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The economic and environmental productivity of agriculture in the process of development

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ABSTRACT

The paper reviews the economic theories that describe the relationship between agricultural productivity growth and economic development. Historical examples of such relationships are also presented. The review proves that improvements in the productivity of agriculture is a precondition for economic development and its catalyst. The article also describes a negative impact of agriculture industrialization on the environment. The present process of extending the traditionally understood economic sense of productivity to ecological aspects is also explained. Furthermore, the author presents how increase in environmental productivity of agriculture can be a catalyst for development, analogous to the past increases in economical productivity. Calculation of environmental productivity has been presented as a still unsolved problem. A short review of methods and metrics used as so far gives general idea about the future area of compromise in that field.

Keywords: development, agriculture, environmental productivity, eco-efficiency.

1. Introduction

In economics the category of productivity is of fundamental importance. This science essentially deals with the problem of managing scarce resources and optimizing their use for the production of goods and services [Czarny and Rapacki 2004, pp. 21-22]. Optimizing „applies to all activities aimed at finding the best solutions, that is, optimal under given conditions, with established assumptions and criteria” [Dowgiało 2004, p. 256]. By defining productivity as „a measure of the effect achieved on each factor of production” [Woś 1984, p. 579], we can consider it as a basic criterion for optimization. Although the use of productivity to assess the degree of optimization of manufacturing processes is more prevalent in enterprise research (so on a micro scale¹), references to this category are frequent also in the macroeconomic studies. Assuming that the factor involved in the production process is a human factor, represented to some extent by the number of inhabitants of a given country, and the effect of this process is GDP, GDP per capita indicator can be identified as a national labor productivity index. Of course, the above

assumptions, both on the side of the inputs and outputs included in the model, are very easy to undermine, but it only proves the imperfection of this commonly used index. It does not question in any way treating it as an indicator of productivity. The basic determinant here is the combination of two categories - inputs and outputs. By pointing out three basic resources - labor, tools (capital) and natural resources (land) and comparing them to the size of the final social product (GDP), we can identify input-output relationships, which together express the overall economic efficiency [Pajestka 1981, p. 38]. This procedure can also be applied to individual sectors of the economy (mesoeconomic scale). This paper addresses the issue of agricultural sector productivity, considering it as a specific sector of the economy that is fundamental to its development. The purpose of the undertaken review is to identify the role that agriculture productivity increase has played over the centuries in the overall economic progress and signaling the expected change in the shape of these relationships in the future. This subject is already well recognized. A Survey of Agricultural Economics Literature Vol. 4 [Martin 1991], which covers the topic of Agriculture

¹ In recent years, a number of publications related to the issue of resource productivity in the context of agricultural holdings can be cited in Polish literature. This subject has been taken by Smędzik and Stępień [2011], Czekał [2008], Kulawik [2008].

in Economic Development, is followed by 200 pages of references related to that topic. Knowing that the survey refers only to less developed countries, deals with the post-World War II period and lists only works in English, French, Spanish, and Portuguese published before 1990, we can see how large the total scope of the literature in the given subject may be. Thus, it might be considered supercilious to claim that the presented review is comprehensive in the matter. It stays in line with a similar paper considering the role of agriculture in development [Timmer 2002, Dethier and Effenberger 2012]. However, it widens the category of agriculture productivity to the environmental dimension. The examples of the interconnections between growth in agriculture and overall economy from the history are used as an analogy to changes taking place nowadays. The article consists of an introduction, three subsections and a summary. The first subsection presents some examples from the history when agriculture productivity influenced overall economic productivity. The second subsection synthesizes the most important views on the role of agriculture in the economy in the economic thought. The third subsection presents a contemporary approach to the role of agriculture in the economy and the new dimension of productivity associated with it.

2. Agriculture supporting economic development – examples from the history

The basic role of agriculture in economic development is reduced from the dawn of history to the creation of appropriate „starting” conditions for further development, which results from a permanent compulsion of food consumption. The need to satisfy hunger is among the basic needs of man. When people are hungry, all activity and desire to meet other needs is abandoned [Maslow 1943]. This psychological presupposition can be transferred to economics, as evidenced by the economic history of the world. Already during the Neolithic Revolution, the transition to sedentary lifestyles and the replacement of harvest and hunting by cultivation and rearing resulted in an increase in food production, which gave incentive for population growth and specialization in activities not connected with ensuring survival [Ziółkowski 2009, p. 31]. It is precisely the phenomenon of the release of resources from agriculture, thanks to the increase in its productivity. Throughout the ages, this process has been gradually progressing through technical and organizational improvements.

In the times of the Roman Empire, the concentration of land within large farms (so called

latifundium), which was necessary for feeding the growing population, contributed to the increase in agricultural production, but also caused a number of negative changes in the social sphere. Due to the demand for labor in growing farms, the phenomenon of slavery and the colonate was widespread, which in turn led people directly involved in land cultivation to be underprivileged and was one of the first premises of the “agrarian issue” [Czyżewski, Matuszcak 2011, p. 7]. In this context it is worth to take a closer look at the colonate system. It was based on renting land from landowners, by free peasants, in return for rent in kind and money. However, often in the inability to settle the obligations, the peasants fell into debt, which over time caused them to lose their freedom and become subjected to landowners. The development of this system combined with the rise of the importance of large land properties is considered one of the causes of the fall of the Roman Empire [Zientara 2006, pp. 9-12]. Thus, in the ancient times, the importance of agriculture in the social sphere emerged, the balance of which is also a condition of economic development.

The colonate system, common in the late years of the Roman Empire, was also the foundations of the feudal system of the Middle Ages. In a situation of money economy disappearance, land has become the basic form of wealth possession and accumulation. And peasants cultivating the land were permanently bound to it. Also characteristic of the Middle Ages was the organization of villages in the form of territorial communities. Within these communities, the peasants were farming on the land they owned and on common land, which most often included pastures, forests and water. For the possibility of land using, peasants paid to the landlord feudal land tenure. Such an organization caused inefficiencies. It contributed to the over-exploitation of common land (see “the tragedy of the commons” [Hardin 2008]), maintained a fragmented agrarian structure and was not conducive to innovation.

This ineffectiveness was ended by the enclosure process, which began in England in the 15th century. At that time, due to the rising prices of wool, the richest landlords began to strip off common areas and allocate them to private pastures. Their growing incomes also enabled them to take over land from small peasants. Combined with the more advanced cropping techniques that improved labor productivity, it was possible to meet the food demand of the growing population with reduced employment in agriculture. This process has obviously been unevenly spread across Europe and the world,

nevertheless, agriculture once again emerged as a sort of „reservoir” for the production capacity of the economy and an „initiator” of economic change. The agrarian revolution that has been taking place in Europe in the sixteenth, seventeenth and eighteenth centuries is therefore cited as the cause of the industrial revolution [Overton 1996, p. 206]. Rapidly developing industry has created the job opportunity for people no longer employed in agriculture.

Kula [1983, pp. 33-34], however, negates the assumption that agriculture, and in particular small farms, were merely an „unlimited source of labor supply” in the growth mechanisms of that period. He points out that „just as they [farms] are unburdened from unnecessary workers ballast - they increase their degree of commercialization and accumulation, they begin to invest and thus increase productivity, they are starting to be the market for industry, and therefore for the commercialized sector”. Nevertheless, it must be borne in mind that whi-

le agricultural productivity has been stimulated by improvements in manufacturing structures and technical progress, its dynamics was significantly different from the overall dynamics of the economic growth. The research by Allen [2000] shows that even in countries with the highest growth in agricultural productivity in the period 1500-1800 - England and the Netherlands, the growth was 43% and 36%, respectively, while the GDP growth per capita in the corresponding period (1500-1820) increased by 139% and 142%, respectively [Maddison 2005, p. 25]. At the same time, the importance of agriculture in the economy declined. Initially for trade. In the longer term for the developing industry. However, it does not mean that the history of agriculture development ends in the 18th century. Actually the years 1800-2000 is the period of the most spectacular growth in agriculture. Federico [2005, pp. 221-222] sums up this period in the form of 15 stylized facts. These facts can be systematized in the four main domains (table 1).

Table 1: Fifteen stylized facts about agriculture in the 19th and 20th century

Agriculture productivity

- Output has increased in the long run, enough to provide more food per capita to a population six times greater than that of 1800.
 - The growth in Total Factor Productivity accelerated throughout the period, achieving very high rates in the OECD countries after World War II.
 - Agricultural production grew thanks mainly to the increase in inputs (“extensive” growth) in the nineteenth century and to TFP growth (“intensive” growth) in the twentieth century
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Markets

- A relative price of agricultural products rose until the 1850s and remained constant or declined slightly (depending on time series) from then on.
 - Markets for factors and goods were quite developed even in traditional agrarian societies and they developed further, well in advance of modern economic growth.
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Agriculture production organization

- The quantity of all factors grew quite fast until the early twentieth century; after (about) 1950, the growth of capital continued unabated, while that of land and labor slowed down.
 - Agriculture has always been a very competitive sector, because economies of scale are modest, and large farms are plagued by serious incentive problems.
 - “Traditional” property rights on land, which still prevailed throughout the world in 1800, have gradually been substituted by “modern” ownership, but the process is not yet over.
 - Most states implemented land and tenancy reforms in the twentieth century, with mixed results.
 - “Family farms” were already fairly diffused in the nineteenth century, and their share substantially increased in the twentieth century.
 - The average size of farms fell in the LDCs throughout the whole period, while, in the “advanced” countries, it remained constant until about 1950, and it has increased fast since then
 - Collective socialist agriculture proved to be very inefficient, and the process of collectivization wrought havoc in agriculture, causing great suffering.
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Agricultural policy

- Public investment in R&D and extension have played a major role in fostering technical progress.
 - The 1930s marked a watershed in agricultural policies, from a period of almost perfect “benign neglect” to an era of massive intervention
 - After 1950, agricultural policies in the “advanced” countries favored agriculture, at the expense of consumers, while in the LDCs, they sacrificed agriculture for the mirage of fast industrial growth.
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The impact of most of these changes can be summed up in 3 channels: (1) product role – providing goods to feed the population and to earn foreign currency; (2) market role – purchasing manufactures, both for consumption and for investment; (3) factor role – supplying manpower and capital to industry and services [Federico 2005, p. 223]. Also in the 19th and 20th centuries this impact was researched intensively by the science of economics.

3. Links between agriculture and the economic development – examples from the economics theory

Among the early schools of economic thought, most attention to agriculture was given by the French physiocrats, organized around Francois Quesnay. By examining the flows of resources and products between different sectors of the economy (input-output model), physiocrats concluded that the source of wealth lies in agriculture, as only the land is capable of producing natural added value (the amount of production which outweighs the costs incurred). At the same time the physiocrats called the rest of the economy „barren”. However, the analysis based on physical measures, not on the units of values expressed in money, and the description of reality from the French perspective (lack of industrial activity on a large scale) has determined the lack of popularization of this school outside France [Landreth, Colander 2005, pp. 71-76].

In the later reflections of economists dominated the view that agriculture was a barrier to economic growth. Firstly, Thomas Malthus paid attention to the problem of farming lagging behind the other sectors of the economy and the negative impact of this situation on the economic development process. Assuming that the world population is growing geometrically and food production only arithmetically, he concluded that in the long run this is the cause of poverty [Landreth, Colander 2005, p. 122]. However, history has shown that Malthus made a significant mistake by not considering technological progress in his deliberations. Another economist, who referred to the specifics of agriculture was David Ricardo, who developed the theory of land rent. His idea was that land rent exists due to the scarcity of land and the diminishing returns, and their value is determined by market prices. When the emergence of rent results from relatively higher fertility of the certain land and is not in any way owed to the owner, it seems natural to postulate their taxation to minimize market inefficiency [Landreth, Colander 2005, pp. 131-137].

What is also worth mentioning here are the views represented in the topic of agriculture by John Stuart Mill [1920]. In opposition to Malthus and Ricardo, he envisaged that the diminishing returns for agricultural production could be overcome through the advancement of agricultural knowledge, and the cost of buying food reduced by decreasing transport costs. In addition, he noted that if non-agricultural sectors increase productivity faster than the rate of increase of agricultural products prices, the decline in the cost of purchasing non-agricultural products will compensate for the increase in agricultural commodity prices, and overall welfare may even improve. However, the progressive industrialization of the economy pushed the agricultural sector into the margin of the economics mainstream. In more and more formalized science, it became typical to assume land factor to be constant, considering only the changes in the capital and labor resources, as decisive for economic growth. At the same time, the share of agriculture in the GDP creation decreased significantly, while the progressive mechanization of production processes and the use of fertilizers and new varieties of crop plants allowed to meet the food needs of the growing population in developed countries.

Unfortunately, there was still no significant improvement in the living conditions of the rural population, which drew the attention of socialists. Rosa Luxemburg [1913], explaining the theory of capital accumulation, pointed that the non-capitalist participants of the system are crucial to its survival. These were largely peasants in capitalist countries and colonies. Kautsky [1911] saw the sources of the crisis of capitalism precisely at different rates of productivity growth in agriculture and industry. In his opinion, a situation in which the agriculture sector, not only a consumer of industrial goods but also a food supplier, is failing to keep up with industry development must lead to crises. Krzywicki [1967] explains this problem in the context of agrarian structure: “The issue of large and small farms cultivation is not just a matter of higher or lower economic efficiency; Their contradiction lies in the difference between a large farm, which allows all powers of centralization and knowledge to be used, but by using the hired labor force, it does not have a spiritual incentive among the workers [...] and a small self-contained farm that can be run very routinely, but it has a caring and attentive job, which in agriculture means a lot. Both large and small farms harm economic development: large because of the impossibility of applying diligent and caring work, small - because of lack of knowledge and technical progress”.

At the beginning of the 20th century Swedish agrarians² represented views similar to the socialists on the issues of agricultural development, however, they drew conclusions from the research on price changes. They observed that under conditions of dynamic economic growth, prices of industrial goods grew faster than agricultural commodities, resulting in the “price gap” widening and the deterioration of the material situation of farmers [Deszczyński 2013, p. 12]. In that period also Alfred Marshall [1936] took part in the discussion, stating rather positively, that even in the face of the constraints associated with the law of diminishing returns in agriculture, both population and well-being can be increased, mainly through the supply of new types of goods, communication costs decrease, improved organization and better knowledge.

The question of the role of agriculture in economic development returned in the 1950s and 1960s. At that time a number of new countries emerged on the wave of decolonization, significantly different in the levels of development from the industrialized part of the world. These events also gave origin to a new branch of economics - the development economics. The goal was to introduce these countries into the path of stable economic growth, taking into account their specificity, which in most cases included agriculture as a sector with a main role in GDP creation. Walt Rostow’s work is particularly important here [1960]. He distinguished five stages of development: (1) traditional society; (2) preconditions for take-off; (3) take-off; (4) drive to maturity; (5) age of high mass consumption. The distinctive feature of these phases, among others, was the level of domination of the country’s production by agriculture and the level of basic needs satisfaction. In addition, Rostow [1960, p. 8] pointed out that „revolutionary changes in agricultural productivity are essential for a successful start-up phase”.

Development economics re-introduced agriculture into the circle of interest of a broader group of economists. Numerous studies on the role of agriculture and its productivity in economic development can be identified. At the

outset, it is worth mentioning Jorgenson’s work [1961], which points to fundamental differences between the theory valid for developed economies and the theory actual in the situation of less developed countries. While the former focuses on the balance between investments and savings, the latter places special emphasis on the balance between capital accumulation and population growth. The author, as an element that bonds both theories, introduces the notion of a dual economy in which the developed industrial production sector and backward agriculture coexist. The economy operates under the asymmetry of productivity of both spheres, which results from insufficient number of technical devices in agriculture. In this model, growth depends on permanent surpluses generated in agriculture³. If they exist, part of the population employed in the agricultural sector can be relocated to the industrial sector. In addition, to begin industrial production, certain initial capital stock is required. When these conditions are met, further growth of the modern sector depends on the price gap of agricultural and industrial products and the rates of savings and investment in the modern sector.

In the alternative model of Clark [1951], the increase in agricultural productivity was associated with income elasticity of the demand for food products, which is less than unity and declining along with the increase in real incomes per capita. Increasing productivity in agriculture enables the transfer of labor from agriculture to the rest of the economy, where productivity also rises, in a situation of balance of demand and supply of agricultural products, with constant or even decreasing real prices. The relocation of labor resources is a response to differences in wages in all sectors.

A wider approach to the role of agriculture and its productivity in economic growth processes is pointed out by Johnston and Mellor [1961, pp. 571-572]. They distinguish five channels of influence: (1) economic development is accompanied by an increase in demand for agricultural products, which unmet can limit further growth; (2) the export of agricultural commodities may contribute to the growth of

² At the beginning of the 20th century a philosophical movement of agrarianism became popular. Among the main assumptions of this school can be mentioned: (a) agriculture as the only profession that offers total independence and self-sufficiency; (b) the rural population, with its community of work, is a model community; (c) farmers, thanks to their attachment to traditional values such as family, religion, culture or place of origin, have a strong and stable position in a dynamically changing world [Inge 1969].

³ With the reduction of the role of agriculture only to the production of surpluses that may be transferred outside the sector. Ruttan [1972, p. 594] points out that in some economies agriculture acts as a reservoir of labor and in others the rate of return on investment in agriculture can be high enough to attract savings from other sectors, which is particularly evident in open economies where investments in technological advances contribute to increasing agricultural productivity and reducing raw material costs for the processing industry.

income and the acquisition of foreign currency, especially at the early stages of development⁴; (3) human resources employed in developing industries and other sectors come mainly from agriculture; (4) agriculture, as a leading sector in less developed countries, is a source of capital necessary for the development of industry; (5) the growing income of the rural population contributes to the development of industry. Corresponding functions of the increasing productivity of agriculture in the process of economic development are distinguished by Mackie [1964, p. 2]: (1) raising the level of food and fiber production above the necessary minimum, as well as minimizing costs and facilitating the development of the non-agricultural sector; (2) stimulating the development of the food processing industry and the means of production for agriculture industry; (3) the release of labor resources that can be used in other sectors of the economy; (4) providing capital for the developing industry and financing state services through taxes; (5) providing opportunities for higher wages for a part of society by increasing production and specialization.

4. A new dimension of agricultural productivity

In the model of economic development outlined above, the increase in agricultural productivity is the primary source of economic development. But what is the role of agriculture in countries that have already developed, and using Rostov's terminology, are at the "age of high mass consumption"? By assessing the importance of agriculture in the richest countries in the world only through the sector's contribution to GDP, it could be considered as marginal and decreasing. According to UN [2016] data, between 1970 and 2014 the share of agriculture, hunting, forestry and fisheries in GDP fell in Australia from 5.93% to 2.29%, in Canada from 4% to 1.6%, in France from 6.96% to 1.5%, in Germany from 2.94% to 0.61%, in the United Kingdom from 2.16% to 0.61%, and in the USA from 2.34% to 1.24%. Of the 176 countries for which the United Nations has data⁵, this share has fallen, on average, from 20.1% to 11.1%. In addition, from a sector that is a source of

capital and tax revenue, agriculture became a recipient of public transfers. This phenomenon is called „the development paradox in agricultural policy” [Poczysta-Wajda 2009, p. 204]. According to World Bank data [2016] in 2011 agriculture support⁶ was highest in countries like Japan (80%), Norway (78%), South Korea (74%), Iceland (58%) and Switzerland (53%). The smallest, among others, in Uganda (-20%), Bulgaria (0.4%) and Romania (2%). But the key question is how the developed countries managed to increase the productivity of agriculture. It was done mainly through industrialization of agriculture. This process is well described by Czyżewski and Hennisz-Matuszczak [2005]. In the first phase of implementation of the industrial model, significant expenditure is spent on intermediate consumption and on redeploying land and labor resources released from agriculture. In the next step, it is necessary to use price regulations that compensate for the increase in intermediate consumption costs. These in turn imply the need for trade policy for defense of domestic, non-competitive production, against cheaper, imported commodities. In the long run, the costs of this policy (through differences in domestic and world prices) are transferred from taxpayers to consumers. At the same time, the industrial paradigm encourages increased production, which, in the face of inelastic demand for food, leads to surpluses, which must be handled by the government. In addition, because of the diminishing returns law, in each successive production cycle, the increase in intensification, concentration and mechanization of crops, causes less increase in yields. Thus, the efficiency of the industrial model is undermined both on the demand and the supply side, which ultimately determines its failure to maintain the farmer's income parity.

Unfortunately, the way of increasing the productivity of agriculture described above has negative consequences not only in the economic sphere. This is well illustrated by the example of „green revolution”. It is based on the introduction of high-yielding varieties of wheat and rice, the increase in fertilizer consumption and the modernization of irrigation systems [Rozłucki 1979, p. 19]. As a result of these activities,

⁴ Preblich's [1959] study on terms of trade in agricultural products shows that the situation of countries basing on this type of production is deteriorating in the long term, which is related to the differences in the income elasticity of demand for agricultural and industrial products. Thus, the long-term effectiveness of a development strategy based on increasing agricultural productivity and exporting the food surpluses is questioned.

⁵ The dataset does not include the countries that changed their political status at that time, among others countries of the former Soviet Union and Yugoslavia.

⁶ The Nominal Rate of Assistance (NRA) was used to measure the level of total agricultural support. It specifies how much gross farmer income is higher (or lower in the case of taxation) than would be, if there was no support from the state [Anderson et al. 2008].

which required substantial capital expenditure, the productivity of the land was increased in the areas covered by the program, especially in India. Thanks to the actions taken, the Punjab and Haryana states, which were the main experimental plots of new cultivation methods, significantly higher yields have been achieved. In the years 1962-1974 wheat yields increased in those states by 84% and 44%⁷, respectively [Rozłucki 1979, p. 61]. Although changes made in subsequent years have allowed food security to be achieved, there is great concern about the impact of the new cropping system on the environment. In particular, the negative impact of new agrotechnics on the quality of soils and the excessive use of groundwater are highlighted [Singh 2000, p. 102]. In Europe, a model of agriculture based on intensive fertilization, mechanization and concentration has led to deterioration in the quality of the environment manifested mainly by: (1) the reduction in the diversity of rural landscapes; (2) the reduction of rural biodiversity; (3) land abandonment in peripheral areas; (4) soil erosion; (5) eutrophication of waters; (6) excess greenhouse gas emissions [Stoate et al. 2009].

The recognition of the significant negative impact of industrialization on the environment coincided with the formulation of the concept of sustainable development, in the context of agriculture and the economy as a whole. The evolution of the concept is well described by Paszkowski [2001, pp. 47-48]. Although the birth date of the paradigm of sustainable development is most often set in 1987, when the Brundtland Report was published, this term has been in use before, as evidenced by the conference organized under the theme „Towards Sustainable Agriculture” in 1977 in Swiss Sisach. However, it was the Brundtland Report that was a „milestone” for shaping this concept in its modern meaning. What began in 1987 was eventually confirmed by the Earth Summit, taking place in June 1992 in Rio de Janeiro. At that time, a program called Agenda 21 was agreed, under which, in Chapter 14, the proposal for the implementation of the Sustainable

Development and Rural Development⁸ (SARD) principle was articulated.

According to Czyżewski [2012, p. 166] „at a certain stage of economic development of the country, the functions of the agricultural sector extend beyond the role of a supplier of agricultural raw materials”. On the one hand, achieving food security reveals higher needs such as the need of keeping ecosystems in an unspoiled form and the need of consuming higher quality agricultural products [Czyżewski, Kułyk 2011, p. 18]. On the other hand, in the face of the agriculture development model basing on the exploitation of environmental resources, they become more and more scarce, which increases their relative value, in comparison to the resources traditionally treated as inputs in agriculture (especially capital). An example of the process of a shift between traditional and modern perception of agriculture can be seen in the evolution of the functions of common agriculture policy (CAP) in the EU. We can read in Article 39 of the Treaty of Rome [1957] that the objectives of this policy are: “(a) to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilisation of the factors of production, in particular labour; (b) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture; (c) to stabilise markets; (d) to assure the availability of supplies; (e) to ensure that supplies reach consumers at reasonable prices”. Article 11 of the Treaty of Lisbon [Consolidated version... 2016] added to the above list a rule that: “Environmental protection requirements must be integrated into the definition and implementation of the Union’s policies and activities, in particular with a view to promoting sustainable development”. Thus, with time agriculture evolved from a food provider to a multifunctional sector which serves economic (food production, positive externalities for real estate and tourism markets), social (rural viability, health improvement) and environmental (con-

⁷ These achievements cannot be perceived completely uncritically. Firstly, doubts are aroused by the spatial limitation of program implementation to the most developed states. Because of that, its overall results have not been so significant and have contributed to deepening economic inequalities between states. The emphasis on the technical aspect of change also resulted in the postponement of socio-institutional reforms [Rozłucki 1979, pp. 83-87]. The importance of the impact of the „green revolution” on the reduction of poverty is also questioned. Das [2002, p. 70] indicates that development was occurring in all Indian provinces, regardless of the implementation of modern crop technologies.

⁸ Since the introduction, the concept of sustainable agriculture has been defined in many ways. Woś [1992] points to the term’s ambiguity and reviews its definitions, finding their common features. The most often sustainable agriculture definitions refer to: (1) the use of natural resources in a way that enables them to renew themselves; (2) an increase in agricultural production that is achieved only by increasing the productivity of the resource rather than by consuming it; (3) low susceptibility of sustainable agriculture to fluctuations and shocks; (4) symbiosis of agricultural and ecoregional objectives.

servicing agri-ecological and agri-environmental systems) development [Van Huylenbroeck et al. 2007]. So it is clear that agriculture can contribute nowadays to economic development by improving its productivity on many fields. In CAP agricultural sector is even, to some extent, remunerated for providing these services. Farmers have to follow cross-compliance rules on environmentally friendly ways of production to be eligible for direct payment support and fulfil additional requirements to obtain the “green” part of the payment [European Commission 2013].

While the environment has become an essential part of modern development agenda, the use of natural resources should also be taken into account when calculating agricultural productivity. So a new category is needed – the environmental agriculture productivity. Defined also as natural resources productivity (NRP), in simple words can be presented as a ratio of units of agricultural output, to units of natural resources consumed or qualitatively depleted [Rickard 2013, p. 49]. Knowing which practices have the best performance, not only in economic but also in environmental sense, is essential at least for three reasons. Firstly, it helps to assess present agricultural techniques, which might be adapted in the future, in less developed countries. Knowing their environmental productivity we can prevent those countries from depletion of natural resources, which has been caused by agriculture in the developed countries. Secondly, all the new technologies should be assessed for their environmental productivity, so that they bring the benefit to the farmer at the lowest possible environmental cost. Thirdly, values of environmental productivity might be an important signal for policymakers which kinds of agricultural practices should be more supported. Dominating contemporarily economic performance assessment could be complemented by environmental productivity, and its improvement may be beneficial to overall economic processes as well to the economical productivity improvements in the past. In reference to three basic roles of agriculture in the historical development by

Federico [2005] it is possible to point out new roles. In the product role, environmentally productive agriculture provides public goods such as clean air and agricultural landscapes and can earn foreign currency from agritourists. In the market role, it purchases green agriculture technologies and invests in renewable energy sources. In the factor role, it supplies spared land and environmental resources to industry (i.e. CO₂ emission limits) and services (i.e. plots for tourist infrastructure).

Knowing how vital environmental productivity of agriculture is, in the context of the sustainable development paradigm, appropriate measurement methods should be developed. However, as so far no universal method of assessing environmental productivity has been developed. The main reason for that might be lack of agriculture environmental impact data available for a large sample of countries and over a longer time horizon. Methods proposed as so far are suited for limited set of data available, for certain countries, regions, areas or farms. A review of the examples is presented in table 2.

A brief review of publications concerning the issue of environmental productivity of agriculture presented in table 2 gives a general picture of the state of the art in this matter. We can notice that the most commonly used indicators of environmental inputs or outputs were greenhouse gases (GHG) emissions and nitrogen (N) balance (soil contamination). Less often indicators of diversity were taken into account. As an economic input, land, labor and capital (represented by different metrics), was used. The most obvious metric for the output was the value of agricultural production, presented either in money or in physical units. The methods varied from simple single input/output productivity indices and scatter plots to more advanced total factor productivity (TFP) indices. The characteristics presented above set the most probable area of a future compromise about the universal method of measuring the environmental productivity of agriculture.

Table 2: Environmental productivity of agriculture – methods of measure

Scale	Author	Metrics	Method
National	Linquist et al. 2012	GHG emission, yield, N fertilization	productivity index
	Hoang 2010	land, labour, fertilisers, pesticide, machinery,	Moorsteen-Bjurek TFP index
	Hoang and Coelli 2011	energy, total water withdrawal, feed and seed, crop and livestock production	nitrogen use efficiency and cumulative energy efficiency
Regional	Caviglia and Andrade 2010	water and solar radiation capture, yield	land equivalent ratio, intensification sequence index
	Gottchalk et al. 2010	land use diversity crop diversity, farmland bird population,	alternative cost calculation, public support efficiency
	Ball et al. 2005	crop and livestock production, capital, land, labor and material input, pesticides runoff and leaching	Malmquist TFP index
Farm	Gadanakis et al. 2015	labour input, machinery, fertiliser, crop protection, water, fuel and energy cost, gross margin – values per ha	DEA
	Firbank et al. 2013	GHG emission, N losses, food production, biodiversity index	scatter plots
	Dillion et al. 2016	GHG emission, N surplus	productivity index

Source: own elaboration.

5. Summary

The review of economic development theories based on increasing agricultural productivity, as well as historical evidence of their accuracy, provide an insight into the fundamental importance of this sector for initiating development processes. In the past, agriculture played mostly the role of the producer (providing goods to feed the population and to earn foreign currency), market creator (purchasing manufactures, both for consumption and for investment) and factor supplier (supplying manpower and capital to industry and services). These traditional roles are still vital among developing countries, where the economic structure has not yet reoriented towards industrialization and servicisation. In highly developed countries the catalog of agricultural functions has been extended to the environmental ones. In accordance to them, agriculture can play a

role of the producer (provider of public goods and positive externalities), market creator (for green agriculture technologies) and supplier (of land and environmental resources) as well. A good example of this extension is the European Union. While part of modern perception of the development process is maintaining the environmental welfare, this paradigm should be included also in the assessment of agricultural productivity. However, with the present data availability, finding a universal and comprehensive method of environmental productivity measurement is difficult. Previous attempts of measurement were based on a single and total factor productivity approach, using the data for land, labor, capital, GHG emission, N balance, and production value output. This characteristic of research methods presents the most probable area of the future compromise about the universal method of measurement.

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