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SPATIAL DIFFUSION OF INNOVATIONS IN HUNGARIAN AGRICULTURE

Introduction

The spatial diffusion of innovations has been an important issue in geographic research since Hägerstrand published his famous book on "Innovationsförloppet" 35 years ago. This research approach put the time/space relationship into a new prospective. The theoretical background of this approach was enlarged in recent decades, by Hägerstrand himself, by his school in Lund, and by a group of North American geographers. Now, geography textbooks refer to time geography, describing the general model, how an innovation is generated in a center, and how it is diffused spatially from this center towards the receiving, less developed areas until the point of saturation.

This approach did not have great influence on the geographers of East Central Europe. We can quote only R. Domanski of Poland and K. Ivanicka of Czechoslovakia, who applied innovation diffusion theory in their empirical research.

The method and approach gained new importance when, since the late 1970s, "an innovation oriented regional policy" has been formulated. There was an urgent need to replace the earlier growth oriented regional policy by a new one emphasizing structural and qualitative changes. Substantial changes in the world economy occurred in the last decade, and these changes forced the re-evaluation of traditional

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regional policy.

This "traditional" approach classified the different regions according to their capacity of growth: local natural resources, manpower, transport-connections, etc. New regional policies distinguished the different regions according to their capacity of emanating, transferring, and absorbing innovations; hence, their R + D potential, sectoral structure size of enterprises, labor qualification, type of settlement network, etc. came into the forefront.

This paper analyses the territorial diffusion of one of the most important agricultural innovations: production systems. Hungarian agriculture proved to be most innovative - perhaps the only really innovative - sector of the Hungarian econony. There is an adequate data base for analyzing the territorial diffusion of production systems. The production systems themselves represent a complex organizational-technological innovation and have been dispersed on the whole area of the country /75 % of the country's area is utilized by agriculture/.

We were looking for answers to the following questions;

- is it possible to describe the life cycle of innovations?

- can we distinguish centers and receiving areas of innovation?

- can we recognize territorial regularities in the diffusion of innovation?

- based upon the above aspects, can we forecast future territorial paths of innovation?

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Production Systems

Production systems represent an industrial-type method of agriculture, when all the details of production of a given plant or that of animal products are accurately elaborated: e.g., the time of sowing, the quality of seed, the quantity of seed to be sown per hectare, the type and quantity of fertilizers, the time of fertilizing, all the types of machinery, etc. The production systems are worked out either by agricultural schools, leading farms, or big agribusiness enterprises /e.g., by food processing and marketing chains/. The owner of the system offers the application of the system as a service to individual farms. The system manager adapts the system to the local ecological conditions; it will supply the farmer with the necessary technology, quality seeds, etc. and will guarantee a minimum yield. Farmers pay a fee for the expertise and services.

The production system idea was worked out first in the U. S. It was applied for the first time in Hungary some 20 years ago, and it started to be propagated in the country between 1969 and 1971. Broiler chicken and corn, then wheat production were incorporated first into production systems; later, all the important plants /including fruit and vines/ and animal products had their production systems elaborated and introduced. The scientific accuracy of the production systems has contributed largely to the spectacular yield take-off of Hungarian agriculture. The yields of the most important products doubled during the last 15 years.

In Hungary, the innovation centers remained almost entirely within agriculture. Some leading

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state farms or cooperative farms took the initiative for working out and propagating production systems. In certain cases - e.g., sugar beet and hemp - the processing industry also took part in managing production systems.

Within a few years, most of the Hungarian large scale farms joined to one or several production systems. Farm managers expected different types of advantages from membership in production systems: higher yield, easier access to quality seeds, and especially to Western technology imported for hard currency. The curve of the life cycle of single production systems showed a regular pattern: after a strong take-off period, a slowly advancing growth, then saturation and even a slight decline. The decline was explained by the worsening economic conditions for agriculture, when the charges for membership proved to be too heavy a burden for poor cooperatives. The profitability of agricultural activity diminished significantly during the last five years because of the growing taxes and the rapidly rising prices of industrial goods used in agriculture.

On the other hand, the original task of production system managers, i.e., the introduction of the new technology, was practically achieved. We do not intend to discuss here what type of future might be forecasted for the production systems. Anyway, their life cycles are long enough for analyzing their regularities.

During fifteen years, the production systems became general in Hungarian agriculture. In 1985, there were 64 industrial type production systems in our agriculture: 20 of them were dealing with crops; 22-22 of them organized the production of animal products and that of truck gardening and fruit and vine growing. Eighty-nine percent of wheat production, 91 % of corn production, and 96 % of sugar beet output are produced using production systems. Two thirds of vine and 60 percent of apple output also come from production systems. As for livestock raising, 71 percent of dairy cows, 89 percent of pigs, and 99 percent of egg laying hens belong to production systems /Data of the collective, large scale farming sector/. There were 8 production systems that had more than 200 member farms; large scale cooperative or state farms participate only in the production systems. There are 1,300 large scale farms in the whole country; they dealt with basic products /wheat, corn, beef/. The majority of the production systems have 10-15 member farms. There is a real competition among production system managers for recruting - and keeping - members. The relation between the manager farms and the member farms has been based on mutual economic interests; there was not any administrative or government intervention into the territorial organization of the production systems. Consequently, their territorial diffusion was guided spontaneously by economic judgements and by the dissemination of information about the systems.

In sum, the spatial distribution of production systems fits to the concept of the territorial diffusion of innovations.

Data Base

Our research covered the area and activity of 3 systems and 4 crops /Table 1/. Here we present a summary of the research of two corn production systems.

Table 1

Production Systems included in the research project

System	Crop	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
		Years										
KSZE	wheat						x	x	x	x	x	x
KSZE	sunflower						x	x	x	x	x	x
IKR	wheat						x	x	x	x	x	x
IKR	sunflower				x	x	x	x	x	x	x	x
IKR	sugarbeet				x	x	x	x	x	x	x	x
IKR	corn	x	x	x	x	x	x	x	x	x	x	x
KITE	corn			x	x	x	x	x	x	x	x	x
KITE	sugarbeet			x	x	x	x	x	x	x	x	x
KITE	wheat						x	x	x	x	x	x
KITE	sunflower				x	x	x	x	x	x	x	x

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The two systems are: Industrial Corn Production System /IKR/, with its headquarters in Bábolna /Bábolna Agricultural Combine, a state farm/; and the industrial Corn Production Association /KITE/, organized by the "Red Star" Producers'Cooperative in Nádudvar. The first center is located in Northwestern Hungary; the latter one on the Great Plain, near the city of Debrecen. These are the largest production systems of the country; IKR had 260 and KITE had 348 member farms in 1981. In the beginning, the two distant systems had separate areas, but later competition developed between them.

Corn is the most important crop in Hungary, occupying 1/4 of the total cropland. During the 1970s, corn enjoyed a good economic position, thus innovative farms turned easily towards the corn production systems. We analyzed the spatial distribution of the corn production systems year by year between 1971 and 1981.

The Analysis

/a/ The development of both production systems show three distinct periods /Fig. 1/. The first period, the take-off, was characterized by a very rapid growth of the number of member farms. The take-off period started earlier in the case of IKR /Bábolna Agricultural Combine was the pioneer of the deep technological-organizational changes in Hungarian agriculture/. The take-off period ended in both cases around 1975. The second period /1975-1980/ was the phase of levelling, when the extension of the systems continued in much slower pace than earlier. This period was different in the two systems: it was more explicit in the case of the

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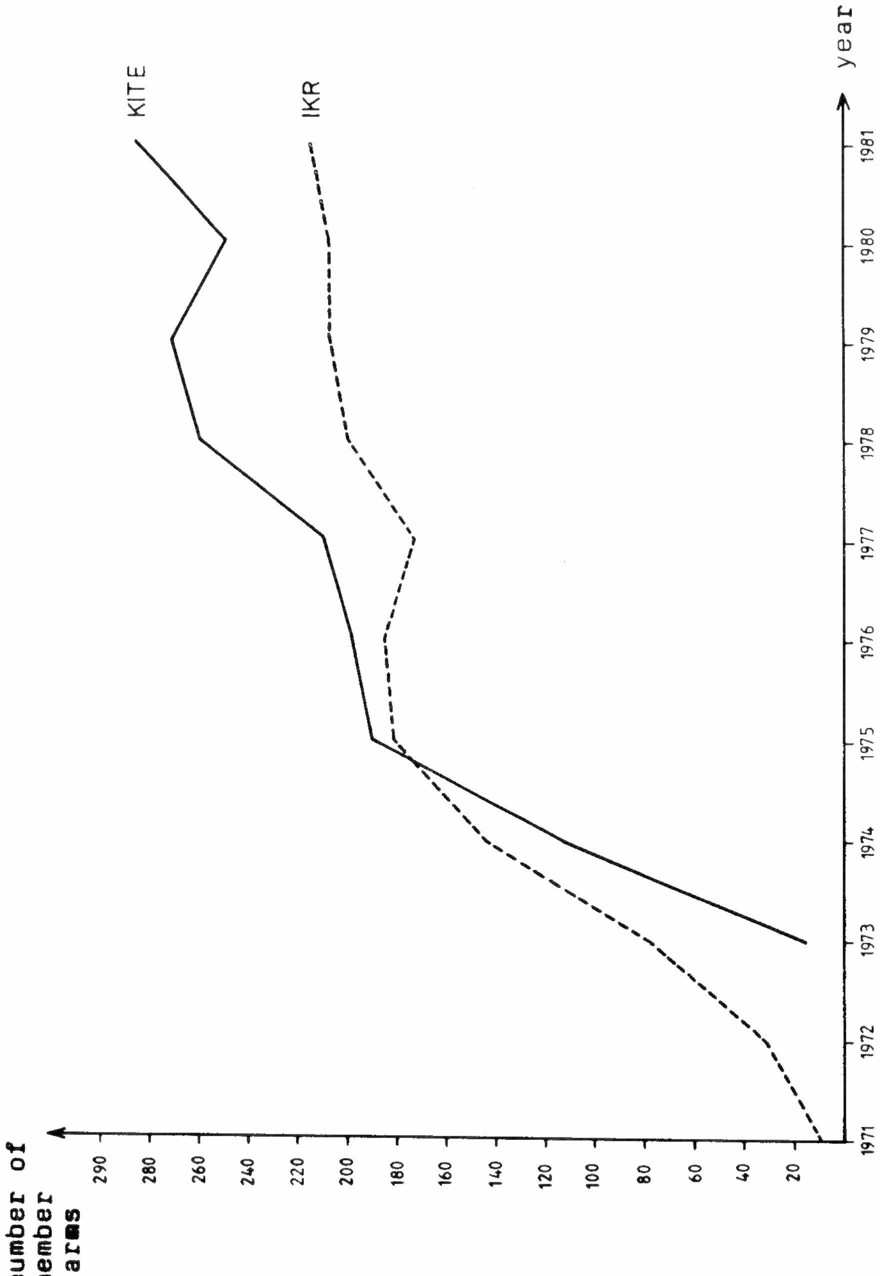

FIGURE 1 KITE and IKR member farms (1971-1981)

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IKR; but KITE enjoyed a second, smaller take-off period /after 1977/, KITE was still able to enlarge their clientee. Due to its more successful and more aggressive business policy, it succeeded in seizing some of the former IKR members. On the other hand, corn areas expanded mainly on the most fertile chernozem zones of the Great Plain, where the KITE headquarters is located. IKR had to withdraw from Northern Hungary, where it tried to introduce corn production systems among relatively poor farms. Due to the modest ecological potential, corn yields in Northern Hungary were not large enough to support the raise in production costs.

Changes in the territory cultivated in production systems were more differentiated. Figures 2 and 3 show the changes in the size of corn area in the two systems, by counties.

In the IKR /Fig. 2/, the take-off period is clear in every county. The system is present in all 19 counties of Hungary. IKR started its activity in the late 1960s in 4 Western Hungarian counties, but it penetrated in some counties as late as 1974. In 1977, there was a sharp drop in corn area in almost all the counties. This decline was explained by the sudden worsening of the economic conditions of the crop. Following the second oil price explosion, the prices of energy, gasoline, and fertilizer jumped, but corn prices remained unchanged. The farms responded to this situation by drastically reducing the area activated with corn. The government was forced to rise the corn price and expansion of the corn area started again - but not everywhere, and not on the same rhythm. In some counties, the saturation became clear already in 1979. Anyway, there was not

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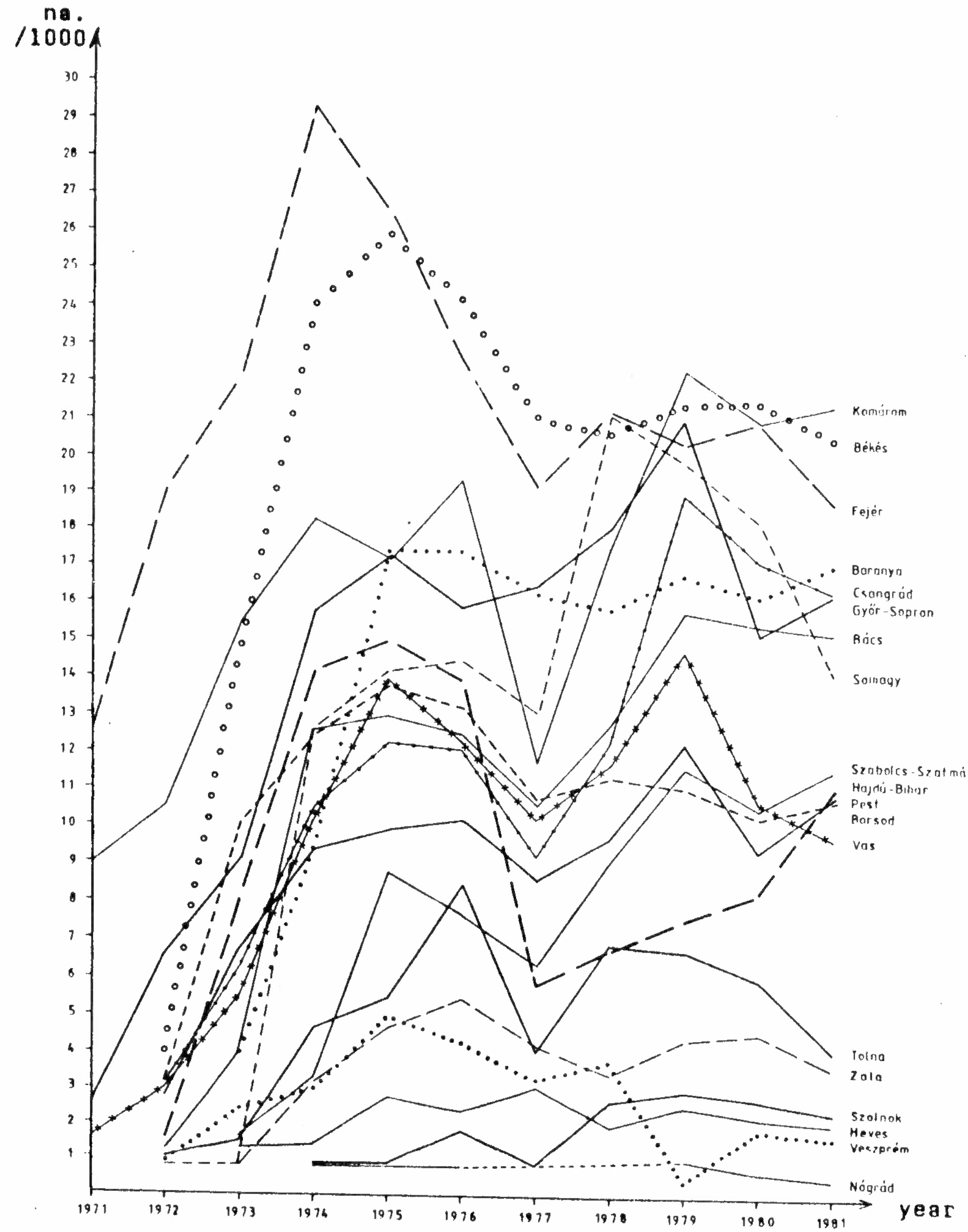

FIGURE 2 Area involved in the IKR system by counties

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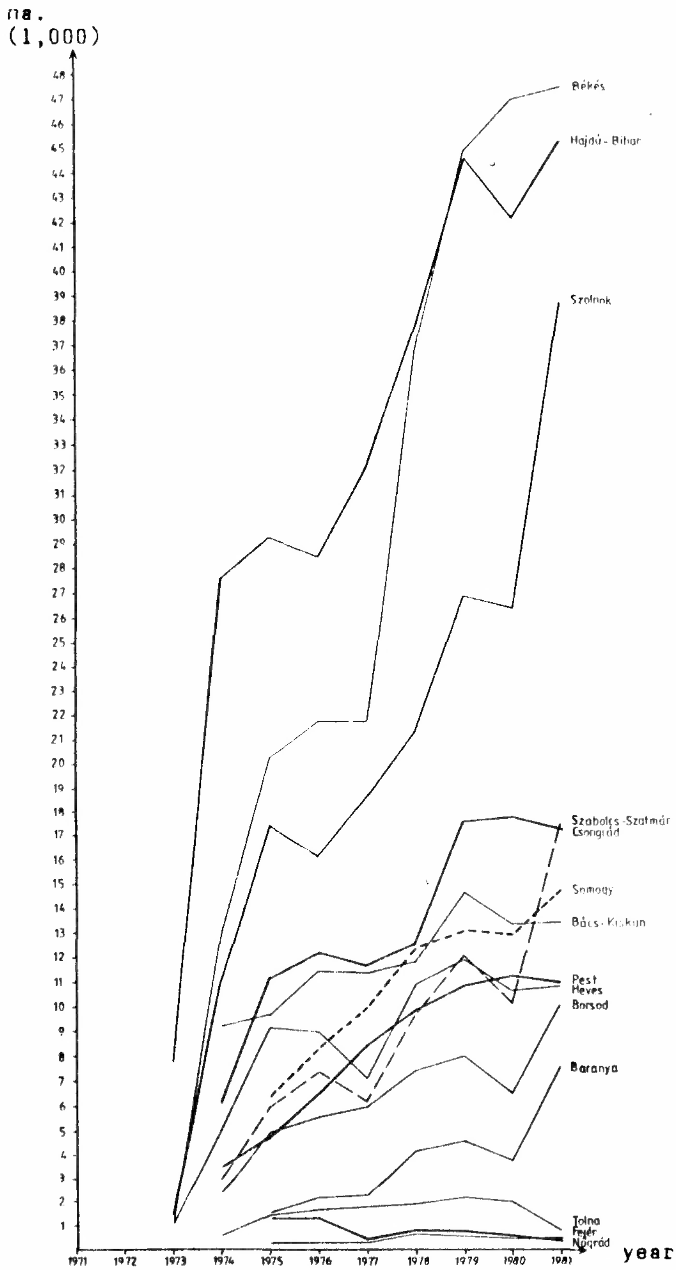

FIGURE 3 Area involved in the KITE system by counties

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a single county that was able to reach the maximum level of the take-off period untill 1981. Corn areas were becoming more and more concentrated in the ecologically most advantageous counties.

The KITE system was organized later, so the take-off period was postponed somewhat. The member farms are less dispersed in the country than in the case of IKR: 5 counties /all of them in Western Hungary/ contain no member farm. The 1977 drop in corn area was slighter than in the IKR area, followed by an explicit new take-off, and, again, by a new slight drop in 1980. In the three leading counties - Békés, Hajdu-Bihar and Szolnok - which have contiguous area and where we can find the three most fetile loess ridges of the country, the take-off continues in full speed. A few of the counties already showed a certain levelling in the corn area, but, as a whole, the system was far from saturation in 1981.

/b/ The next question was: whether there was any spatial continuity in the expansion of the systems. Evidently, there was not a clear geographical continuity, since IKR and KITE tried to advertize their services in the whole country and so the information was not passed from neighbour to neighbour, as in the classical Hägerstrand model.

Nevertheless, there are distinct geographical groups that became "core areas" of the system. Geographical proximity helped to establish relations between agricultural enterprises; the ecological conditions were similar, too. In the IKR system /Fig. 4/, the take-off started in Komárom and East of Győr-Sopron Counties, close to the Bábolna headquarters. The next contiguous areas of the take-

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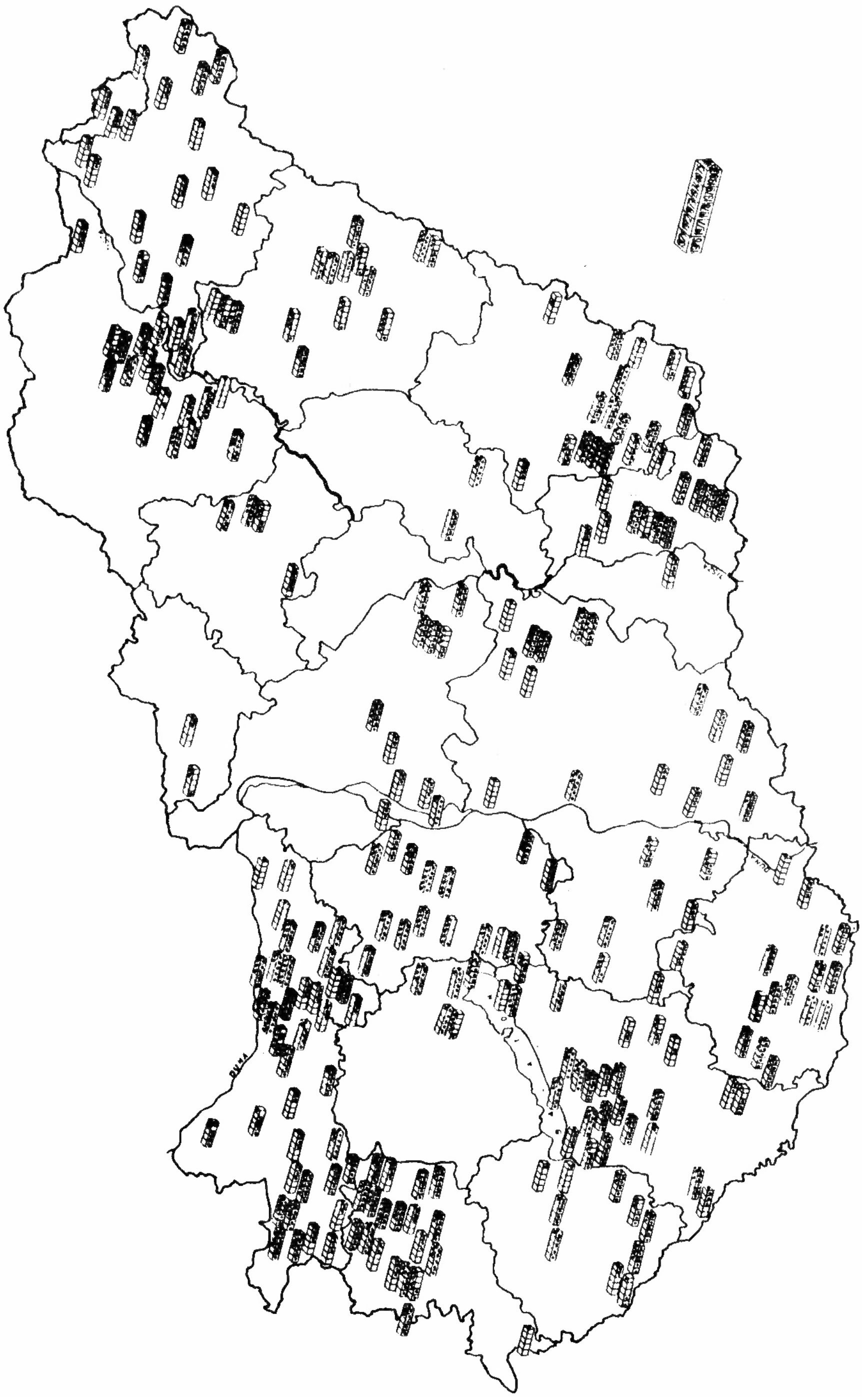

FIGURE 4 IKR memberships: their duration between 1971-1981

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off were: Vas and West of Győr-Sopron Counties; South Eastern Plain /Békés and Csongrád Counties/; Fejér County and the Szerencs Loess Ridge /in Borsod-Abauj-Zemplén County/. The last wave of expansion created zones in Somogy and Baranya Counties. New farms that joined the system during and after the late 1970s were dispersed geographically. The importance of the geographical connectivity is also shown while we analyze the core areas of the systems /Figures 5 and 6/ in a more detailed way.

We can conclude our time/space analysis as follows:

/1/ one can describe the life cycle of the systems by a regular curve. The IKR system has already reached its saturation; the KITE has more dynamism. The saturation does not mean that the systems will be ended, though: they make efforts to keep their positions and they introduce ever newer production systems and diversify their activities. The earlier successful corn production system provides a reference for other crops. Rural settlements, where the headquarters of production systems were located, became innovation centers at the national and in some cases, international scale. They exported production systems - mostly for corn and poultry - to several countries. This fact had a great impact on the functional diversification and on the overall development of the given rural communities.

/2/ There were regularities in the geographical expansion of the systems. The take-off started in a spatially concentrated manner; later, a few local centers were formed that conveyed the innovations received from the production systems'

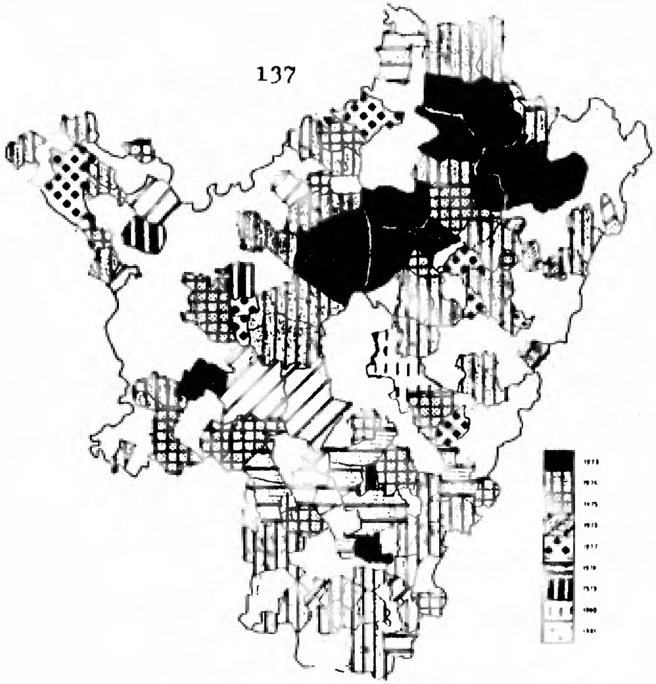

FIGURE 5 Member farms within the KITE core area by their year of joining the system

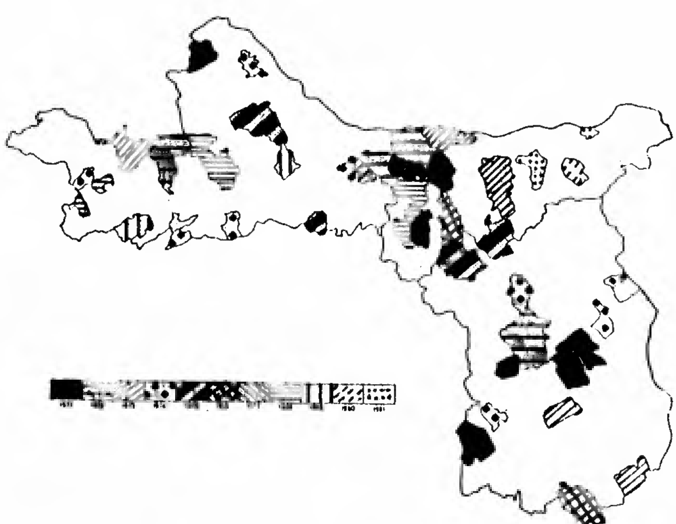

FIGURE 6 Member farms within the IKR core area by their year of joining the system

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centers towards the neighbouring villages.

The Models

After analyzing the empirical data, and concluding the above mentioned main tendencies, we tried to describe the general relations of the spatial diffusion of production systems in forms of models. /Mathematical modelling was carried out by Dr. J. Rechnitzer./

/1/ The saturation of the systems - the "snowball" model

The snowball model explains the intensity of the propagation and the level of the saturation in the case of a process developing in time and in space. The model applies a logistic estimation of a function for defining the size of growth. The model was elaborated at the county level.

The model predicts the saturation level /in hectares/ of the systems by counties. Comparing the saturation level and the actual size of corn area, we can estimate the further expansion of the production system in a given county. The life curve of the production system is different from county to county. In sum, the model proved the saturation of the IKR system. KITE still has some potential for further expansion, but - because of its rapid growth - it is nearing rapidly the upper limit of its expansion.

/2/ The role of distance in the diffusion of production systems - the center of gravity analysis

The center of gravity method is used mainly in population geography. One analyses the general

——— displacements of KITE centers of gravity within counties

- - - - - displacements of IKR centers of gravity within counties

——— displacement of KITE center of gravity within Hungary

- - - - - displacement of IKR center of gravity within Hungary

FIGURE 7 Displacements of the IKR and KITE centers of gravity (1971-1981)

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trend of population location within a given area by determining the movement of the center of gravity for the whole country and on county levels as well. In the calculations, we weighted the geographical coordinations of each member farm by the corn area of the given farm. The calculation was made year by year between 1971 and 1981.

In the take-off period, the center of gravity of the IKR system was close to the center of the production system, in Komárom County. We can distinguish three phases in the movement of the center of gravity. Between 1971 and 1974, the center of gravity "crossed" the Danube and it moved to Pest County as a consequence of the intensive expansion of the system in the Great Plain. In the period of levelling /1974-1980/, the movement exhibited different directions, but the center did get somewhat closer to Transdanubia. In 1980-1981, the center of gravity moved to the NE, which showed the saturation of Transdanubia and the slow advancement in the Great Plain.

In the case of the KITE system, the movement of the center of gravity has been less exaggerated. In the take-off period, the center of gravity moved Westward, as the production system penetrated Transdanubia. Later, the movement slowed down, and the center of gravity remained within the same region.

Concerning the movement of centres of gravity on the county level, we get a similar picture: the IKR system has had a more intensive territorial movement within the counties, with South-South-East as the main direction /Table 2/.

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Table 2

The direction of movement of the center of gravity in the IKR system by counties, 1971-1981

N

W	E
1. Szolnok 2. Heves 3. Békés	1. Komárom 2. Fejér 3. Szabolcs-Szatmár
1. Vas 2. Somogy 3. Bács-Kiskun	1. Veszprém 2. Nógrád 3. Hajdu-Bihar 4. Baranya 5. Csongrád 6. Borsod-Abauj-Zemplén 7. Pest 8. Győr-Sopron 9. Tolna

S

The order of counties expresses the intensity of the movements /from low to high/.

The movement of the KITE-system has been less intensive. In several counties, the movement was so insignificant that the location of the center of gravity remained practically unchanged. In most cases, the direction of the movement has been N-NE /Table 3/.

Table 3

The direction of movement of the center of gravity in the KITE-system /1973-1981/; by counties

	W	E
N	1. Szolnok 2. Békés 3. Heves	1. Baranya 2. Hajdu-Bihar 3. Bács-Kiskun 4. Csongrád 5. Fejér
S	1. Borsod-Abauj- -Zemplén 2. Szabolcs-Szatmár	1. Nógrád 2. Pest 3. Somogy

It is interesting to note that the direction of movement of the two systems has been indentical in six counties, especially in the case of NW movement. We can suppose the existence of an intensive competition for the good corn areas in these counties.

/3/ Groups of member-farms; cluster analysis

In the third level of modelling, we tried to classify the member farms according to their spatial peculiarities /from the point of view of the propagation of the corn production systems/. The following variables were used by farms:

1. the location of the farms /their geographical coordinates/;

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2. the year of entering /or re-entering/ into the system;

3. the size of the corn area /including changes in size/.

We used the well known cluster analysis method for grouping the member farms. We carried out cluster analysis separately for the two systems.

We summarize here the result of the analysis in the case of the IKR. We grouped the 260 member farms of the production system into 7 groups /clusters/.

In the first cluster, we found only 2 farms: the Bábolna Agricultural Combine and the Agárd Agricultural Combine. Their corn area has shown a steady growth: these two leading state farms played a decisive role in the propagation of the production system. Bábolna originated the innovation, but Agárd was developed later into the position of co-center of the innovation.

In the second cluster /15 farms/ we find the local centers of the innovation. These farms joined the production system between 1972 and 1974, and they had large /1,500-4,000 hectares/ corn areas. These local centers - which conveyed the innovation into their surrounding regions - are dispersed in the country /in 10 countries/.

In the third cluster /22 farms/ are the member farms of the first take-off period. They joined the system in an early period with large corn areas. But these farms have not been stable elements of the system: they have reduced continuously their areas or at least there were sudden drops in area.

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The seventh cluster /55 farms/ also contains the farms of the first wave but they represent the stable elements of the system, with a corn area of 1,000-2,000 hectares. The changes in their territory have been insignificant.

There are again only 2 farms in the fourth cluster. They are close to the third cluster. They joined the system in the first take-off period with large corn area, which fell to half its size during the period under investigation.

The fifth and sixth clusters /32 and 32 farms/ represent the second wave of the propagation of the system. The farms joined the system in 1977 and 1978. The fifth cluster's farms were stable in their territory /800-1,000 hectares/, remaining unchanged or extending slightly. In the sixth cluster, the farms remained marginal from the point of view of the system. Their corn area /500-800 hectares/ was at a minimum level, since about 800 hectares of corn area are needed for the fully efficient utilization of the complex technology chain of the production system. Some of them quit the system and re-entered later. They will be the first to leave the system in case of unfavourable conditions.

Conclusion

We can conclude the results of our analysis as follows:

1. We proved that there are spatial regularities in the diffusion of innovation /i.e., the corn production system/. We were able to distinguish innovation centers and member farms that were ready to absorb innovations to variable extents.

2. We were able to describe the life cycle of innovation, and to distinguish the phases of take-off, levelling, and saturation. The life cycle curve was disturbed by the strong drop of the corn area in 1977, which was a consequence of the drastic worsening of the profitability of corn production. We can expect a regular curve of the life cycle in the case of continuously favourable conditions for the propagation of innovation. The modelling of the life cycle makes it possible to forecast the time of saturation and the places of the possible further expansion of the system.

3. We defined the main geographical directions in the propagation of the system, i.e., the role of distance in the diffusion of innovation.

4. We distinguished different groups of the member farms according to their location, the extent of their corn area, and to their relation to the production system.

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