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MEASURING EXTERNAL EFFECTS OF AGRICULTURE SPECIAL REGARD TO PRECISION FARMING TECHNOLOGY

POMIAR EFEKTÓW ZEWNĘTRZNYCH ROLNICTWA ZE SZCZEGÓLNYM UWZGLĘDNIENIEM ROLNICTWA PRECYZYJNEGO

Key words: precision farming, environment impact
Słowa kluczowe: rolnictwo precyzyjne, wpływ na środowisko

Abstract. The external effects of agriculture has got strong link with classical agricultural production. These externals appear in the soil, in water, in air, and in biodiversity. The key factor of high yield is the soil fertility. The conventional farming system uses all over the filed the highest average amount of fertilizer (synthetic or organic). Precision farming technology is able to ameliorate economic, environmental and social impacts of the agricultural production. The elements of the agricultural production are the same with conventional and with precision farming technology only the amount of the input and the working time are different. So the type of the external is also the same but the dimension of the effect is different. This paper examined the external effects change with adopting precision farming technolog.

Meaning of external effects of agriculture

Established definition of the external effects is the following: the activity of farmers influence (positive or negative) the others activity without offset. The common property of the positive of negative externality is that any activities affects the a kind of opportunities of individual or group without payments or compensation [Pretty et al. 2000]

When the effects of the technology adaptation were examined in economic point of view the researchers usually not calculated the external effects. The cause of this lack that the agricultural outputs – expect the yield (primary and secondary) – not measured or not measurable. The external effects of activity appear in two ways [Szűcs et al. 2004]:

- connected to production,
- not connected to production.

The external effects of agriculture has got strong link with classical agricultural production (crop/plant for food, purpose and energy). These externals appear in the soil, in water (ground an superficial), in air (carbon-dioxide absorption and oxygen production), and in biodiversity [Takács-György et al. 2008].

In lots of international literature we can read about the importance of measuring externals. Numerous researchers work to solve the problem of measurement and make an evaluation methods to find the fee of externals [Pretty et al. 2000, Szűcs et al. 2004]. One more is necessary to mention is the connection between the externalities and the risk of sustainability. Regarding the limit of the paper, I will not focus on this issue [Chilinsky et al. 1998].

Negative and positive externals of conventional farming system

Difficult to find the costs of some pollution comes from agriculture. First of all it is necessary to know about the values of natural resources and services, and what happens when these are lost. Second is the difficulty of putting a value on non-market goods. The problem is how we value the blue sky, the song of the birds, the landscape, etc. There is two type of estimated damage cost [Pretty et al. 2000]:

- cost of treatment or prevention of the agricultural effects. For example: clean up the water, restore human healthy, or return the effects to an undamaged state,
- administration and monitoring costs. For examples: agencies for monitoring environmental, food and health parameters.

Table 1. Most important externals of agricultural production
Tabela 1. Najważniejsze efekty zewnętrzne w rolnictwie

Negative external/*Negatywne efekty zewnętrzne*	**Positive external/*Pozytywne efekty zewnętrzne***
Pesticide in sources of drinking water/ *Pestycydy w źródłach wody pitnej*	Save biodiversity/*Zachowanie bioróżnorodności*
Nitrate, phosphate in sources of drinking water/ *Azotany i fosforany w źródłach wody pitnej*	Landscape/*Krajobraz*
Zoonoses in sources of drinking water/ *Choroby odzwierzęce w źródłach wody pitnej*	Labour stay in rural areas/*Zasoby pracy pozostają na obszarach wiejskich*
Monitoring pesticides and nutrients/ *Monitoring pestycydów i substancji odżywczych*	Protect again erosion/*Ochrona przed erozją*
Emission of green-house gases/*Emisja gazów cieplarnianych*	
Nutrient losses from soil/ *Straty składników pokarmowych z gleby*	
Wildlife losses/*Straty w dzikiej przyrodzie*	
Bacterial and viral outbreaks in food/ *Epidemie bakteryjne i wirusowe w żywności*	

Source: own study on Pretty et al. 2000
Źródło: opracowanie własne na podstawie Pretty i in. 2000

Also not easy to measure the positive externals of agricultural production. Positive externals for example: flood control, storm protection, soil formation, landscape, etc.

The Table 1. contains the type of negative and positive externals of the agricultural production based on Pretty and colleagues work in UK.

Precision farming technology and external effects

In the modern agriculture the main task is to efficiency utilize resources, integrate the biological processes and regulating mechanisms of the production where is possible. From the point of technical efficiency it must be mentioned that over capacity is characteristic in most European Union countries. The partial efficiency of machines used in precision farming can be improved by forming so called "virtual farms" [Takács et al. 2008, Takács 2009]. The prime mover of the agricultural production is the profitability of the agricultural manipulation and save the human resources of the agricultural and the living-standard of provincial society [Barkaszi et al. 2006, Csiba et al. 2009, Sándor et al. 2009].

Nowadays the agriculture should produce the food for greater population on smaller field all over the world. The researchers, the machinery producers and the farmers try to find a new or rediscovered technology to make higher yield with less input. These technologies for example are ecological production, low-external-input farming system, precision farming (site-specific) technology, etc.

The key factor of high yield is the soil fertility. The conventional farming system uses all over the filed the highest average amount of fertilizer (synthetic or organic). In agricultural production both the cultural plants and both the weeds increase the soil fertility. The nutrient demand differs among species, so the fertilization can shift the balance of competitive relationship between plants and weeds [Liebman, Davis 2000].

In contradiction to the conventional farming system the precision farming technology is able to ameliorate economic, environmental and social impacts of the agricultural production. Thanks to the site-specific optimisation (fertilizer, seeds, herbicide, pesticide, etc.) on parcel-level the precision farming technology makes increase of yield and makes decrease of environmental-damage effect [Swinton 1997, Weiss 1996, Batte 1999, Székely et al. 2000, Takács, György, Barkaszi 2006].

The elements of the agricultural production (tillage, nutrient supply, weed management, plant protection, and harvest) are the same with conventional and with precision farming technology only the amount of the input and the working time are different. So the type of the external is also the same but the dimension of the effect is different (Tab. 2).

Thanks to the site-specific pesticide treatment less pesticide goes to the water and toxic it and besides this kind of treatment is more efficient against pest so there will be less bacterial and viral outbreaks in food (No. 1 and 9. in Tab. 2).

The site-specific nutrient supply is able to spread the amount of nitrogen, phosphorus, etc. agent which really need for the optimal yield of culture plants. Hereby increase the redundant and damageable nitrate and phosphate accumulation in soil and in drinking water. (No. 7 and 8. in Tab. 2).

Table 2. Changes in external effects with precision farming technology contrary to conventional farming system
Tabela 2. Zmiana efektów zewnętrznych generowanych przez rolnictwo precyzyjne w porównaniu do rolnictwa tradycyjnego

Number of external/ *Liczba*	**Type of external/*Typ***	**Changes by adopt precision farming technology/*Zmiana w wyniku wprowadzenia rolnictwa precyzyjnego***
1.	Bacterial and viral outbreaks in food/ *Epidemie bakteryjne i wirusowe w żywności*	less/*mniej*
2.	Damage by erosion/*Zniszczenia w wyniku erozji*	same/*tyle samo*
3.	Emotion of green-house gases/ *Emisja gazów cieplarnianych*	not known/*brak danych*
4.	Labour stay in rural areas/ *Zasoby pracy pozostałe na obszarach wiejskich*	same/more/*tyle samo/więcej*
5.	Landscape/*Krajobraz*	same/more/*tyle samo/więcej*
6.	Monitoring pesticides and nutrients/ *Monitoring pestycydów i nawozów*	less/*mniej*
7.	Nitrate, phosphate in sources of drinking water/ *Azotany i fosforany w źródłach wody pitnej*	less/*mniej*
8.	Nutrient losses from soil/ *Straty składników pokarmowych z gleby*	less/*mniej*
9.	Pesticide in sources of drinking water/ *Pestycydy w źródłach wody pitnej*	less/*mniej*
10.	Save biodiversity/*Zachowanie bioróżnorodności*	not known/*brak danych*
11.	Wildlife losses/*Straty w dzikiej przyrodzie*	not known/*brak danych*
12.	Zoonoses in sources of drinking water/ *Choroby odzwierzęce w źródłach wody pitnej*	not known/*brak danych*

Source: own study
Żrodło: opracowanie własne

The key elements of precision farming technology are the yield maps, the nutrient maps and off-line treatment maps or on-line sensors. The off-line systems are more wide-spread. These maps are necessary for treatment (in different plots which amount should spread out) and for monitoring. Maps get save on computers and in anytime we can control the used amount of input. (No. 6. in Tab. 2.) At large farms extra workers need to make administration work for precision farming technology, so this technology helps to save peoples at rural area because it makes "new employment" (No. 4. in Tab. 2).

The landscape of precision farming technology and of conventional technology looks the same, but the plants of site-specific farming are stronger, and the productivity of these are higher, although the traverses or tourists do not see this (No. 5. in Tab. 2).

Based on an Hungarian farm experiments the biggest negative effect of adoption the precision farming technology are the following [Sinka 2009]:

– both the workers and both the manager should learn a lot for use the precision farming technology. They have big resistance to learn something new and difficult,
– the precision fertilization system can spread only mono-fertilizer, so the machinery should go on the field tree time to spread N, P and K.

The precision farming technology has numerous social costs. For example the planting cost is higher than in the conventional technology because the farmers spend more time in the office to make treatment maps and check the amount of inputs. The biggest social benefit of precision farming technology is to save resources in the agriculture production, for example: field, labour, etc. [Jongeneel et al. 2008].

Conclusions

When profitability changes of the new agricultural technology was examined not enough to calculate only with costs and benefits. The farmers should think about the environmental and social effects of technology adaptation before make the decision. The sustainability of the production is one of the most important not economic factors in complex investment analysis.

If examined precision farming technology in view of external effects contrary to conventional technology we find the same type of negative and positive externals but in different dimension. For example the plant will reduce the nutrient in soil but thanks to the site specific fertilization we can supplement it with the amount of fertilizer which really needs for production so there will not be surplus of fertilizer which goes to ground and drinking water. In the future I would like to find the correct value of the external change to examine the economic changes for adaptation precision farming technology.

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Streszczenie

W artykule podjęto próbę oceny wpływu rolnictwa precyzyjnego na efekty zewnętrzne generowane przez rolnictwo. Szczególną uwagę poświęcono wpływowi nawożenia na skalę generowania pozytywnych i negatywnych efektów zewnętrznych.

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