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INNOVATIONS ON THE POLISH FARMS, THEIR SCOPE OF IMPLEMENTATION AND SIGNIFICANCE

Abstract

After the accession, as compared to the pre-accession period, the Polish agriculture witnessed a growth in the volume of products manufactured with the resources spent under intermediate consumption. Diffusion of innovations and progress related to it were among the significant reasons for the productivity growth. The phenomenon of growth in the volume of products produced with the resources spent under intermediate consumption overlapped with the effects of the accession, which brought, inter alia, a considerable increase in subsidies.

This was the most important factor of improvement of the competitiveness of the Polish agriculture. If before 2004 only about 25,000 farms showed any features pointing to competitive capacity, in 2007 there were already 290,000-300,000 farms of natural and legal persons, which demonstrated competitive capacity or any prospects to achieve it. It is estimated that they produce 50-60% of the national value of agricultural production.

The impact of innovations on the progress taking place in the Polish agriculture could have been greater if there had been less farms failing to implement innovations. These were mainly smaller farms, but this group also included about 1/3 of farms with an area of 8 or more ESU.

Introductory remarks

Exactly 100 years ago J. Schumpeter formulated, for the first time, the definition of innovation in the economy (Kleer J. 2004). He understood this term as significant changes in the production function, whose essence is combining factors of production in a way different than before. He considered only the big entities to be innovative, because they can afford to create innovations that then

they use in their business practice. Tested in this way, they are later taken over by other entities.

P. Drucker (1992) treats innovation as an important entrepreneurs' tool, which they can use in the creation of competitive ability of their firms. The success in this area depends on: systematic evaluation of the possibilities to innovate, as well as the quality of the labour force. In this latter case it is knowledge, ingenuity, customs and mentality of employees. The quoted author believes that internal sources of innovation are more valuable, because the implementation of innovations derived from outside of the company is associated with a high risk.

M.E. Porter (1998) shared the view that the constant environment analysis combined with tracking innovation and proposing their own original solutions, allows the company to achieve success in the competitive struggle. It is a better strategy than reducing production costs by reducing employment. Human resources co-determine the success of such an approach, because it does not run out with time, and on the contrary – by collecting experience, they gain in value.

In the early 1980s, it became a widespread view that innovation was to be understood as the ability to create innovation and to apply it in management. It is not only an inherent feature of large enterprises, but it is also justified in medium-sized and small enterprises. For some time, a view dominated that innovation does not have to be located in economic entities. It is possible and reasonable to divide the creation of innovations and development phase from the implementation one. Even small businesses (e.g. farms) can, therefore, adapt innovations created elsewhere.

The implementation of innovations is associated with a high risk for economic entity. The phase of creating innovations should not end with the prototype's preparation, but with the implementation of a sufficient number of economic entities[1]. On this basis companies are able to determine its usefulness in the business practice. But even so, the popular textbook (Podręcznik Oslo 2008) refers to completed implementation of innovative activities that are not necessarily a commercial success and to discontinued operations before implementation of an innovation.

From the perspective of an economic entity, the following sources of innovation are mentioned: technology transfer, research and development activities, market research, collecting ideas (e.g. through the so-called "brainstorming"), consulting (e.g. provided by consulting firms) and encouraging appropriate attitudes among workers (Podręcznik Oslo 2008).

This indirectly indicates that the definition of innovation deviates from the one proposed a century ago by J. Schumpeter. In the handbook (Podręcznik Oslo 2008), an innovation is any significant change in the product (launching new products and services, and a significant improvement in already produced products) and/or in the manufacturing processes (manufacturing techniques, product sourcing methods, or simply the method of production).

[1] For example, there is a proposal (Innovation under... 2011) to increase the share of farms' prototype implementation costs co-financed by the European Union, in 2014-2020, with funds allocated to the Common Agricultural Policy (CAP).

Each of these methods is characterised by fixed or relatively fixed relations of streams and resource factors of production in terms of quantity and quality of manufactured product types. The introduction of innovations changes these relations, and this leads to a new method of production, which after a trial period can become part of the daily activities of an economic entity. Furthermore, organisational innovations (often conditioning benefits from the introduction of other types of innovation) and marketing innovations (e.g. change in the form of sale of the finished product) are also distinguished.

In the above-cited source, there is also information that innovations cannot include changes in the volume of production, capital resources and factors of production that result solely from price changes (fluctuations). Innovations are not a cessation of certain activities, even if it leads to improved efficiency management, or launching or adjusting volume of production of a particular type, where there are no new functional or performance characteristics. An innovative product, a new method of production and innovation of organisational or marketing nature is, however, an innovation for a given economic entity, even if it has already been implemented elsewhere.

The result of the creation of new methods of production through the use of specific innovations, but also the introduction to the business practice of other three types of innovation may be an increase in the value of sales and income of an economic entity and the related efficiency improvement of its operation, conducive to the growth of competitive ability. Moreover, innovation can in varying degrees influence the environment. Finally, the successful use of innovations can encourage the use of other innovations (Mirkowska Z. 2010).

Implementation of innovations is not accidental. Innovations are used to save on expensive inputs, run lucrative types of production and replace ineffective organisation and to introduce more effective marketing methods. They are also implemented when it is related to budget subsidies.

At a country level, a different division of innovation sources is used than for economic entities, namely: production in the country of innovative solutions on the basis of licences purchased abroad, overseas purchasing of ready-made innovative means of production, results of national research and local inventions and rationalisation.

From a national perspective diffusion of innovations is important (Łoboda J. 1983). It is understood as a phenomenon and the processes by which individual innovations spread from where they appeared and were prototypically implemented in other economic entities. It is clear that the diffusion of innovations concerns only these activities that bring positive effects to the economic operators who introduced them. Quick diffusion of innovations and their large coverage may become important determinants of competitiveness, not only of individual entities, but also of the entire economic sectors, including agriculture. Different rates of diffusion can also cause differentiation of individual regions and countries. In such a situation, what in one area is regarded as an innovation elsewhere may already be only a routinely performed practice.

Given the above general knowledge about innovation and its economic consequences, the article assesses a range of different types of innovations applied in the Polish agriculture, indicating the more important determinants influencing the occurrence of innovations in agriculture and attempts to assess the impact of direct payments on the absorption of innovation at farms. There is also an attempt to demonstrate the relationship of the problem with the competitive ability of the Polish farms. This elaboration does not include the assessment of the overall problem of the role of innovation issues in the Polish agriculture and acts only as a preliminary analysis of this problem.

Farms and innovation in the agriculture and the social progress

The majority of businesses in the agriculture (farms) are very small entities in the possession of individuals and with the dominant share of their and their family members own labour in the total labour input. Farms are so small that they cannot be the only source of income for people working on them and, therefore, part of family income must come from outside of the farm. This means that the holders of such farms do not have free capital stemming from agricultural production income, so they can only replace worn means of production, while they usually lack funds for introducing innovative solutions that are generally more expensive. In a better situation are larger farms, the holders of which employ external labour force, take out loans and lease land. Income of these farms is large enough to allow them to pay for outside factors of production at market level prices and make a profit from the management. Therefore, they are able to invest at a level ensuring extended reproduction of assets. At the same time, this means that they have capital, which allows them to acquire innovative means of production or introduce such procedures.

New challenges for innovation are formulated in the document (Innovation under... 2011). Policy relating to innovation and prototype implementation should make it possible to solve the most important problems today facing the EU agriculture – global competition and the effects of climate change, maintaining biodiversity in rural areas, etc.

Innovations used in modern agriculture consist of:

– launching production of food products with specific characteristics, for example organic or integrated production;
– launching new products with specific and, at the same time, desired functional properties (e.g. vegetable products harvested from modified seeds using genetic engineering, i.e. GM plants), which are raw materials for such industries as: feed, pharmaceutical, cosmetic or biofuels, etc.;
– introducing techniques (methods) of production, which allow for rational use of limited resources: labour, agricultural land, water for irrigation, etc.;
– replacing varieties of crops and breeds of animals kept so far with such whose traits bring more benefits for farmers;
– applying ways of production reducing unit consumption of agrochemicals (fertilisers, herbicides, medicines for animals, etc.) and fuel, which

lowers production costs and at the same time its negative impact on the environment;
- implementing practices reducing losses of finished products during their maintenance, storage and pre-processing;
- introducing practices lowering environmental pollution caused by storage of organic fertilisers, which, however, when adequately used, store significant amounts of carbon dioxide, thereby reducing the negative impact of agricultural crop production on climate;
- constructing or modernising facilities for animals to meet the conditions of animal welfare;
- introducing practices preserving biodiversity and landscape;
- reorganising production on the farm due to the restriction of their own labour input potential (for example, finding a new paid employment by the farm owner) or buying a set of high performance machines;
- purchasing and using collectively expensive machinery and equipment, as well as group sales of finished products, which is important, particularly in a fragmented agriculture, etc.

Innovations can be implemented gradually in individual farms, when it is appropriate or when novel means of production and services appear on the market or when there is information about the existence of demand for new products and innovative organisational and marketing practices. Innovation can be placed in a larger number in a short time when, for example, new farm owner carries out modernisation.

Progress is not identical with the introduction of all sorts of innovations, but with diffusion of certain kinds of them, because this is a testimony, that they bring beneficial effects to farms that introduced them. Progress can be expressed by an increase in farm income, improvement of production efficiency, increase in competitive ability of agricultural holdings relative to their foreign counterparts, decline in real prices of sold products and services, reduction in weed succession on land previously used for agriculture, improvement of animal husbandry, elimination of groundwater contamination with nitrogen and potassium, storage (sequestration) of additional quantities of carbon dioxide in arable soil, etc.

The multiplicity of effects of innovative agricultural practices can lead to conflicts. Local social conflict may arise, for example, when the purchase of a new machine eliminates some local demand for seasonal wage labour. Such conflicts may also have a much larger range, even a global one. Examples are the side effects of a new generation of more effective pesticides, because it turns out that some of them, even in trace amounts, threaten the lives of bees. Supply of honey falls and threatens to decrease yields of plants pollinated by insects. Therefore, the interest of farm holders is contrary to the interests of beekeepers and the general public interest, because a large part of the production of seed plants must be preceded by pollination. Analogous examples can be multiplied. It should be noted, however, that conflict situations due to the introduction of innovations are generally not permanent. People, who lost the opportunity of

earning, may with time find a job elsewhere, and the life of bees can be saved by a withdrawal from the market of certain agrochemicals.

Sources and scope of innovation in the Polish agriculture

There is a great interest expressed by many individuals and research teams at universities and research institutes in sustainable development. This issue largely meets new range of innovation proposals presented by the Danish Ministry of Food, Agriculture and Fisheries, which was mentioned earlier. This interest of research groups, however, is not accompanied by significant implementations of an innovative nature. Only 0.9% of farms is engaged in organic farming, and integrated farming and a method of agricultural production called precision agriculture enjoy even less interest among farmers. Wider dissemination of these ways of production would rationalise consumption of agrochemicals and thus decrease negative impact of plant production on the environment.

A large proportion of innovations used for improving production methods in the Polish agriculture are created outside the borders of our country. Their positive and negative effects, however, are checked first in national research institutes and at the universities with regard to the specificity of the Polish agriculture (worse soil quality, less favourable climate, reduced water resources for irrigation, incidence and severity of specific pathogens of crops and livestock, etc.). ISSPC-SRI verified, e.g. the usefulness of plant species from all over the world giving high yield per surface unit as a raw material for the production of biofuels.

There are also known cases of direct transfer of agricultural innovations implemented at farms in the countries of the former EU-15 undertaken by eminent Polish producers.

A range of technical and technological innovations, which appeared in the Polish agriculture after 2000 as a result of diffusion includes:

- Very significant were innovations associated with the storage of produced goods, which was forced by increase in customer requirements regarding the quality of products sold by agricultural producers.
  The largest changes in this area occurred in the production of milk. Farms specialising in this type of production invested in milking machines for mechanical milking and tanks for cooling and storing milk, which had a positive influence on the quality of the product. New technologies of preserving green forage reduced losses of this product caused by variability of weather, and as a result contributed to improving the profitability of milk production, but also of breeding other types of ruminants.
  Positive changes were also recorded in the storage of cereals in the form of cereal silos, which limited the losses caused by fungal diseases and by rodents. Some progress is also visible in the storage of apples – some growers in place of storing apples in basements, built refrigerators and refrigerators with controlled atmosphere. Some vegetable producers built refrigerated storage buildings for finished products.

- Process of implementing innovations replacing labour was continued. Marginal labour profitability in the Polish agriculture was close to zero (Czekaj T. 2009), while the return on capital exceeded interest on credit. This was mainly associated with labour-intensive activities related to dairy cows breeding, as well as harvest. An example is the use of milking robots and combine harvesters in the case of industrial apples and platforms for collecting dessert apples.
- Introduction of modern equipment for plant production under shelter (early vegetables, flowers, seedlings), which limit energy consumption and environmental pollution, also introduced simplified forms of cultivation (also called no-till farming), for the same purpose.
- Dissemination of water-saving practices for irrigating crops despite the worsening droughts caused by climate change, was, however, small. Only 0.4% of the orchards are covered by irrigation and water-efficient solutions are only a part of them.

The situation in the case of technical innovation concerning improvement of the genetic potential of crops (growing new varieties) is better. National certified seed material has a significant share in the case of ear cereals (49% of registered varieties are owned by domestic firms), and dominates in the case of legumes, potatoes and grass crops (Dzun W., Adamski M., Burchardt A. 2011). In the case of rape, however, the share is only 16%, 24% for maize and 28% for sugar beet. Adaptation of the Polish legislation to the EU *acquis communautaire* created the conditions for unrestricted access to our market for companies from the other EU countries which are larger, have better marketing and greater financial resources allocated to expanding markets.

Innovations in breeding new varieties of plants are being developed in different institutions (Dzun W., Adamski M., Burchardt A. 2011). In the case of products such as cereals, potatoes and sugar beet, creation of new varieties is dominated by the Agricultural Property Agency's (APA) companies and the Plant Breeding and Acclimatization Institute (PBAI). In 2005-2009, the APA's companies registered 117 varieties of plants in the National Register of Varieties (NRV) and PBAI's companies registered 78. At the same time, the first group of companies deleted from the register 146 unprofitable varieties and the second one only 58. As a result, the number of variations recorded in the NRV, and owned by APA companies decreased by 39 and in the case of PBAI companies increased by 20.

The situation with certified seed looks bad. It is estimated that in the case of ear cereals, the use of certified seed stands at approximately 8% of the total[2], and for seed potatoes the figure is 4%, although in the production of maize, rapeseed and sugar beet almost exclusively certified seeds were used. Ear cereals and

[2] This figure is taken from (Dzun W., Adamski M., Burchardt A. 2011), but in the literature it can be found that the share of certified seeds amounts to 5% of the total consumption of seeds (Podgórski B. 2005). One study claims that this share is 31%, but in this case the total purchase of seeds was probably equated with purchase of certified seeds.

potatoes, however, occupy about 75% of the national crops area, while maize, sugar beet and rape only about 11%.

The situation is different in the case of implementing innovations in livestock production. First of all, continuing the import of soybean feed made of GM soybeans reduced significantly the cost of livestock production, mainly of poultry and piglets (Józwiak W. 2012).

Moreover, in Poland the doctrine of breeding lowland black-and-white cows was rightly abandoned. This breed is aimed at improving features related to the production of both milk and beef. Now cows are bred separately for milk or for good quality cattle for slaughter. In dairy farming innovations were based primarily on achievements of the world genetics, namely: use of semen from Holstein-Friesian bulls from countries with the highest achievements in breeding, transplanting embryos derived primarily from imports but also from domestic cows-donors and import of high quality heifers (Dzun W., Adamski M., Burchardt A. 2011).

Innovation to improve the genetic potential in farming pigs and sheep are also implemented to a large extent based on breeds of foreign origin (Dzun W., Adamski M., Burchardt A. 2011). Increasingly this does not concern APA's companies and research institutes (as in the case of milk cows), but individual farms. In the case of pigs, the following breeds are bred: Large White Landrace, Polish Landrace, Hempshire, Pietrain, Duroc and Landrace Belgian. While popular sheep breeds are: Polish Merino, Châteauroux, Charolais, Suffolk and the only native breed – Blackface sheep.

However, the scope of implementation of innovations in the case of pig breeding was inadequate, as evidenced by a slight increase in the share of meat in carcasses and productivity of the average animal. Thus, production of pork becomes uncompetitive in relation to production in Denmark, Germany and the Netherlands, and the effects of this phenomenon can be seen in the import's share in pig carcasses and products made from pork growing for years, and more recently the import of piglets and weaners from Denmark.

In horse breeding, conducted in APA's companies, Poland has achievements valued in the world. The scope of this husbandry is shrinking, however, for obvious reasons, because the demand for horses is currently generated mainly by the development of horsemanship sports and recreational needs.

Two other issues should be emphasized. One of them is a change in the quality of goods produced to meet the new consumer demands. An example is the significant change in the quality of milk, as mentioned earlier, and change in the structure of cultivated varieties of apple. For example, currently conducted is the final phase of replacing once very popular Jonathan variety with such varieties as: Jonagold, Golden Delicious, Ligol, Gloster and others.

Lacking are signs of greater interest in the nature of organisational innovations, involving, *inter alia*, group purchasing and using of more expensive machines, as well as innovations in marketing, such as, for example, the search for the most favourable ways of selling finished products, etc.

Level of innovativeness of the Polish agriculture compared to the other EU Member States (selected issues)

The Polish agriculture vs. the EU-15 agriculture has roughly two times lower land productivity than the EU-15 average (Poliquen A. 2011). The main reason for this is the small scope of the implementation of innovations involving the improvement of the genetic potential of crops. New varieties have higher yields as a result of resistance to pressures exerted by the environment and better use characteristics. Their more common implementation would lead to a reduction in unit production costs and improvement of the quality of produced goods, and this would facilitate obtaining better prices.

Wheat is an important crop in Poland. The increase in yields indicates, among other things, the degree and extent of implementation of innovations involving the enlargement of the genetic potential of this species' varieties. In 2000-2007, the average rate of increase in yield was about 70 kg per year, but as it is indicated in Table 1, it was positively correlated with the size of farms.

Table 1

Farm agricultural area and annual average growth rate of wheat yield in 2000-2007[a]

Farm area (ha)	Yield increase rate (kg)
5-10	45
10-20	58
20-50	65
50+	103

[a] Calculations made on the basis of a sample.

Source: Own calculations based on IAFE studies covering the years 2000-2002 and Polish FADN 2003--2007 data.

It should be added that increase in wheat yields was also a result of other factors. In 2000-2009, wheat growing area shrank by about 11%, and almost the sole cause of this was the reduction of the acreage of spring wheat by about a half. This was most likely due to two kinds of causes. One is the negative impact of changing climate on crops, as spring crops react with a particularly strongly decrease in yields to droughts, which occur in growing seasons increasingly more often. Another important reason for the drop in wheat sowing area was probably the withdrawal from production by small plantations, which indicates that this phenomenon mainly concerned smaller farms. Small plantations were characterised by smaller yields, which increased their unit costs of production. The figures given in Table 2 illustrate this observation. The fact that they concern winter wheat does not change the essence of the phenomenon.

It can be assumed that farms with high production costs withdrew from wheat growing. High costs, typical of small plantations, coincided with the negative effects of droughts. Varied pace of innovation implementation determining wheat yield is confirmed by the figures in Table 3 – the larger the farm, the more often it implemented innovations, which resulted in higher yields.

Table 2

Yields and unit costs of production of winter wheat cultivated in different areas in 2006

Specification	Planted area per farm (ha)	
	1-4	10-20
Number of farms covered by monitoring	45	45
Average planted area (ha)	2.32	14.20
Yield in dt per 1 ha	38.5	43.9
Production cost of 1 dt of yield (PLN)	40.00	37.47

Source: According to (Augustyńska-Grzymek I. 2008).

Table 3

Wheat yields in dt per 1 ha[a] at individual farms covered by the Polish FADN in 2005-2007

Farm size (ESU)	Years			Year average
	2005	2006	2007	
2-4	44.2	35.0	41.1	40.1
4-8	44.8	37.5	43.8	42.0
8-16	48.8	41.1	45.7	45.2
16-40	52.5	44.5	48.6	48.5
40-100	54.3	44.5	50.8	49.9
100+	63.6	52.6	62.5	59.6

[a] Own calculations based on a sample.

Source: Results of the monitoring of the Polish FADN.

Wheat yields in Poland could be greater if all farmers exchanged seeds to the ones having favourable genetic characteristics. The study (Augustyńska-Grzymek I. 2008) shows, however, that in 2006 only 19-20% of the winter wheat seed came from the exchange. Thus, on average, wheat seeds were changed almost every 5 years, but this number is misleading. To this average contributed farms with the size of 2 or more ESU that were changing seeds more often, and those that change them rarely or never.

As shown in Table 4, average wheat yields in Poland amount only to a half of yields in the EU-15 agriculture. Comparison with average yields in these countries can withstand only these Polish farms of 100 ESU or more (Table 2).

Table 4 also shows that in 1986-2007 the difference between average wheat yields in Poland and other EU countries deepened. In Polish agriculture, there was even a small decline in yields in the analysed period, but this may be due to the calculation method. If the increase in wheat yields in Poland was calculated based on econometric model of the multi-annual trend of changes in the yields, they would amount to 2.9 dt/ha, and thus they would be similar to the ones recorded in the Danish agriculture.

Table 4

Changes in average annual yields of wheat (dt/ha) in selected EU-15 Member States and in Poland in 1986-2007

Countries	Years		Difference
	1986-1990	2005-2007	
Denmark	67.2	69.3	+2.1
France	60.0	66.6	+6.6
Germany	63.8[a]	72.3	+8.5
United Kingdom	65.3	77.4	+12.1
Poland	37.5	37.1	- 0.4

[a] Only West Germany; in this period, wheat yields in East Germany amounted to 52.1 dt/ha.

Source: (Dzun W., Adamski M., Burchardt A. 2011).

One more symptomatic phenomenon is worth noting. In the EU-15 increasing yields are accompanied by decreasing unit use of mineral fertilisers. Figures in Table 5 refer to its average consumption in the compared countries, so the above observation should be regarded as preliminary. However, if it finds confirmation in the detailed analyses, it will be a proof, that in the wheat production of the EU-15 Member States diffusion of other innovations progressed rapidly and covered a larger number of farms than in Poland[3]. They could, for example, consist of the use of methods accurately matching doses of fertilisers with the soil nutrients and the needs of plants in various stages of development.

Table 5

Consumption of mineral fertilisers (kg NPK per 1 ha of arable land) in selected EU-15 countries and in Poland in 1996 and 2007

Countries	Years		Difference
	1996	2007	
Denmark	161.2	115.6	-45.6
France	163.8	130.2	-33.6
Germany	162.7	136.1	-26.6
United Kingdom	125.2	87.8	-37.4
Poland	84.5	132.6	+48.1

Source: As in Table 4.

In the Polish agriculture a restricted diffusion of genetically improved wheat varieties was accompanied by "simple" increase in the use of mineral fertilisers, which looks as if it was to compensate for deficiencies in the application of procedures and means of production resulting from the implementation of newer generation of innovations.

[3] A similar opinion was formulated in the study (Józwiak W., Kagan A., Floriańczyk Z. 2011) on the basis of figures for all the EU Member States in the past decade. This study applied changes in the size of Malmquist productivity index divided into sub-indices that characterise the technical and technological progress.

However, it is a probable hypothesis that the improvement of wheat production methods has already been initiated in the Polish 100+ ESU farms and – maybe – in some slightly smaller farms.

A similar situation as in the plant production was observed in animal production, which can be presented on the example of cow milk yield. In 1989-2009, this ratio increased in a linear way with the average annual rate of nearly 82 litres of milk per cow (Józwiak W., Mirkowska Z. 2011). It could, however, be greater, taking into account the fact, that less than 60% of cows was inseminated with semen from foreign bulls or bulls of national dairy breeds with distinctive beneficial characteristics. There was also small demand for high class heifers.

The growth rate of cow milk yields – similarly as in the case of wheat yields – was varied depending on the farm size (Fig. 1). This was mainly due to different degrees of implementation of biological (genetic) progress; greater progress was characteristic of larger farms.

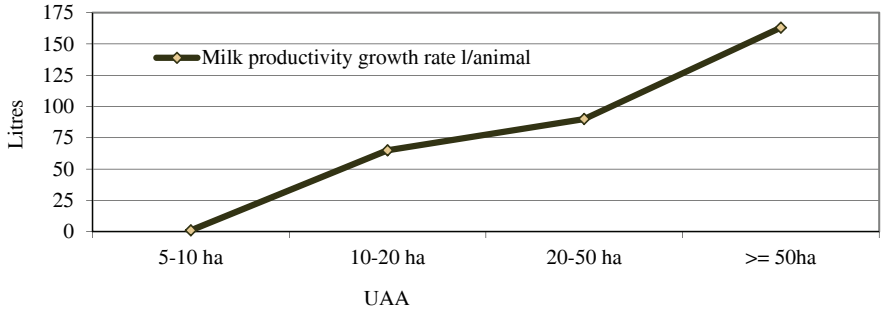

Fig. 1. Farm agricultural area and average annual productivity growth rate of dairy cows (litres per cow and year) in Poland in 1995-2007

Source: Study (Józwiak W., Zieliński M. 2010).

The decrease in the number of cows to a small extent contributed to the growth of their milk yield. A downward trend slowed down by 2003 and in subsequent years population of this group of animals stabilised. However, the phenomenon intensified the liquidation of small herds, while increasing the number of cows on farms with larger herds and this was the cause of the zero balance of the population changes. Such conversions have an impact on the improvement of the average national cow milk yield.

Diverse growth rate of cow milk yield of and resignation from small scale milk production led to large differences in performance among farms of different sizes (Table 7).

The growth rate of cow milk yield in Poland did not keep pace with the increase in the EU-15 Member States. An important reason for this phenomenon was (and still is) a large share of cows in small herds in Poland in which – as mentioned above – an increase in the size of this indicator progresses very slowly.

In 2010, for example, about 57% of cows were in herds of up to twenty cows and compared with the situation in 2005 this share decreased by 7 percentage points. Bridging the gap between Poland and the former EU-15 in the rate of productivity growth of dairy cows will require not only a reduction in the share of cows in small herds, but also the implementation of various innovative methods in larger herds.

Table 6

Individual performance, cost and income from milk production in variously sized herds of cows in 2006

Specification	Number of cows in a herd	
	2-5	35-75
Number of analysed herds	21	20
Average number of cows in a herd	4.0	48.7
Milk yield in litres per cow	3,409	6,295
Costs per 1 litre (PLN)	0.96	0.83
Price of a litre of milk (PLN)[a]	0.82	1.03
Income per a litre of milk (PLN)	0.14	0.21

[a] In the market of milk production there was a huge quality leap, the expression of which are significant differences in prices of this product (depending on the scale of breeding cows).

Source: According to (Skarżyńska A. 2008).

Table 7

Average annual cow milk yield (litres/cow) at individual farms under the Polish FADN in 2005-2007

Farm size (ESU)	Years			Year average
	2005	2006	2007	
2-4	3,359	3,264	3,278	3,300
4-8	3,572	3,610	3,645	3,609
8-16	4,199	4,205	4,332	4,245
16-40	4,941	4,922	5,105	4,989
40-100	5,829	5,904	6,096	5,943
100+	5,907	6,237	6,101	6,101

Source: As in Table 2.

Table 8

Changes in average annual milk yield per cow (kg) and differences between cow milk yield in selected European Union Member States and in Poland

Countries	Years and differences		Years and differences	
	1989-1991	difference[a]	2007	difference[a]
Denmark	6,227	2,965	8,434	4,014
France	4,797	1,535	6,338	1,918
Germany	4,931	1,669	7,048	2,628
United Kingdom	5,206	1,994	7,177	2,757
Poland	3,262	-	4,420	-

[a] Differences between cow milk yields in Poland and in the other countries.

Source: As in Table 4.

Main factors influencing implementation of innovations on farms

There are two types of factors that influence the uptake of innovations on farms. The first includes factors of mental and social character. Attitude to innovations depends on the agricultural producers' values, their expectations about the standard of living, tendency to undertake risky actions (the degree of risk aversion), knowledge resulting from education and work experience, skills enabling quick search for the necessary knowledge, possession of a successor, etc.

This kind of factors are associated with social status of agriculture and farmers, social environment of rural areas and gminas, access to knowledge on innovative methods (education, agricultural consulting, participation in exhibitions and demonstrations, etc.), as well as transparency and predictability of the legal system regulating the business of production and sales of generated goods.

The second type of factors that influence the implementation of innovations are of economic and financial nature. These factors are relevant to the current situation of farms, the prospect of their future operation and the situation on the domestic and world agricultural markets. Subsidies granted to agricultural holdings by the state and within the Common Agricultural Policy should also be added here. The relationships between these factors are complex and non-linear, because the increase in income is not always accompanied by an increase in the propensity to implement innovative methods of conducting agricultural activity.

Four groups of farms can be distinguished when analysing the interaction between the innovative techniques and technologies and achieved revenues. Each group is characterised by a different level of willingness to undertake innovative actions in response to changing economic conditions (Fig. 2). Independently from market fluctuations, each farm can be included into one of these groups, although favourable or unfavourable market situation may affect the course of the border division between the groups and the number of farms in each of them.

The first group is characterised by a very small income from agricultural activity or even by incurring financial losses. Majority of farms included in this

group has a very small or small scale production, and their activity often is treated as a hobby or recreation, or the holders derive additional income or benefits from other sources (no property tax, low cost of pension insurance scheme, etc.).

The first group consists also of farms of larger sizes of production, but poorly managed, or performing production exposed to structural problems (e.g. horse stables). In both subgroups of this group, the propensity to implement innovations is low or none, even though these farms need restructuring – for example, by changing type of production. In this situation, it is difficult to expect the introduction of new products, innovative production methods, more effective forms of selling, or of supplying means of production.

Farms of the second group under average conditions are able to ensure pay for external factors of production, and individual holdings – to generate surplus (which is a payment to the owner family for their labour input on the farm) at an acceptable level. The only obstacle in the implementation of innovations is thus availability of funds, but the situation is changing at times of economic downturn. Farms then try to introduce methods proven at other farms or slightly expand the scale of their operations. Undertaken are also other activities involving the search for market niches in order to launch a new type of production, new methods and channels of selling goods, the products or acquiring specific customers.

The farms of the third group, with average income level, express the greatest readiness to undertake innovative changes. Under good market conditions, they generate economic surplus while covering costs of all factors of production, and individual farms provide own labour remuneration at a level guaranteeing acceptable living conditions for families. This surplus can be used to finance all or part of the investment with higher level of risk and thus also having an innovative nature. At farms of this group innovations of creative nature (mainly rationalising ones) can occur. Thus, the innovations there are not only the ones resulting from diffusion of new ideas.

Farms in the fourth group are characterised by diverging capabilities and no willingness to innovate, though fortunately their number is relatively small. This attitude is characterised by the saying "why would one change something that works well". In less favourable conditions, however, there appears the tendency to undertake new challenges and thus the farms of this group can become a source of innovation (group of pioneers), which will be a model for other entities.

The presented analysis is simplified, but it is confirmed by the numbers shown in Table 9 containing the characteristics of two size groups of farms owned by individuals who differ in the relation between the profitability of revenues[4] and the indicator of the efficiency of agricultural activity measured using DEA method. In this framework, the following farms were distinguished:

[4] Rentability was calculated as a relation between profit and value of production. While profit was calculated as a difference between agricultural incomes and cost of used own production factors at market prices.

– leading, with profitable and efficient production;
– with development potential that – producing not fully effective – they can, however, join the leading group of farms, introducing innovative methods because they have profitable production;
– problematic with unprofitable and inefficient production whose owners must reduce the standard of living to be able to invest in methods enabling getting out of this unfavourable situation;
– endangered, whose owners have made a mistake in the selection of production structure and therefore production is unprofitable. Thus, they should reorganise production, but with the loss incurred it is generally no longer achievable.

Table 9

Structure of individual farms differing in size, efficiency and profitability of production (average for 2005-2007)

Groups of farms[a]	Farm size in ESU		Average
	2-8	8+	
Leading	1.7	1.8	1.7
With development potential	25.4	61.0	36.4
Problematic	70.7	37.0	60.3
Endangered	2.2	0.2	1.6
Total	100.0	100.0	100.0

[a] Detailed characteristics of these groups can be found in the text above the table.

Source: Own calculations based on the paper by M. Zieliński and J. Sobierajewska prepared using the results of monitoring of the Polish FADN.

It is not difficult to see the similarities between the groups enlisted in Table 9 and four groups of farms which have been shown in Figure 2. Problematic and endangered farms, regardless of size, compose the first group, whose total share reaches 62% of all farms larger than 2 ESU. They are too small, poorly managed or require changes in the structure of production, for which they lack capital. Farms with developmental potential, with the size of 2-8 ESU, correspond to the second group (about 9% of the total); do not allow their owners to maintain the standard of living at levels characteristic of parity remuneration for labour input. Farms with development potential, with the size of 8 and more ESU, or leading, with the size of 2-8 ESU, are in the third group (about 27% of the total), which has the greatest tendency to implement innovation. Very small (less than 2%) is the share of larger and, at the same time, leading farms, which can be equalled with the fourth group of farms presented in Figure 2.

In total, constantly or periodically only about 38% of farms of 2+ ESU have the financial means to implement various innovations. In relation to the total number of farms in the country with an area of 1 and more hectares of agricultural land this share is, however, only 18-19%. Among these farms there should be innovators who achieved a success in the implementation of innovations on their farms and they become co-creators of progress occurring in the Polish agriculture.

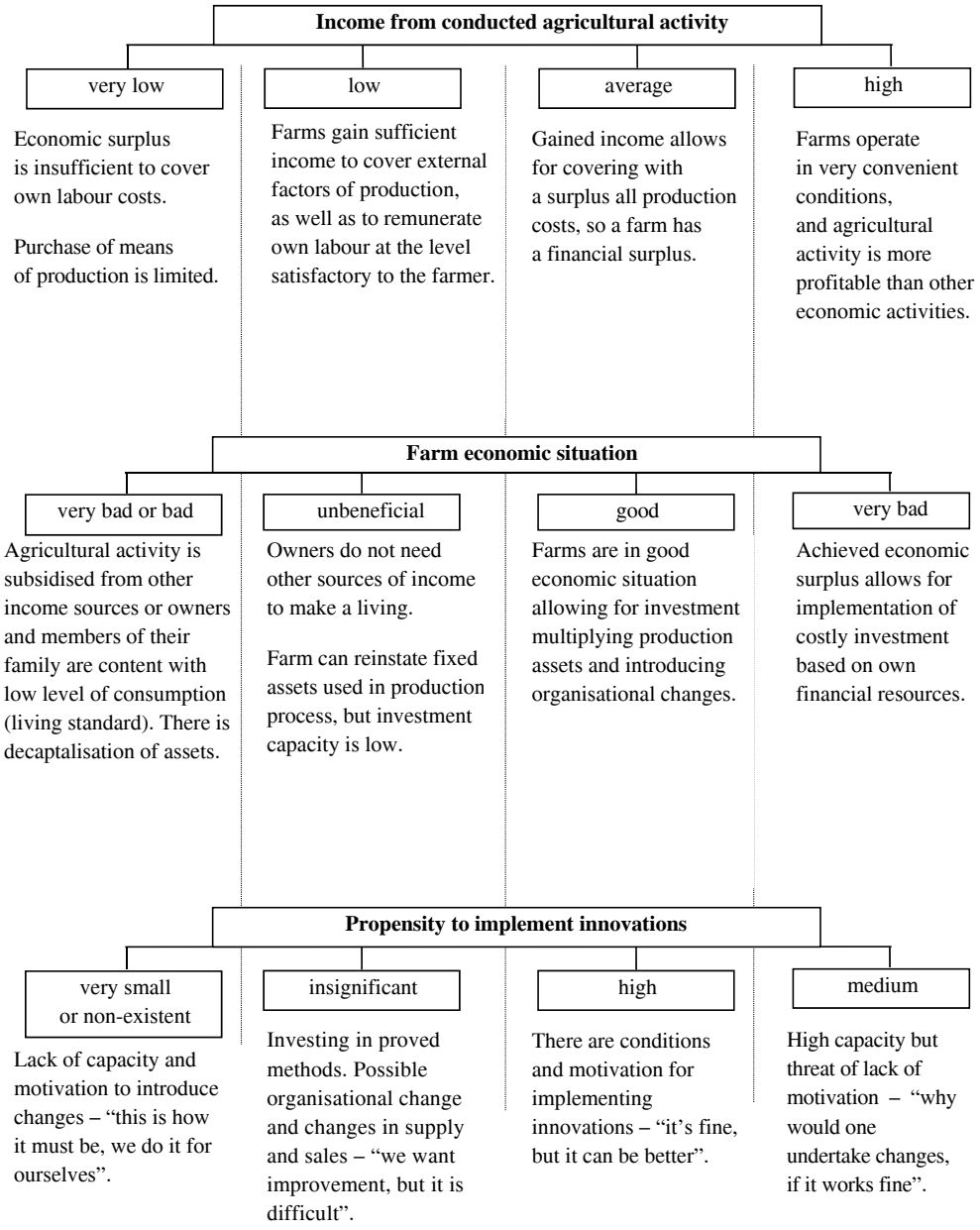

Fig. 2. Profitability of agricultural activities, situation of agricultural holdings and their propensity to innovate

Source: Own study based on (Duraj J., Papiernik-Wojdera J. 2010).

Budgetary support and innovativeness of the Polish farms

Inclusion of the Polish agriculture into the Common Agricultural Policy was undoubtedly one of phenomena with the most significant consequences impacting the farm propensity to implement innovative methods. Direct support for agriculture increases agricultural income and thus directly affects the situation of farms, moving up their propensity and capacity to implement innovations and, as a result, changes the distribution of farms in the groups discussed above.

The stabilisation aspect of the subsidies draws attention. Direct support (with some exceptions, such as payments to hops and tobacco) is that part of farm revenue and income that is predictable and not subject to variations due to changes in size or value of agricultural production. The larger the share of direct support in revenue, the less risk is borne by a farm in relation to price changes on the sold products and insolvency of contractors, changes in weather conditions, or other unforeseen events. The stabilising effect of subsidies reduces the risks and also has a positive effect on the diffusion of innovations.

Indirect impact of subsidies can be identified. It occurs in the situation when owing to them a farm has free funds and using them increases its material assets and thus the volume of its production to benefit from economies of scale (Bergström F. 2000). Such activities have a positive impact on the willingness and ability of farms to undertake innovative projects. In this regard the loss of about 232,000 (13.9%) small farms (with up to 20 ha of UAA) and a simultaneous increase of about 8,000 (7%) in the number of large units in 2005-2010 should be considered a positive change. In the same period, the ownership of agricultural land by small area farms decreased by about 9% and the larger ones increased to the same extent.

Economic theory and empirical observations in countries with long-term use of budget support suggests that direct forms of support to agricultural producers have a significant impact on the amount of land rent obtained by the owners of agricultural land in the form of lease payments and obtained or potentially achievable prices of agricultural land. Both land value and lease payments are a resultant of possible to obtain income from the sale of agricultural products as well as received direct payments (Patton M. et al. 2008). A positive correlation between direct payments both decoupled and to some extent coupled with production, and both the land prices and land lease payments is not disputed. This interrelation is confirmed by the results of American (Roberts M., Kirwan B., Hopkins J. 2003) and West European studies (Guyomard H., Latruffe L., Le Mouël C. 2007) as well as Polish experiences (Ciodyk T., Zagórski T. 2010).

The system of direct support implemented in Poland (despite the attempts to support the actual land users) favours – except for people combining the functions of farm owner and its user – additionally farm owners who let out their property to other users and arrogate to themselves the right to direct payments. This reduces the size of the income of farms renting land and, therefore, restricts the scope of implementation of innovations. W. Józwiak and W. Jagła (2010) estimated that this situation led in 2007 to incomes of actual land users

to be lower by approximately PLN 1.2 billion, i.e. about 11%. The inability to purchase leased land increases the risk, which further reduces the tendency to implement innovations.

The main CAP instruments directly influencing the implementation of innovations on farms in Poland are the EU funds supporting expenditure for investment purposes. In 2005-2009, such funds significantly increased spending on fixed assets in relation to the pre-accession period (Table 10). Their purpose is the modernisation of agriculture, which contributed to the diffusion of many innovations.

Table 10

Value of investments in the Polish agriculture in 1995-2009 (current prices) and share of the EU funds in their financing

Years	Investment[a] (PLN billion)	Investment assets replacement rate[b]	EU funds support (PLN billion)[c]	Share of the EU funds in investment expenditure (%)
2009	3,710.3	273.5	1,673.7	45.1
2008	3,929.1	289.7	1,579.5	40.2
2007	3,554.9	262.1	1,923.3	54.1
2006	2,958.6	218.1	1,755.5	59.3
2005	2,398.0	176.8	1,213.1	50.6
2004	2,155.4	158.9	395.2	18.3
2003	2,026.8	149.4	-	-
2002	2,183.9	161.0	-	-
2000	2,078.7	153.3	-	-
1995	1,356.4	100	-	-

[a] Total investment in the agriculture and hunting.

[b] The reference point was the expenditures incurred in 1995.

[c] Total expenditures in the programmes: SAPARD "Investments in agricultural holdings"; SOP "Restructuring and Modernisation of the Food Sector and Rural Development 2004-2006" – measure: Investments in agricultural holdings; RDP 2007-2013 – measure: Modernisation of agricultural holdings.

Source: Own calculations based on ARMA data.

Beneficiaries of the programmes used this support mainly for the purchase of machinery, tractors and equipment, which led to positive changes in the level of production technology, working conditions and safety, quality of produced goods and the environment. Research carried out in the IAFE-NRI's Economics of Farm Holdings Department concerning large area farms indicates that because of the EU funds these farms introduced innovative machines and equipment. These included sprayers with adjustable stream of administered fluid (saving water and chemical pesticides) and combine harvesters, tractors and fertiliser distributors with precise positioning devices (GPS) enabling the creation of a field fertility map, and then an application of precise doses of fertilisers, etc. (Kagan A. 2011).

The effect of modernisation of agriculture was observed, but there also appeared opinions claiming the negative effects of direct payments.

Support to farms and, as a result, a much improved level of their owners' safety decreasing the threat of low income could result in stagnation. This led, at least in part of the largest holdings (from the fourth group in Figure 2), to a reduction in the number of implemented innovations.

A negative effect of the subsidies is the emergence of a group of beneficiaries who only pretend they conduct agricultural activity (without actual production on the owned land) and are interested in maximising benefits in the form of the largest stream of payments.

Moreover, some of the smallest farms in terms of their area, invested in machines and equipment, but it was not accompanied by an increase in agricultural area and, as a consequence, there was no increase in the scale of production. As a result, part of the funds granted under the RDP 2007-2013 (measure: Modernisation of agricultural holdings) was not fully utilised.

This lack of rationality may not be real, however, at least in many cases. Table 8 shows that about 140,000 farms of 8 ESU are likely to enlarge and modernise their property, because they produce effectively or in a manner similar to that level. Thus machinery, tractors and equipment purchased with public funds will allow part of these farms to actively solicit the purchase of land. In addition, assets purchased with public support are readily marketable and even after the end of the grace period their sale is likely to give an amount similar to the own funds spent.

Despite various claims, funds offered under the CAP were well spent. The study (Józwiak W. 2011) containing calculations at constant prices shows that in the five years of 2005-2009 there was an increase in the value of production by 8.6% in relation to the situation in 1999-2003, while reducing the cost of intermediate consumption by 9.6%. As a result, the gross value added after the accession[5] increased by 37% compared with the situation before the accession.

Summary

In the post-accession period in the Polish agriculture there was a dramatic increase in the productivity of funds spent under the intermediate consumption compared to the period before accession. Calculated in fixed prices the value of farm production per PLN 100 spent on intermediate consumption increased from about PLN 143 on average in 1999-2003 to about PLN 162 on average in 2005-2009, an increase of about 13%. There were several important reasons for this, namely: abandonment of agricultural use of less favoured areas, resignation from unprofitable plant or animal production conducted on a small scale or replacing it with production conducted on a larger scale, growing use of chemicals and probably others. These changes do not have the character of innovations and took place in case of a large part of farms. One of the major causes of productivity growth was also diffusion of innovations. Although various types

[5] Amounts calculated without direct payments.

of innovations were used only by 18-19% farms, but they operated on more than a half (55% of the total) of the national agricultural area.

The improvement of productivity of funds spent on intermediate consumption coincided with the beneficial effects of the accession, which led to a significant increase in the level of subsidies. In total, incomes increased approximately two--fold, with about one third of this increase in the 2005-2008 period compared to the five-year period of 1999-2003 being a result of improvements in productivity.

This situation became a leading cause of improving the competitiveness of the Polish agriculture. Before 2004 only about 25,000 farms had characteristics indicating possession of competitive ability (over-parity income and extended reproduction of fixed assets), which provided 2-3% of the national value of agricultural production (Józwiak W. 2011). In 2007, there were already 290,000--300,000 farms managed by natural and legal persons with competitive ability or having the ability to achieve it. It is estimated that they produced 50-60% of the national value of agricultural production.

The impact of innovations on the progress taking place in the Polish agriculture could be greater, were it not for a large proportion (81-82%) of farms that do not implement any innovations. These were mainly smaller farms, but in this group there were also about 1/3 of farms with the size of at least 8 ESU. To this situation contributed the creation of a group of farm owners who only pretended to conduct agricultural activities in order to maximise the benefits in the form of the largest possible stream of payments. Moreover, a portion of direct payments was received not by the tenants actually cultivating land, but by its owners, thus reducing the financial resources available that could be used to expand the scale and scope of innovations implemented on farms.

There is also a presumption that a significant increase in the level of payments in 2004, reducing the threat of low income, could decrease the tendency of agricultural producers to implement cost-effectiveness or increase income innovations. It is worth noting that this is the case of the holders of actually functioning farms who be able to afford introducing innovations on their farm.

A widening gap in the level of technical and manufacturing indicators was also observed between agriculture in Poland and the countries of the former EU-15. This shows that agriculture in the countries that are seen as a reference point entered the path of progress, which enables limiting the means of production inputs that have harmful effects on the environment, without compromising on productivity per unit of land and livestock growth rate. There are indications that only the largest farms (with the size of 100 ESU and more) are at this stage in Poland. There is no doubt, however, that also farms with the size of 8-100 ESU and possibly a small proportion of even smaller farms must follow this trend. It would be advisable to strengthen this process by: reducing aversion to the risk associated with the implementation of innovations on farms with funds for such projects at their disposal and putting a stop to the practice of receiving direct payments by land owners and not by tenants actually cultivating the land, and to other pathological phenomena related to the subsidisation of agriculture.

In conclusion, it should be added that a method needs to be found that would assess the impact of innovations on the progress taking place in the Polish agriculture. It is also advisable to deepen the analysis of the differences between Polish and the other EU countries' agriculture in relation to the diffusion of various innovations.

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