.*

JEL classification: F15; Q18.

Introduction and research question

Right from the beginning of the formulation of the European Common Agricultural Policy (CAP), policy makers have shown great interest in the regional and spatial aspects of the CAP (see for instance the minutes of the Stresa conference where the implementation of the CAP was launched). Despite the interest of policy makers, the amount of scientific literature on this subject is relatively small, and studies covering the whole area of the EC/EU are hardly available at all (see Laurent and Bowler, 1997, for an overview). Van Hecke (1983), Bowler (1985, Ch. 7 and 8), Henry (1981) and Laurent and Bowler (1997) are probably the only studies in which regional changes in agricultural production and land use is quantitatively analysed in a systematic way. In these studies, the EC, or a large part of it, is considered on a spatial level below that of the national state, and they cover a longer period. However, all these studies focus mainly on regional changes, while spatial patterns get no or very little attention.

* J. Paul Elhorst, Faculty of Economics, University of Groningen
Dirk Strijker, Faculty of Spatial Sciences, University of Groningen, P.O. Box 800, 9700 AV, Groningen, The Netherlands.
Email: STRIJKER@FRW.RUG.NL

When the regional development of a certain activity is analysed, it is done with the purpose of finding out which regions have been able to increase their share in the activity, and which regions have lost their position. Regions that increase their share may or may not be neighbours, indicating that the picture of a study done from a regional perspective can differ considerably when compared to a study done from a spatial perspective. When an activity is fully concentrated in just a few regions of the EU, it makes quite a difference whether these regions are contiguous, or spread across the continent. If, at a certain point in time, the cultivation of a certain crop is fully concentrated in three contiguous regions, and at another period in time the cultivation is fully concentrated in just two distant regions, the degree of regional concentration has increased but the degree of spatial concentration has decreased.

In this article, regional and spatial changes in the cultivation and land use of wheat and tobacco are analysed, using different methods to measure these changes. The analysis is based on a unique data set on agricultural production and land use, covering the regions of the EC/EU-9 during the period 1950/53-1993/96.

Methodology

The Gini Coefficient has been used to identify the degree of *regional* concentration of a certain activity. X denotes the size of an agricultural activity and Y the size of agricultural land within a region. n denotes the number of regions being studied. The Gini Coefficient G of the agricultural activity is thus defined as:

$$G = 1 - 2 \times \sum_{i=1}^n (s_{X_i} \sum_{j=1}^n s_{Y_j}) + \sum_{i=1}^n s_{X_i} s_{Y_i}, \quad (1)$$

where $s_{X_i} = \frac{X_i}{\sum_{j=1}^n X_j}$, $s_{Y_i} = \frac{Y_i}{\sum_{j=1}^n Y_j}$, ($i=1, \dots, n$) and $\left(\frac{X}{Y}\right)_1 \leq \dots \leq \left(\frac{X}{Y}\right)_n$,

that is, regions are ranked according to increasing intensity. The Gini Coefficient equals 0 when the activity is evenly distributed over the regions, and it equals 1 if the activity is fully concentrated in just one region. A change in its value over time shows the extent to which the activity has become regionally more concentrated or less concentrated.

The Gini Coefficient only yields information about the degree of *regional* concentration. If two regions switch positions, the Gini Coefficient remains unchanged. Whether or not the position (ranking order) of the regions has changed can be analysed by a ranking order correlation coefficient, such as the Spearman Coefficient:

$$r_s = 1 - \frac{6}{n(n^2 - 1)} \sum_{i=1}^n D_i^2, \quad (2)$$

where D_i is the difference in ranking number of region i between two periods of time. The value of r_s is 1 if the ranking of the regions is unchanged, and -1 if the ranking in the last period is the opposite of the ranking in the first period.

Other methods should be used to analyse the *spatial* structure of the activity in a quantitative way. The development of the spatial structure over time can be analysed by calculating the centre of gravity of an activity, in other words, the average longitude and latitude weighted with the regional shares of that activity. This measure shows whether, and in which direction, a certain activity is moving across the continent over a particular course of time.

To detect *spatial* patterns or trends in the regional values, we may calculate Moran's I statistic for spatial autocorrelation. Data $\{z_i\}$ are said to be spatially autocorrelated if neighbouring values are more alike than those further apart. If data exhibit spatial autocorrelation, the locations of the regions provide information about the spatial pattern of variation in these data.

Moran's I statistic is defined as:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{ij} (z_i - \bar{z})(z_j - \bar{z})}{\left(\sum_{i=1}^n (z_i - \bar{z})^2 \right) \left(\sum_{i=1}^n \sum_{j=1, j \neq i}^n w_{ij} \right)}, \quad (3a)$$

where w_{ij} is the $(i, j)^{\text{th}}$ element of the matrix W , describing the spatial arrangement of the regions under study. Two types of spatial weight matrices are commonly used in practice: a binary contiguity matrix, and an inverse distance matrix. In a binary contiguity matrix, $w_{ij} = 1$ is used to indicate that two regions are contiguous, whereas $w_{ij} = 0$ is used to indicate the separation between two regions. In an inverse distance matrix, all the off-diagonal elements are positive and defined by d_{ij}^{-1} , where d_{ij} denotes the distance between the two regions i and j .

Moran's I has a sampling distribution which is approximately normal with:¹

$$E(I) = -\frac{1}{n-1}, \quad (3b)$$

$$\text{Var}(I) = \frac{n^2 S_1 - n S_2 + 3 S_0^2}{(n-1)(n+1) S_0^2}, \quad (3c)$$

where $S_0 = \sum_{i=1}^n \sum_{j=1, j \neq i}^n w_{ij}$, $S_1 = \frac{1}{2} \sum_{i=1}^n \sum_{j=1, j \neq i}^n (w_{ij} + w_{ji})^2$, $S_2 = \sum_{k=1}^n \left(\sum_{j=1}^n w_{kj} + \sum_{i=1}^n w_{ik} \right)^2$.

Given I , $E(I)$ and $\text{Var}(I)$, we can easily test the null hypothesis (H_0) of no spatial autocorrelation against the two-tailed alternative (H_1) that the data are spatially autocorrelated.

Crops, study area and data sources

In this section, the methods listed above were applied to the development of the *regional* and *spatial* patterns of production and land use of wheat and tobacco in the regions of the EC-9. Wheat is a crop that is cultivated all across Europe. This crop plays an important role in the CAP; the regulation of the marketing of wheat is one

of the cornerstones of the agricultural policy on arable farming (Tracy, 1989, pp. 255-263). It is therefore interesting to analyse the regional and spatial structure of this crop. It could be expected that the changes over a course of time will be limited due to the political sensitivity of the crop. Tobacco has been analysed because its situation is quite different from that of wheat. Traditionally, tobacco was cultivated in large parts of Europe. Today, production is mainly concentrated in southern Europe, especially in Italy, which held a share of 33% of total land use in the EU-15 for tobacco in 1998, and in Greece, which held 44%. In terms of production the shares of Italy and Greece were equal in 1998.

The analysis has been performed on 88 regions across the EU-9 (the original 6 countries plus Denmark, the United Kingdom and Ireland), at several points in time from the period 1950/53 until 1993/96.² Unfortunately, Greek regions could not be included in the analysis since comparable, harmonised time series were not available. Given the fact that Greece is an important tobacco producer in the EU, its exclusion (especially the region of Thrace) may have affected the results below.

The data set is unique because the whole territory of the EC-9 is covered over a very long period (40 years). Data are taken from different sources. For the period 1950-1973, most data are taken from a research project conducted by the Institute for Economic Research at the University of Groningen (see Strijker, 1999). For the period 1980-1996, data are taken from Eurostat regional statistics. Missing observations are compensated by data taken from other sources, such as various EU publications, national statistics, Mitchell (1988), and Selected Agri-figures. To avoid problems resulting from missing values, four-year averages were constructed (1950/53 etc.), and three or two-year averages were accepted if data for certain years were missing. More or less complete data were constructed for the years 1950/53, 1960/63, 1970/73, 1980/83, 1986/89, 1989/92 and 1993/96. Data for the latest point in time are preliminary.

The observation period also covers instances of major change in the agricultural policy of the EU. The period 1950-1960 may be characterised as the pre-EU situation. From 1970 onwards, the CAP was fully implemented. The first effects of the MacSharry reforms (1992) should be traceable in the figures for 1993/96.

In order to provide a clear view of the empirical context of the research problem, we will first present two maps in which the regional structure of the production of wheat in 1950/53 and 1993/96 is visualised (Figure 1). In these maps the regions are grouped together according to their wheat production per hectare of agricultural land (the regional intensity). The regions with the highest intensity, which together make up the first 10% of the EU's total production, are the first group (decile). The next group is the regions that make up the second 10% of the EU's total production, and so on, down to the fifth decile. Maps for tobacco are not included because they do not provide more insight than the verbal treatment below gives.

Empirical Results

The maps for wheat show that there were two important production areas that both existed in 1950/53 and in 1993/96: the northern part of France and the eastern regions of England. In 1950/53 the northern part of Italy was also an important production area, but by 1993/96 this area had lost its position to a large extent. During this period the importance of Denmark increased. The global picture shows that in 1950/53, 23 regions

(out of 88) produced half of the EC-9 production of wheat, whereas in 1993/96, 21 regions were responsible for this wheat production.

The situation concerning tobacco is quite different. In 1950/53, 7 regions produced the first half of the production of the EC-9 (4 regions in Italy, 2 in France, 1 in Belgium), whereas in 1993/96, there were only 2 (Italian) regions.

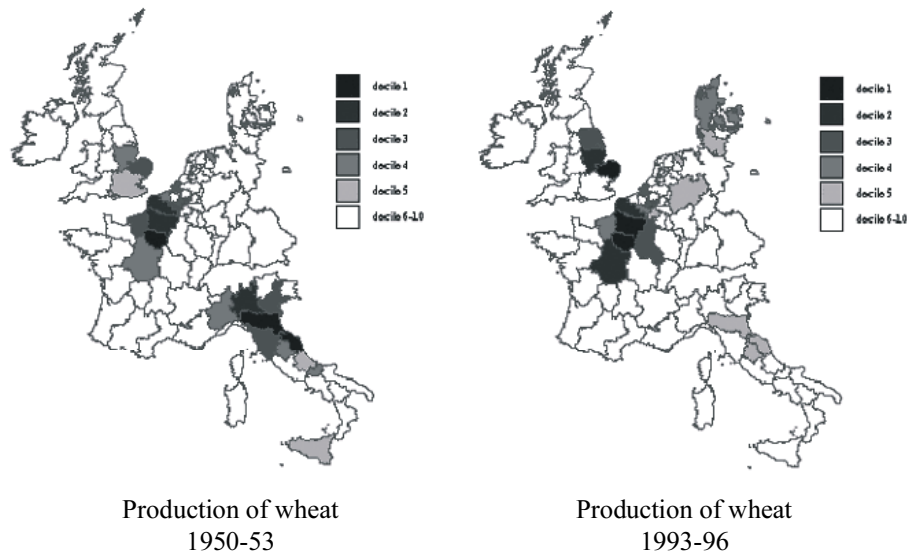


Figure 1.

Table 1 reports the Gini Coefficients for the production and land use of wheat and tobacco and provides information on the development of the regional structure of production and land use. For wheat, the changes over time are small, especially when the length of the observation period is taken into account: the value of the coefficient remains almost stable. The values of both Gini Coefficients (approximately 0.4) indicate that wheat cultivation is widely spread over the regions, that is to say, the degree of regional concentration is relatively low. The difference between the coefficients for production and land use is small, but gradually increases. The degree of regional concentration of production is somewhat higher than that of land use. This indicates that wheat cultivation has become more and more concentrated in regions with a high production per unit of land (yield).

Table 2 reports the coefficient of Spearman measured over the entire forty-year period from 1950/53 to 1993/96. The value of this coefficient (between 0.6 and 0.7) indicates that changes in the ranking order of regions have been relatively small. The combination of the Gini and the Spearman Coefficients confirms the stability of the regional structure of wheat cultivation in the EU-9.

For tobacco, the values of the Gini Coefficient are not only greater than those for wheat but they also increase over time. This indicates that the production of tobacco has become concentrated in fewer regions. The coefficient of Spearman is also very high (>0.9), but that is mainly due to the fact that the majority of regions do not have any tobacco cultivation, which limits the possibilities for changes in ranking. We may nonetheless conclude that both production and land use of tobacco are heavily regionally concentrated and that the degree of regional concentration has increased over time.

Table 1. Gini Coefficients for Production and Land Use of Wheat and Tobacco

Period	Wheat		Tobacco	
	Production	Land use	Production	Land use
1950/53	0.43	0.41	0.76	0.76
1960/63	0.42	0.40	0.77	0.80
1970/73	0.44	0.42	0.79	0.82
1980/83	0.47	0.44	0.91	0.90
1983/86	0.47	0.43	0.92	0.91
1986/89	0.45	0.40	0.91	0.91
1989/92	0.45	0.40	0.92	0.92
1993/96	0.45	0.39	0.91	0.91

Table 2. Coefficients of Spearman for Production and Land Use of Wheat and Tobacco

Period	Wheat		Tobacco	
	Production	Land use	Production	Land use
1950/53-1993/96	0.61	0.69	0.95	0.95

To investigate whether, and in which direction, wheat and tobacco production have moved across the European continent, we have calculated the centre of gravity of production and land use for both crops (Figure 2).

**Figure 2.** Movements of the centre of gravity for wheat and tobacco, production and land use

For tobacco the centre of gravity has gradually moved from the vicinity of Milan to Rome. The fact that the centre of gravity is in some cases located in the Tyrranean Sea makes it clear that there need not necessarily be production at the centre of gravity: it is just a theoretical construct.

The development of wheat is also quite interesting. Although the coefficients of Gini and Spearman indicate that the regional structure remained almost stable, the centre of gravity has shifted quite dramatically in a north-westerly direction. This holds true for both production and land use. Such a movement implies that the northern and western part of the EU-9 have increased their share in production and land use at the expense of the southern and eastern part. The map also shows that the centre of production is always located north-west of the centre of land use. The logical explanation for this would be that yields in the north-west tend to be higher than those in the south-east. Another interesting feature is that the largest movements took place in the period before 1980. Initially, land use moved to the north and production to the north-west. After 1983-86, the centre of production remained more or less fixed (east of Paris), while that of land use continued to move (slightly) further to the north-west.

Table 3 and 4 reports Moran's I concerning wheat and tobacco.

Table 3. Moran's I for W specified as Inverse Distance (ID) and Binary Contiguity (BC) matrix

Period	Wheat			
	Land use/agricultural land		Production/agricultural land	
	W=ID	W=BC	W=ID	W=BC
1950/53	0.187	0.620	0.083	0.439
1960/63	0.114	0.511	0.043	0.390
1970/73	0.080	0.424	0.050	0.345
1980/83	0.079	0.401	0.061	0.363
1983/86	0.075	0.388	0.078	0.413
1986/89	0.078	0.386	0.083	0.424
1989/92	0.081	0.394	0.081	0.422
1993/96	0.078	0.388	0.080	0.385

Table 4. Moran's I for W specified as Inverse distance and Binary Contiguity matrix

Period	Tobacco			
	Land use/agricultural land		Production/agricultural land	
	W=ID	W=BC	W=ID	W=BC
1950/53	0.057	0.143	0.020	0.112
1960/63	0.076	0.157	0.025	0.084
1970/73	0.063	0.080	0.026	0.020
1980/83	0.037	0.018	0.021	0.002
1983/86	0.040	0.028	0.026	0.016
1986/89	0.040	0.047	0.026	0.024
1989/92	0.037	0.052	0.026	0.030
1993/96	0.037	0.056	0.028	0.039

A first remark about these tables concerns the fact that nearly all the results in Table 3 (wheat) differ statistically in a significant way from zero, while the opposite is the case for the results in table 4 (tobacco). The latter result may be explained by the large number of regions that do not have any tobacco cultivation, the problem of the 'zero' regions. This problem is aggravated if the Binary Contiguity matrix is used. When the inverse distance matrix is used, 'non-zero', distant regions still have a certain influence. In that respect the Distance approach is superior to the Binary approach.

For wheat, the degree of spatial autocorrelation of *land use* declines at the beginning of the observation period and then stabilises. The initial decline indicates that land use has become less concentrated in contiguous regions and reflects the declining share of a large group of Italian regions in the EC-9. Their position has partly been taken over by Denmark and Schleswig-Holstein, but these two regions do not have many nearby regions for which wheat cultivation is also important.

The picture is quite different for the *production* of wheat. Table 3 shows that the degree of spatial autocorrelation for *production* at the beginning of the observation period first declines, just as we found for land use, but then, in contrast to land use, increases again. The explanation could be that the Italian regions, although important in terms of land use, were less important in terms of yields. In 1950/53 there were 8 adjacent Italian regions in the group of regions that produced the first half of the total wheat production in the EC-9 (and two more at some distance), whereas in 1993/96 there were only three regions: Emilia-Romagna, Umbria and Marche. The situation of those regions in the northern part of the EC-9 which increased their share of wheat production is quite different in the sense that they are characterised by relatively large and increasing outputs on a relatively small acreage. This is not only the case in Denmark and Schleswig-Holstein, but also in some nearby regions in Germany and the Netherlands (Groningen, and the new region of Flevoland) and even in northern France. The influence of these nearby but not adjacent regions only affects the calculations based on (inverse) distance, whereas these regions are neglected in the calculations based on binary contiguity. The procedure based on distance is in general, and certainly in this case, to be preferred over the one based on binary contiguity.

To summarise, it is possible to say that the figures for land use show a decline of concentration in Italy at the beginning of the observation period, and a stabilisation afterwards, while the figures for production also show a decline at the beginning, but then point to the emergence of a new concentration area in the north of the EC.

Integration and discussion

The different quantitative methods to analyse the degree of regional and spatial concentration as presented in this article not only throw more light on the dynamics in space and time, they also complement each other. Although they may be regarded as different views of the same object, namely the development of EU agriculture in the post-war period, it is hard to draw any conclusions on regional concentration without studying changes in the ranking order of regions and spatial concentration. Similarly, it is hard to interpret measures of spatial concentration without studying changes in the centre of gravity and regional concentration.

First of all, we shall attempt to present an overall picture based on the results for wheat. Although the skewness of the regional distribution of wheat production has hardly changed during the last forty years (the coefficient of Gini is almost constant),

some regions have improved their position at the expense of others (the coefficient of Spearman is 0.6–0.7). It is especially those regions in the north-west of Europe that have improved their position (the centre of gravity has moved in that direction). This has led to spatial deconcentration. Figure 1 shows that quite a large group of (adjacent) Italian regions have lost their position, especially in terms of production, and have been replaced by Denmark, Schleswig-Holstein and Flevoland. The results of Moran's I indicate that production (land use times yield) in the northern part of the EU caused a revival of spatial concentration at the end of the observation period, but only in terms of production and not in terms of land use.

It has not been the key objective of this article to present a detailed economic or physical interpretation of these results. Nevertheless, some observations concerning the stable regional distribution, the tendency towards spatial deconcentration, and the gradual movement of the centre of production to the north-west can be made. The first interpretation is that production and land use in the northern regions increased relatively fast during the early period (1950-60), as compared to the developments in the southern regions. This was before the Common Agricultural Policy came into being, but the development continues after the initial implementation of the CAP. The background to this is primarily technical. Apart from the fast agro-economic development in the north-western part of the EC, two specific elements should be mentioned. First of all, in some parts of Germany potato cultivation has been replaced by cereal cultivation for economic-technical reasons (Stinshof, 1967, p. 25; further elaborated in Strijker, 1999, p. 146). Secondly, rye was traditionally an important cereal crop for relatively dry and poor soils in the north-western part of the EC (*ibid.*, p.138). Thanks to reallocation schemes, water management and fertilisers, rye has gradually been replaced by wheat, and even more so by barley. Wheat and barley can now be produced in areas where this was not possible before. These two elements (a decrease in potatoes and rye) have caused a relative increase in the production (both land use and yield) of wheat in regions where, traditionally, this crop was less important. This might explain the global tendency towards spatial deconcentration of wheat production in the EC/EU-9 at the beginning of the observation period.

The influence of the CAP can be traced back to the increasing share of Denmark and the British regions. In these regions, membership of the EC has led to higher prices for cereals, stimulating the production of cereals. This development can be seen on the maps: the movement of the centre of production to the north-west is probably also partly caused by this change in price level. The fact that the centre of production did not move further after 1983/86, while the centre of land use continued to move to the north-west, is probably caused by the more general increase of yields per hectare, not only in the north-west but also elsewhere (the gap between the south and the north is still increasing in absolute terms, but not in relative terms). On the other hand, it can be seen that land use for wheat, especially in Italy, has declined even further.

For tobacco the interpretation is quite different. During the 1950s there was still considerable production of tobacco in Germany and Belgium, and even more so in France (Alsace, Aquitaine). Due to a rise in income and changes in taste, there has been a shift in demand, and hence in production, from black tobacco varieties to the Virginia and Burley types. Consequently, the production of tobacco was first terminated in the northern countries of the EC-9. Later, it also decreased in the French regions. Due to climatic conditions, Virginia types of tobacco can only be grown efficiently in the southern part of Italy, and indeed, tobacco-growing these days is fully concentrated in a few Italian regions, reflecting the situation in the EU-9. If Greek regions had been included in the

analysis, the picture would have been somewhat different. It should be noted however, that Greece does not so much specialise in light tobaccos but rather in Oriental varieties. These developments took place regardless of the fact that tobacco production is strongly regulated by intervention schemes and quota systems. These instruments of agricultural policy have apparently not been able to withstand the pressure of changes in taste and hence in demand.

Notes

1. Cliff and Ord (1981) provide a formal derivation of this formula.
2. For the calculation of the coefficients of Gini and Spearman the regional division is slightly different because 90 regions are then distinguished: Denmark counts as three regions instead of one.

References

- Bowler, I. (1985). *Agriculture under the Common Agricultural Policy*. Manchester: Manchester University Press.
- Cliff, A.D. and Ord, J.K. (1981). *Spatial autocorrelation*. London: Pion.
- Hecke, E. van (1983). *Regional structure of the agricultural production in the European Community*. Brussels/Luxembourg: Commission of the European Communities.
- Henry, P. (1981). *Study of the regional impact of the Common Agricultural Policy*. Luxembourg: Commission of the European Communities.
- Laurent, C. and Bowler, I. (eds.) (1997). *CAP and the region: building a multidisciplinary framework for the analysis of the EU agricultural space*. Paris: INRA.
- Mitchell, B.R. (1988). *British Historical Statistics*. Cambridge etc.: Cambridge University Press.
- Selected Agri-figures, various years. The Hague: MLV.
- Stinshoff, H.-W. (1967). 'Der Pflanzkartoffelmarkt in der Bundesrepublik Deutschland'. *Agrarwirtschaft, Sonderheft 22*. Hannover: Alfred Strothe Verlag.
- Strijker, D. (1999). *Ruimtelijke verschuivingen in de EU-landbouw 1950-1992 (Spatial changes in EU agriculture 1950-1992)*. Groningen: Stichting REG.
- Tracy, M. (1989). *Government and Agriculture in Western Europe 1880-1988 (3rd edition)*. New York etc.: Harvester Wheatsheaf.