INSTITUTE OF AGRICULTURAL
AND FOOD ECONOMICS
NATIONAL RESEARCH INSTITUTE

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nr 13.1
Warsaw 2012

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MULTI-ANNUAL PROGRAMME
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This publication was prepared as a contribution to the research on the following subject **Economic modeling in the analysis of competitive growth of agri-food sector** within the framework of the research task *Equilibrium growth of domestic agri-food sector and its union and global competitiveness*

The purpose of this research was to develop an economic model of agri-food sector` growth. The model presented includes the demand side based on behaviors of consumer on retail as well as a food processor on farm markets as opposite to the supply side based on farm producer` behavior.

Reviewer
dr Mirosław Drygas

Translated by
Contact Langvage Services

Cover Project
AKME Projekty Sp. z o.o.

ISBN 978-83-7658-218-4

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Introduction

Demand for finished food products provides market conditions for agri-food processors. They, in turn, create demand conditions for agricultural producers. This assumption constitutes the standpoint of analysis conducted in this work. That is also the structure of the growth model of agri-food production, which is central herein. The growth model, at this stage, is subjected to a preliminary empirical verification. Due to the fact that the presented formulas and mathematical objects included in the model are mainly analytical rather than estimating, empirical study is relevant mostly to illustrate and confirm the assumptions and analytical solutions adopted in the model.

Demand conditions, in the case of agricultural raw materials and agricultural producers that produce them, are: firstly, the final demand of consumers, and secondly, the intermediate demand of agri-food processors. Both these entities, i.e. both the consumer and the processor shape the market situation of the grower.

Agri-food market in fact is comprised of two combined markets. First, the market of finished food products (goods) with own regularities of a general and specific nature. Second, the market of agricultural raw materials also with general and specific regularities typical of this market. Relationships and dependencies of a microeconomic nature between them will be presented in the first chapter,. which aims at outlining the background for further analysis. In the second part we raise the question of food processors and their impact on the producers through prices of agricultural raw materials. Chapter three is dedicated to the increase in agricultural production and the factors shaping it.

1. Consumer, agricultural producer and agri-food processors in the model

1.1. Consumers

Theoretical description of the agri-food market allows for identification of three entities whose interactions determine the market balance. In this perspective, we can distinguish consumers, agri-food processors and agricultural producers. They form a kind of circular flow of interdependent entities. The behaviour of each of them conditions the behaviour of others.

It is assumed that the conditions of consumer determine the equilibrium conditions of the producer (in this case, both agricultural producers and agri-food processors). Therefore, one can assume that the balance of the consumer, i.e. the final purchaser of food, determines the balance of the agricultural producer and the agri-food processor, and that the balance of the processor determines the balance of the agricultural producer, assuming a correlation here, which results from the nature of management in the agri-food sector. With that in mind, the above interrelation can be translated into foundations for our further analysis. Namely, the balance of the food and agricultural markets is a derivative of the consumer balance in the sense of maximizing its objective function (utility). Thus, it can be assumed that the level of income of agricultural producers is ultimately determined by the consumer who chooses between acquired value (quantity and price) of food in relation to the value of non-food goods[1].

For the purposes of our analysis we divide consumed goods in two types: food and non-food goods[2], as uniform goods.

Thus, in this context, with food and non-food goods, the conditional function of the consumer objective (mechanism of behaviour) can be written as follows:

$$U(P, \dot{Z}) \rightarrow \max \tag{1.1}$$

where:

$$m = P \cdot C_P + \dot{Z} \cdot C_{\dot{Z}} \tag{1.2}$$

where:

U – consumer utility function, m – consumer income, budget limit, P – non-food consumer goods, C_P – non-food consumer goods prices, $\dot{Z}$ – agricultural food goods, $C_{\dot{Z}}$ – prices of food of agricultural origin.

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[1] Of course, the issue here is the optimal choice to maximize one's own utility function at a given time, but also indirect interim choice, which is not analysed herein. In microeconomic terms, the issue is presented in the form of conditional optimisation of the consumer choice.

[2] We adopt microeconomic classification, according to which a good is what the consumer buys, and what is produced by the manufacturer is defined as the product with the same value of use. This is expressed by the necessary condition of manufacturer rational behaviour in the sense that he produces what is purchased by the consumer, i.e. the product becomes a good when it is purchased. In other words: the producer produces what is in demand, taking into account other considerations, such as prices, preferences, etc. Cf. W. Rembisz, A. Sielska, *Mikroekonomia – zarys w ujęciu analitycznym*, Vizja Press&IT, Warsaw 2011.

The solution to optimization tasks defined in this way, allows for explaining the mechanism of consumer behaviour. This determines the demand notified by the consumers for food products from agricultural sources and allows to determine the approximate size of the demand. Therefore, with the condition given by the formula (1.2) it is easy to determine the demand for food[3]:

$$\dot{Z} = \frac{m}{C_{\dot{Z}}} - \frac{C_P}{C_{\dot{Z}}} P \tag{1.3}$$

As can be seen in the above, the demand for food is determined by the two direct economic factors associated with the market category. Firstly, the demand is determined by the level of real prices of food measured by their relationship to consumer spending, that is:

$$\frac{m}{C_{\dot{Z}}} \tag{1.4}$$

The second factor included in the above formula is the relationship of food to the prices of non-food products - industrial products (and others) and their level of consumption at any given time, that is:

$$\frac{C_P}{C_{\dot{Z}}} P \tag{1.5}$$

As one can see, there are no high or low prices, there are only relatively high or relatively low prices in relation to income or in relation to the prices of other goods. Both of these indicators reflect the real level of food prices. It may be noted that the level of real prices defined in this way is a reflection of efficiency relationships occurring between producers in the economy and its various sectors. The important conclusion following from the above, is that the real level of food prices is not only dependent on agricultural producers or, to put it more broadly, on food producers. It depends on the

[3] If this formula (1.3) is differentiated, we would obtain rates of changes of the values contained on the right side, i.e.:

$\frac{\partial m}{m} \cdot \frac{1}{t}$ the growth rate of income, $\frac{\partial C_{\dot{Z}}}{C_{\dot{Z}}} \cdot \frac{1}{t}$ rate of increase in food prices, $\frac{\partial C_P}{C_P} \cdot \frac{1}{t}$ which are easily converted into indexes. This is easy to illustrate in the conventional analysis. Relevant data were compared in the table below, they illustrate the economic sense of the formula (1.3) and (1.4) and (1.5), showing the food getting relatively cheaper in relation to income, and the lack of significant change in real prices, i.e. the ratio of food prices to prices of other products, which is shown analytically by the first quotient on the right side (1.3). These issues will be revisited in the analytical approach developed in the second part of the research.

Indicators (indexes) of the increase in prices of non-food and food products and salary (income) increases in 2000-2010

Item	2000-2003	2004-2006	2007-2009	2010	2004-2010	2000-2010
Consumer goods and services	119.3	106.8	110.5	102.6	121.1	144.5
Food and non-alcoholic beverages	113.5	109.2	115.8	102.7	129.9	147.4
Wages and salaries in the enterprise sector	128.6	113.8	125.5	103.3	147.6	189.8

Source: CSO data.

income of real consumers, which is known to be determined by the productivity of labour in the economy, especially in the non-agricultural sectors"[4].

Ratio of non-food product prices to food product prices is expressed as a coefficient: $\frac{C_P}{C_{\dot{Z}}}$ that reflects[5] the possibility of substitution that occurs between these two types of goods. By differentiating the utility function given by (1.1) under the condition (1.2) we obtain:

$$\frac{\Delta \dot{Z}}{\Delta P} = \frac{\partial U / \partial P}{\partial U / \partial \dot{Z}} = -\frac{C_{\dot{Z}}}{C_P} \tag{1.6}$$

This means that the consumer balance[6] is determined by the reciprocal of the ratio of marginal utility to the inverse relationship of prices for those goods, namely:

$$C_{\dot{Z}} = \frac{\partial U}{\partial \dot{Z}} \tag{1.7}$$

$$C_P = \frac{\partial U}{\partial P} \tag{1.8}$$

Note that if the condition defined by equality (1.6) is not satisfied, the consumer will change the selected items, substituting certain goods with others, to bring new relative relationships between utility and prices, according to the scheme, which can be written as:

$$\downarrow C_{\dot{Z}} > \frac{\partial U}{\partial \dot{Z}} \uparrow \tag{1.9}$$

$$\downarrow C_P > \frac{\partial U}{\partial P} \uparrow \tag{1.10}$$

In the described case of discrepancy between goods' prices and marginal utilities some role is played also by agricultural producers and agri-food processors involved in the production of food products. If the price of food products on the retail market is higher than their utility to the consumer ($C_{\dot{Z}} > \frac{\partial U}{\partial \dot{Z}}$), the consumer will be inclined to reduce the amount of purchased products, the producers and processors can, however, in this case, take action to increase the utility of goods. This process of substitution (replacement of demand for goods characterised by a relatively higher price and lower utility with demand for goods with higher utility and lower price) will continue until the equality (1.6) is satisfied[7]. Thus we have, the following:

$$\dot{Z} = \frac{M}{C_{\dot{Z}}}, \quad P \neq \frac{M}{C_P} \tag{1.11}$$

[4] W. Rembisz, *Mikroekonomiczne podstawy wzrostu dochodów producentów rolnych,* Vizja Press&IT, Warsaw 2007, p. 14.

[5]As can be seen by solving the task of maximizing consumer utility function with constant budget limit (i.e. with unchanged income).

[6]The optimal basket of food and non-food goods selected by the consumer.

[7]Of course, there are certain limits, it is not possible to consume only non-food goods, while the opposite case is possible.

Both price relationships shown in the above formulas (1.4) and (1.5) are exemplifications of regularities associated with the Engel law. In the context of this law, the most important relationship is the relationship between the demand for food and the income. This is illustrated by the demand function:

$$\dot{Z}^D = f(m) \tag{1.12}$$

where: $\dot{Z}^D$ – demand for food products.

The share of expenditure on food in consumer spending is important in shaping the demand for food, in the context of the law. With (1.2) this ratio is in the following form:

$$m_{\dot{Z}} = \frac{\dot{Z} \cdot C_{\dot{Z}}}{m} \; \dot{Z}^D = f(m) \tag{1.13}$$

This index is illustrated empirically (tables 1.6, 1.7 and graph in Figure 1.12). It should decrease along with the increase in income. It is also an expression (illustration) of increasing prosperity, when accompanied by an increase in the value of food consumption per capita, which is also illustrated empirically (Table 1.7).

Knowledge of flexibility is important for the study of the formation of the level of demand for products of agricultural producers and services of agri-food processors. This can be written as[8]:

$$(1 - m_{\dot{Z}}) \cdot E_P^D + m_{\dot{Z}} \cdot E_Z^D = 1 \tag{1.14}$$

E_P^D – income elasticity of demand for non-food products,

$E_{\dot{Z}}^D$ – income elasticity of demand for food products.

Elasticity is also important to estimate the total revenue of the producer (defined as the product of prices and quantities of products) and the possibility of increasing it[9].

It is assumed[10] now that the possibilities of increase in prices of agri-food products are small. This is due to the low income elasticity of demand for food products (presented in Table 1.1 also in relation to non-food goods) in the analysed countries of the European Union. These elasticises were at a similar level, but the elasticity of demand for food products was the highest in the Polish market. This illustrates regularities mentioned above. Demand for food was less elastic in relation to changes in income than in case of other goods. Therefore this variable (i.e. income through elasticity) should be included in the demand conditions of growth in agri-food production. The values of this ratio for Poland are also shown in Figure 1.1.

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8 Rembisz W., *Mikroekonomiczne…,* op.cit. p. 19.

9 According to W. Tomek, K. Robinson, it can be noted that *"If demand is elastic in consideration of price, the price and total revenue vary inversely. The increase in price causes a decrease in total revenue, while its decline - a drop in revenues. This is a direct consequence of the definition of elastic demand (...)".* On the other hand, if demand is inelastic, and the property is usually attributable to the demand for food products, *"one must expect that with other factors unchanged, the price and total revenue of the producer will change in a manner directly proportional".* The same authors also cite words of H.A. Wallace, who in 1915 concluded that *"from the principles of demand it follows that agriculture is punished for too high level of production and rewarded for too low level of production"* Tomek W.G., Robinson K.L, *Kreowanie cen artykułów rolnych*, PWN, Warsaw, 2001, p. 38.

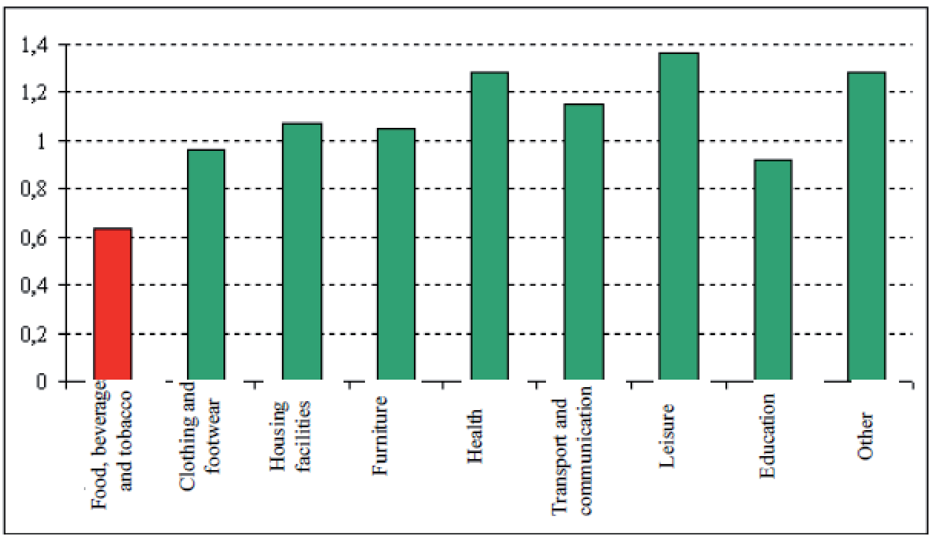
10 W. Rembisz, *Mikroekonomiczne podstawy wzrostu dochodów producentów rolnych,* Vizja Press&IT, Warsaw 2007.

Table 1.1. Comparison of income elasticity of demand for selected categories of goods and services in the analysed countries of the European Union in 2005

Goods / Country	Food, beverages and tobacco	Clothing and footwear	Home furnishings and household maintenance	Furniture	Health	Transport and communication	Leisure	Education	Other
Poland	0.628	0.965	1.065	1.049	1.282	1.147	1.359	0.919	1.285
Hungary	0.612	0.965	1.064	1.049	1.273	1.145	1.345	0.918	1.276
Czech Republic	0.583	0.965	1.063	1.048	1.261	1.141	1.325	0.917	1.263
Sweden	0.513	0.964	1.062	1.047	1.239	1.134	1.293	0.914	1.241
Italy	0.508	0.964	1.062	1.047	1.238	1.134	1.291	0.914	1.240
Belgium	0.507	0.964	1.062	1.047	1.238	1.134	1.291	0.914	1.240
Spain	0.503	0.964	1.062	1.047	1.237	1.134	1.289	0.914	1.239
France	0.492	0.964	1.062	1.047	1.235	1.133	1.286	0.914	1.236
Germany	0.477	0.964	1.061	1.047	1.232	1.132	1.281	0.913	1.233

Source: USDA.

Figure 1.1. Income elasticity of demand for different categories of goods in Poland in 2005



Source: Author's own compilation based on the data from the USDA.

Significant differences in the evolution of income elasticity of demand refer to the cereal products and fats. The relevant data are presented in Table 1.2. There is a similarity in this field in Poland and in the Czech Republic and Hungary. In each case, the change in income affected the most the demand for beverages and tobacco, a bit less sensitive was the demand for dairy products and meat.

Table 1.2. Comparison of income elasticity of demand for selected categories of food products in the analysed countries of the European Union in 2005

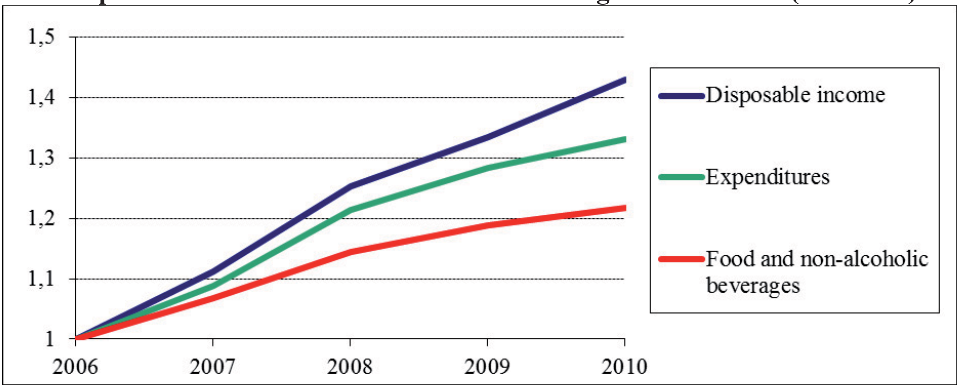
Goods / Country	Cereals	Meat	Fish	Dairy	Oils and fats	Fruit	Other	Drinks and tobacco
Poland	0.205	0.622	0.494	0.643	0.255	0.434	0.830	0.794
Hungary	0.194	0.605	0.480	0.626	0.244	0.421	0.807	0.772
Czech Republic	0.135	0.577	0.454	0.597	0.194	0.392	0.760	0.730
Sweden	0.103	0.498	0.390	0.515	0.157	0.335	0.653	0.628
Italy	-0.009	0.508	0.391	0.525	0.078	0.325	0.655	0.633
Belgium	0.042	0.488	0.378	0.504	0.111	0.319	0.634	0.611
Spain	-0.246	0.511	0.384	0.529	-0.074	0.303	0.648	0.629
France	0.019	0.482	0.372	0.498	0.093	0.312	0.624	0.602
Germany	0.035	0.473	0.366	0.489	0.103	0.309	0.613	0.591
Netherlands	0.039	0.469	0.363	0.484	0.105	0.306	0.608	0.586
United Kingdom	-0.015	0.458	0.351	0.473	0.066	0.292	0.589	0.569

Source: USDA.

To illustrate the above formulas we present the evolution of expenditure on different goods (both food and non-food products) in household budgets. We restrict ourselves to the illustration of the demand for food in Polish households in a relatively short period of time: 2006-2010. The relevant period was characterised by an increase in both disposable income and total expenditure of households. Changes in these two figures are shown in Figure 1.2, which also includes, for comparison, the change of food expenditures. Also for illustrative purposes we estimated the trend functions describing these changes[11]. The results are given in Table 1.3.

[11]In fact, for the above analytical formulas one should apply indexes (rates) of growth introduced from the very trend function.

Figure 1.2. Indexes of increase in disposable income, expenditure in general, as well as expenditure on food and non-alcoholic beverages in 2006-2010 (2006=100)



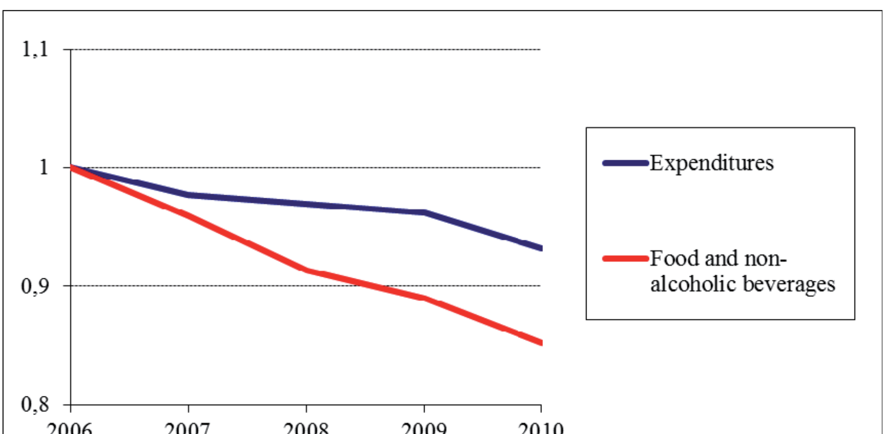
Source: Authors' own compilation based on the data of the Central Statistical Office.

Table 1.3. Estimates of the linear trend function describing the changes in disposable income, expenditure and expenditure on food and non-alcoholic beverages in Polish households in 2006-2010

Variable	Slope	Constant	R^2
Disposable income	0.1081 (0.0058)	0.9018 (0.0192)	0.9915
Expenditures	0.0859 (0.0081)	0.9256 (0.0270)	0.9738
Expenditures on food and non-alcoholic beverages	0.0556 (0.0055)	0.9566 (0.0183)	0.9712

Source: Authors' own compilation based on the data of the Central Statistical Office.

Figure 1.3. Changes in the share of total expenditure and expenditure on food and non-alcoholic beverages in disposable income in Polish households in 2006-2010 (2006=100)



Source: Authors' own compilation based on the data of the Central Statistical Office.

Figure 1.3, in turn, shows the development of relative categories included in analytical formulas (the relationship of total expenditure and expense on food and non-alcoholic beverages to the disposable income). This is consistent with the approach presented in formulas (1.3) and (1.4). One can notice that over time the share of these expenditures in consumer disposable income declined. The share of expenditure on food products declined even faster. However, from the perspective of the developed model, it is the evidence of the correctly specified variables. Estimates of relevant trends functions - subject to the length of time series as above - are presented in Table 1.4.

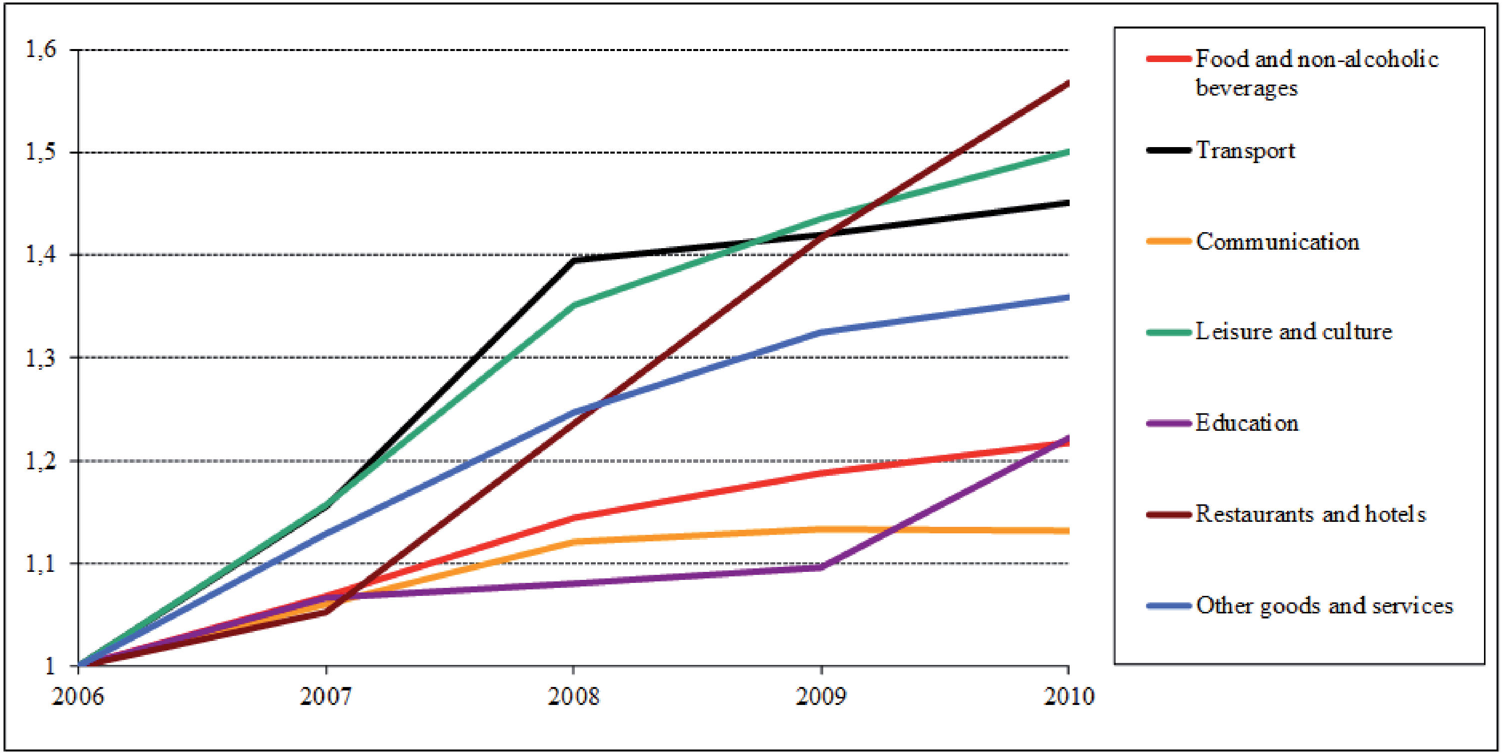
Table 1.4. Estimates of the linear trend function describing the change in the ratio of expenditure and expenditure on food and non-alcoholic beverages to disposable income for Polish households in 2006-2010

Variable	Slope	Constant	R^2
Ratio of expenditure to disposable income	-0.0136 (0.0021)	0.9045 (0.0069)	0.9346
Ratio of expenditure on food and non-alcoholic beverages to disposable income	-0.0089 (0.0005)	0.2450 (0.0017)	0.9903

Source: Authors' own compilation based on the data of the Central Statistical Office.

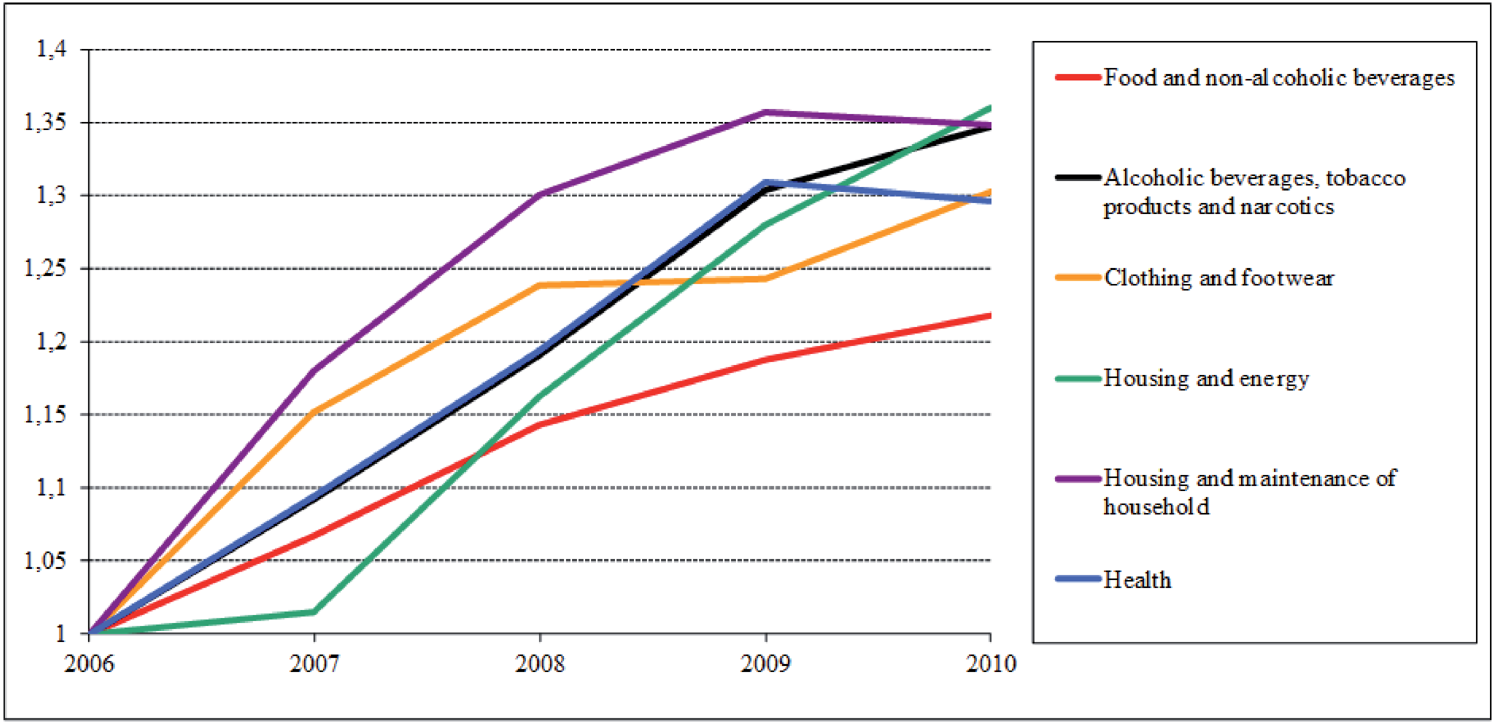
The figures 1.4 and 1.5 show the changes in expenditure on food products (food and non-alcoholic beverages) compared to changes in spending on non-food products (in broad categories used by the CSO). As one can see, the expenditure on food products are arranged according to upward trends, but not as expenditure on other products, with the exception of spending on education and communication. This is confirmed by the previous considerations. To confirm that we made an estimation of the respective trend functions, included in Table 1.5.

Figure 1.4. Changes in expenditure of Polish households on food and selected non-food products in 2006-2010 (a)



Source: Authors' own compilation based on the data of the Central Statistical Office.

Figure 1.5. Changes in expenditure of Polish households on food and selected non-food products in 2006-2010 (b)



Source: Authors' own compilation based on the data of the Central Statistical Office.

Table 1.5. Estimates of the linear trend function describing the changes in expenditure on food goods and non-food services in Polish households in 2006-2010

Type of goods	Slope	Intercept	R^2
Food and non-alcoholic beverages	0.0556 (0.0055)	0.9566 (0.0183)	0.9712
Home furnishings and household maintenance	0.0874 (0.0216)	0.9752 (0.0715)	0.8456
Education	0.0472 (0.0111)	0.9511 (0.0368)	0.8580
Health	0.0809 (0.0129)	0.9364 (0.0428)	0.9292
Restaurants and hotels	0.1499 (0.0135)	0.8046 (0.0448)	0.9762
Housing and energy	0.0985 (0.0115)	0.8679 (0.0380)	0.9610
Clothing and footwear	0.0697 (0.0151)	0.9782 (0.0501)	0.8763
Communication	0.0338 (0.0085)	0.9879 (0.0282)	0.8398
Leisure and, culture	0.1278 (0.0156)	0.9050 (0.0516)	0.9574

Source: Authors' own compilation based on the data of the Central Statistical Office.

Table 1.6 presents estimates of the trend function for expenditure on food products. As one can see, they were, in line with expectations, rising trends. It is clearly an expression of the growing prosperity - both increase in food consumption, as well as favourable changes in its structure, if one observes and illustrates increase in well-being in such a simple way. Adjustments of accepted trend functions to the real data are very good.

Despite the above-mentioned changes, the share of expenditure on individual food items in expenditure on food products remained - as shown by figures 1.6 and 1.7 - at a relatively constant level. One can therefore conclude that the demand for various food products remains stable. If this is due to the relatively high level of wealth, which does not lead to a further increase in food consumption (saturation level), the prospects for growth in agricultural production, as a response to a possible increase in demand, are small.

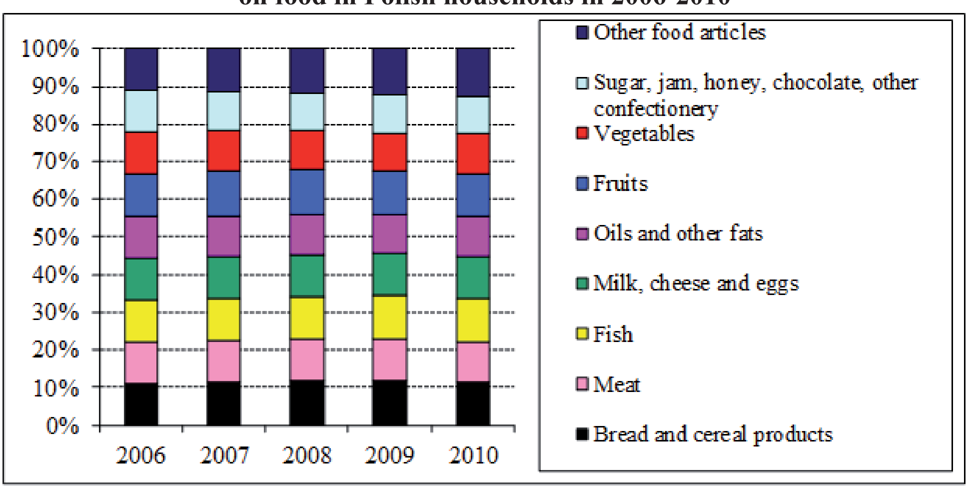
Table 1.6. Estimates of the linear trend function describing the changes in expenditure on different categories of food products in Polish households in 2006-2010

Type of goods	Slope	Intercept	R^2
Food	0.0535	0.9587	0.9686
	(0.0056)	(0.0185)	
Bread and cereal-based foods	0.0658	0.9684	0.8725
	(0.0145)	(0.0482)	
Oils and other fats	0.0390	0.9693	0.9009
	(0.0075)	(0.0248)	
Fruit	0.0523	1.0029	0.7229
	(0.0187)	(0.0620)	
Non-alcoholic beverages	0.0798	0.9316	0.9860
	(0.0055)	(0.0182)	
Alcoholic beverages, tobacco and narcotics	0.0906	0.9151	0.9860
	(0.0062)	(0.0207)	

Source: Authors' own compilation based on the data of the Central Statistical Office.

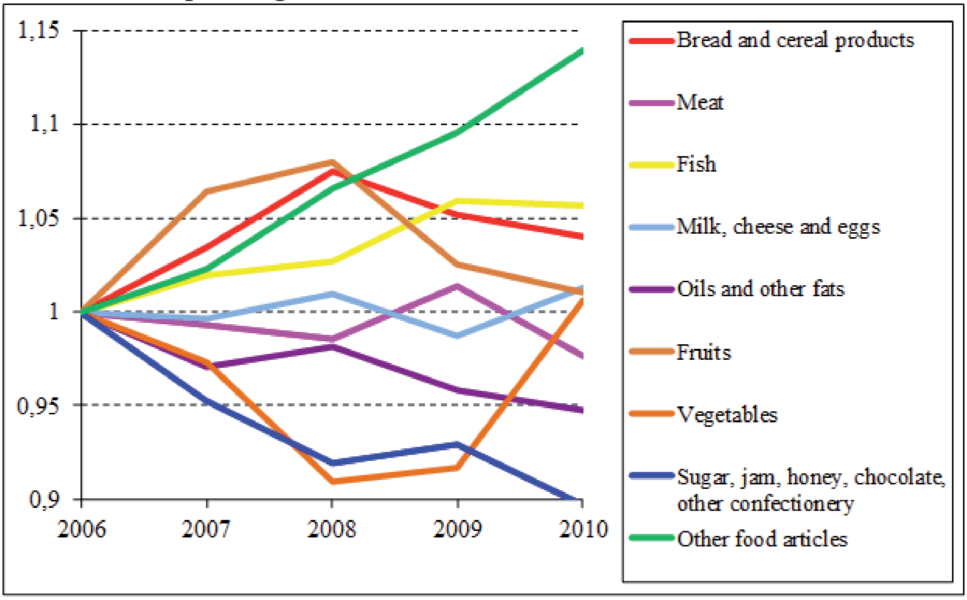
As a side note, it can be seen that values included in Figure 1.6 and 1.7 show the evolution of relatively healthy consumption patterns. This is not good news for domestic producers, in view of the analysis of the developed model and the Heady's convention. This means, in fact, that they cannot count on an increase in demand for traditional Polish products as a source of revenue growth both in size and price. These are the demand conditions resulting from the economic interpretation of these patterns. The above affects the value of the main indicator in the developed model, which is the rate of agricultural production (r), discussed in chapter three.

Figure 1.6. Share of expenditure on individual food products in the expenditure on food in Polish households in 2006-2010



Source: Authors' own compilation based on the data of the Central Statistical Office.

Figure 1.7. Changes in the share of expenditure on individual food products in spending on food in Polish households in 2006-2010



Source: Authors' own compilation based on the data of the Central Statistical Office.

So much space was devoted to the final demand for food products, not only because of the developed growth model for agri-food production. Research on the demand for food products are important in the theory of agricultural economics and agricultural policy. They allow for explaining important conditions of the income of agricultural producers. This is of practical importance to agricultural producers and agricultural policy. Indeed, the demand - its lower rate, is one of the factors that may limit the growth in the agri-food sector, including increase in the income of agricultural producers.

The increased spending on food products, observed in the EU countries, results from the greater role of processing - as will be discussed further on - and greater demand for highly processed products. It is important that now, thanks to technological advances, the possibilities of increase in production in relation to demand are virtually limitless. In this situation, the producers, seeking to improve the current level of profitability (and consequently revenue), have to change manufacturing techniques and improve the resulting efficiency[12].

With microeconomic foundations, we can present the demand for finished food products in macro-economic terms. In this perspective, the demand for food products

[12]Improving efficiency is currently the only fundamental and least expensive to society way to improve the income of agricultural producers, including in relation to wages in other sectors of the economy. This is especially true of highly developed countries, including of course the EU countries analysed in this paper. The issue of production efficiency and its multidimensional nature is discussed in the last paragraph of the third chapter.

is determined by two values: population and the demand per capita[13]. Consequently, the demand for finished food goods in macroeconomic terms is determined in accordance with the following formula:

$$\dot{Z}^D = L_K \cdot \frac{\dot{Z}^D}{L_K} \tag{1.15}$$

$$\dot{Z}_L^D = \frac{\dot{Z}^D}{L_K} \tag{1.16}$$

$$\dot{Z}^D = L_K \cdot \dot{Z}_L^D \tag{1.17}$$

where: $\dot{Z}^D$ – demand (consumption) for food products at the macroeconomic level (in the country); L_K – population in the country; $\dot{Z}_L^D$ – average food consumption, demand per capita.

After appropriate transformations of the above equation we get an equation describing the dynamic formula of demand:

$$\frac{\Delta\dot{Z}^D}{\dot{Z}^D} = \frac{\Delta L_K}{L_K} + \frac{\Delta\dot{Z}_L^D}{\dot{Z}_L^D} \tag{1.18}$$

where: $\frac{\Delta\dot{Z}^D}{\dot{Z}^D}$ –growth in demand for food in the country (total demand for food, the demand for food as the aggregate total) ; $\frac{\Delta L_K}{L_K}$ – rate of population or consumers growth; $\frac{\Delta\dot{Z}_L^D}{\dot{Z}_L^D}$ – growth rate of demand per capita.

This approach is of course a consequence of the microeconomic approach, as discussed and illustrated above, which related to the second component of the right-hand side of (1.18), i.e. $\frac{\Delta\dot{Z}_L^D}{\dot{Z}_L^D}$. In extended terms, in the above equations (1.15-1.18) we also take into account factors that influence the development of the demand for food, including import and export of products, changes in the relation of prices of non-food products to the food products or the price elasticity of demand, as mentioned earlier.

Macroeconomic formula in the extended form, with microeconomic variable components describing the mechanism of growth in demand, is suggested by other authors[14]. It includes the rate of change in the ratio of prices for non-food products to food products, changes in the general level of consumption and the rate of per capita income and the corresponding elasticity of demand:

[13]This is the approach which takes into account the consumer behaviour discussed above, resulting in the unit demand for food products, and the balance sheet recognition through adding the sum of consumers.

[14]Y. Yamaguchi, A. Binswanger, *The role of Sectoral Technical Change in Development*. University of Minnesota, pp. 85-7, 1985.

$$\frac{\partial \dot{Z}^D}{\partial t}\cdot\frac{1}{\dot{Z}^D}=\frac{\partial a}{\partial t}\cdot\frac{1}{a}+\frac{\partial L_K}{\partial t}\cdot\frac{1}{L_K}\pm\frac{\partial\left(C_P/C_{\dot{Z}}\right)}{\partial t}\cdot\frac{1}{\left(C_P/C_{\dot{Z}}\right)}\cdot E_C+\frac{\partial m}{\partial t}\cdot\frac{1}{m}\cdot E_{\dot{Z}} \qquad (1.19)$$

where: $\frac{\partial a}{\partial t}\cdot\frac{1}{a}$ –shift of the demand function; $\frac{\partial L_K}{\partial t}\cdot\frac{1}{L_K}$ – rate of population growth; $\frac{\partial\left(C_P/C_{\dot{Z}}\right)}{\partial t}\cdot\frac{1}{\left(C_P/C_{\dot{Z}}\right)}$ – changes in the ratio of prices of non-food products to prices of food products; E_C – price elasticity of demand; $\frac{\partial m}{\partial t}\cdot\frac{1}{m}$ – rate of change in per capita income; $E_{\dot{Z}}$ – income elasticity of demand.

The equations of demand for food, in the above-presented form, are subject to empirical parameterization and verification. Such attempts have been made in previous studies conducted by the IAFE[15]. Theoretical basis of food demand equations were shown earlier[16].

It can be assumed that an increase in agricultural production is more and more dependent on the demand for processing services included in the finished food products[17]. E.O. Heady noted that *"in the course of further income growth, the consumer does not consume more physical quantities of food, does not buy more kilograms, but consumes food in other forms, better packaged, easy to prepare and eat"* and *"increase in spending on food per capita in U.S. is expressed... by the purchase of services related to the processing of food, and it is not associated with the size of agricultural products. The increasing expenditure per capita in the United States are in particular related to refrigeration, packaging and preparation of ready-to-eat food"*[18]. J. Mellor and R. Ahmed, wrote that *"in developed countries, the increase in food expenditures primarily represents the increase in expenditure on services related to the processing of agricultural products in the non-agricultural sector"*[19]. The above fact is of apparent significance for the development of the demand-conditioned growth model of agri-food production. It is also confirmed by empirical research.

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[15] E.g. *Rynek rolny - analizy tendencje oceny. Rynek żywnościowy,* K. Świetlik.

[16] S. Figiel, W. Rembisz, *Przesłanki wzrostu produkcji w sektorze rolno-spożywczym – ujęcie analityczne i empiryczne*, IAFE-NRI, Warsaw 2009.

[17] B. Senauer draws attention to this fact by writing *"... food economy and food production is increasingly driven by factors on the side of consumption rather than on the side of agricultural production. More and more emphasis is moving from production to processing, distribution and trade."* This will be addressed later in the study. It is important that the consumer independence is increasing, the consumer is not condemned, as was the case in the previous system, to market deficiencies. This is the basis of rational consumer behaviour, which has an impact on moderate growth of demand for food. B. Senauer, *Major Consumer Trends Affecting the US Food System*, University of Minnesota, pp. 89-16, p.5.

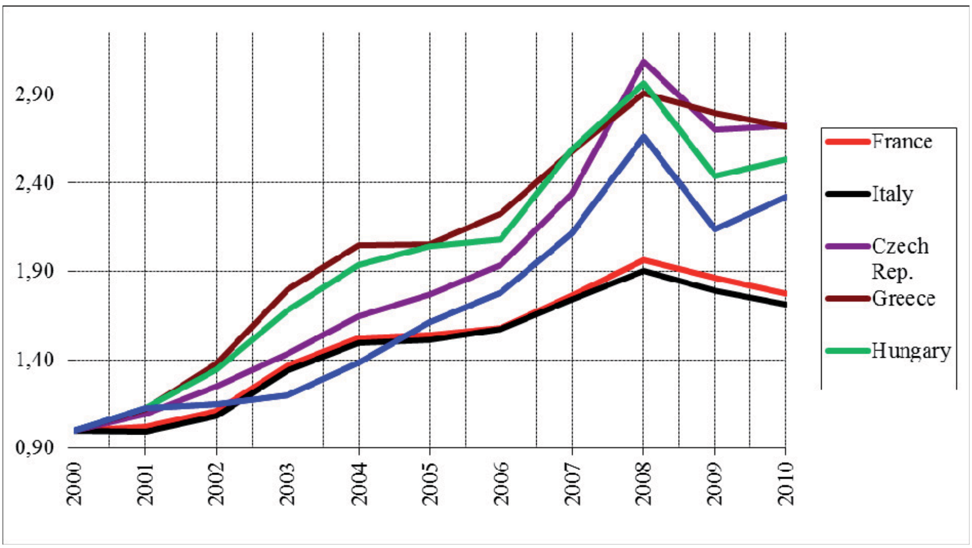
[18] E.O. Heady, *Agricultural...,* op. cit., p. 40.

[19] J. Mellor, R. Ahmed, *Agricultural Price Policy for Developing Countries*, The Johns Hopkings University Press, 1988, p. 61.

The figures 1.8 and 1.9 show the changes in expenditure on food in selected European Union countries during the last decade. Despite the presence of typical fluctuations of time series, one can find that these expenditures are shaped in accordance with the increasing trend. The corresponding estimates of parameters of these trends are given in Table 1.7. It is probably associated with the increase in the unit value of consumed food. This reflects the increasingly high value-in-use, resulting from better processing of agricultural raw materials. This does not change the fact associated with the Engel regularity that the share of expenditures on food in consumer spending decreases. This is indicated in figures 1.10 and 1.11. The changes can be described by the trend function, whose parameters are shown in Table 1.8. Downward trend is not as pronounced as in the case of the upward trend.

For the record, we also show the evolution of expenditure on food as a percentage of total expenditure in the European Union countries with the evolution of this category in less developed countries. This is depicted in Table 1.9, presenting summarized expenditure on food in the selected EU countries expressed as a percentage of the total expenditure incurred by consumers for the purchase of goods and services compared to expenditure in selected countries with different levels of development[20].

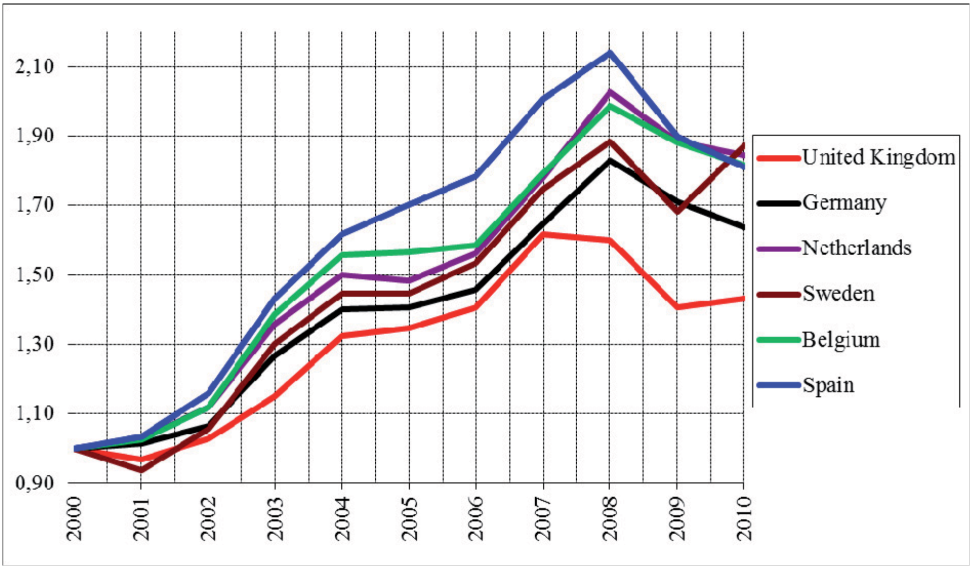
Figure 1.8. Growth rate of expenditure on food in absolute terms in selected countries of the European Union in 2000-2010 (2000=100) (a)



Source: Author's own compilation based on the data from the USDA.

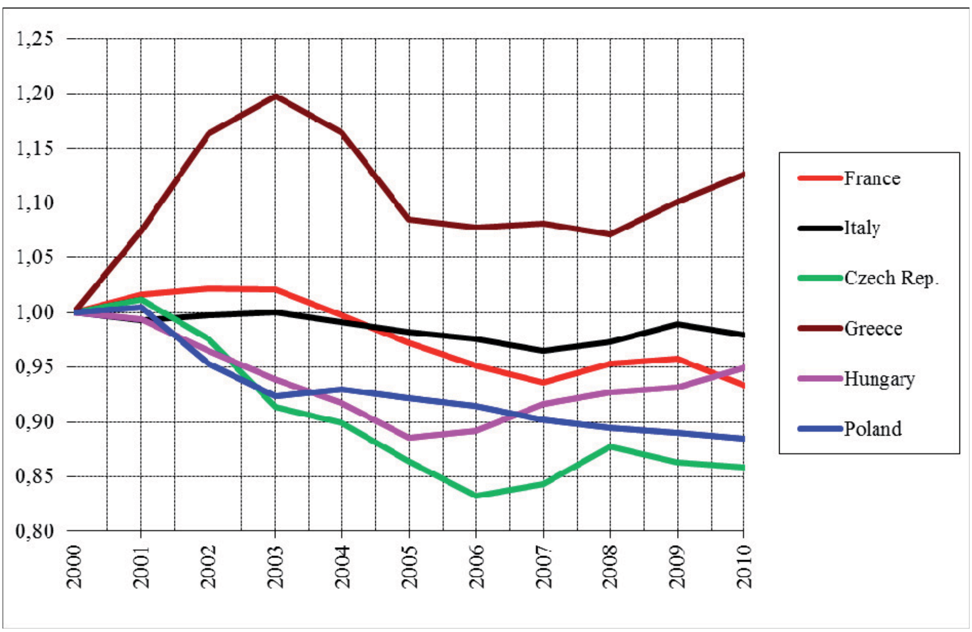
[20]This is nothing new, we confirm the regularities relating to the Engel law. At the same time, a relatively small part of expenditure on food in consumer spending in India can also be an expression of lower consumption than in the EU countries in absolute terms. But this is not important for the main argument of the analysis.

Figure 1.9. Growth rate of expenditure on food in absolute terms in selected countries of the European Union in 2000-2010 (2000=100) (b)



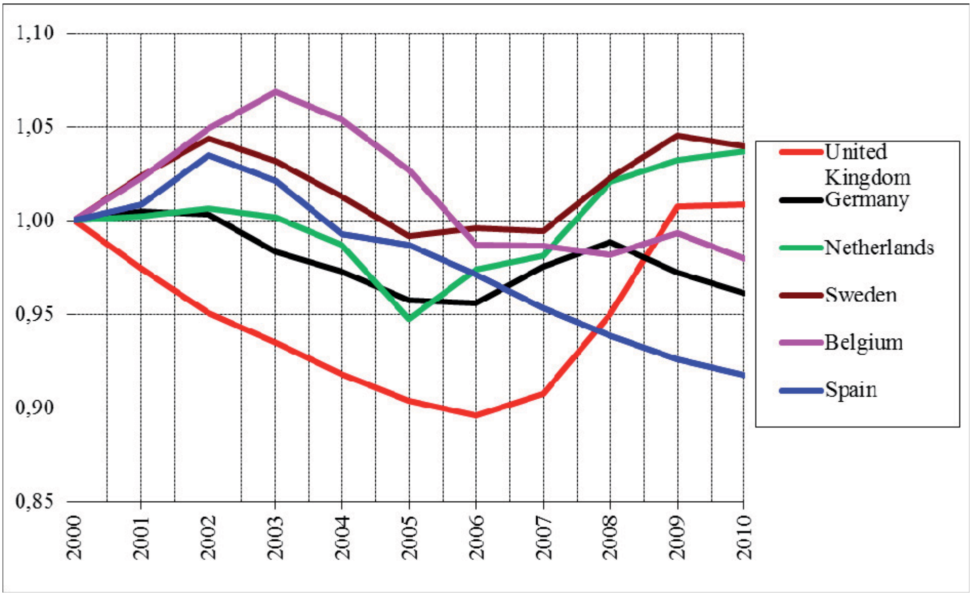
Source: Author's own compilation based on the data from the USDA.

Figure 1.10. Rate of changes in the share of food expenditure in total expenditure in selected countries of the European Union in 2000-2010 (2000=100) (a)



Source: Author's own compilation based on the data from the USDA.

Figure 1.11. Rate of changes in the share of food expenditure in total expenditure in selected countries of the European Union in 2000-2010 (2000=100) (b)



Source: Author's own compilation based on the data from the USDA.

Table 1.7. Estimates of linear trend function describing the growth of expenditure on food in absolute terms in 2000-2010 for selected countries of the European Union

Country	Slope	Constant	R^2
United Kingdom	0.060	0.936	0.757
Germany	0.083	0.908	0.892
Netherlands	0.103	0.892	0.915
Sweden	0.098	0.856	0.916
Belgium	0.099	0.923	0.898
Spain	0.107	0.957	0.818
France	0.097	0.918	0.897
Italy	0.092	0.916	0.882
Czech Republic	0.206	0.671	0.915
Greece	0.197	0.877	0.938
Hungary	0.179	0.900	0.874
Poland	0.158	0.730	0.873

Source: Authors' own calculation according to the USDA data.

Table 1.8. Estimates of the linear trend function describing the percentage share of food expenditures in total expenditure in 2000-2010 for selected countries of the European Union

Country	Slope	Constant	R^2
United Kingdom	0.001	0.945	0.005
Germany	-0.004	1.002	0.456
Netherlands	0.003	0.983	0.117
Sweden	0.001	1.011	0.036
Belgium	-0.006	1.049	0.372
Spain	-0.011	1.042	0.835
France	-0.009	1.032	0.766
Italy	-0.003	1.001	0.501
Czech Republic	-0.016	1.002	0.722
Greece	0.001	1.096	0.006
Hungary	-0.006	0.975	0.312
Poland	-0.012	0.998	0.860

Source: Authors' own calculation according to the USDA data.

Table 1.9. Share of food expenditures in total expenditure in 2000-2010 for selected countries (in %)

Country / Year	India	Russia	Romania	Macedonia	Ukraine	Poland	Germany	France	United Kingdom
2000	41.75	46.76	34.89	29.40	46.49	22.83	11.49	14.12	9.62
2001	41.67	45.80	35.49	32.21	47.50	22.94	11.55	14.36	9.37
2002	39.48	41.70	34.78	33.52	45.99	21.77	11.53	14.43	9.15
2003	38.82	37.70	35.25	35.77	44.89	21.09	11.30	14.42	8.99
2004	34.36	36.00	33.47	33.12	43.88	21.22	11.18	14.08	8.83
2005	34.03	33.20	29.77	34.00	42.89	21.05	11.01	13.73	8.69
2006	32.52	31.60	29.11	32.87	42.28	20.88	10.99	13.44	8.62
2007	32.16	28.40	27.94	32.83	42.28	20.59	11.21	13.22	8.73
2008	30.52	29.10	28.04	32.99	42.23	20.43	11.36	13.47	9.14
2009	29.49	29.69	29.29	33.04	42.12	20.33	11.18	13.53	9.69
2010	27.69	29.00	29.69	32.92	46.86	20.20	11.05	13.18	9.70

Source: USDA.

1.2. Agri-food processor

As noted above, consumers report an increasing demand for services related to the processing of food, and more convenient form of consumption. Thus, the relationship between the agricultural producer and the consumer needs an additional link, i.e. the agri-food processor[21]. It creates a market demand for agricultural products as raw materials and supply on the market for finished food products. We have shown that in relation to the formula (1.14). Agricultural products, before they reach the final recipient, are subject to increased processing, resulting in additional charges for these services. Agri-food processor responds to the preferences and needs of saving time on food consumption "by changing and adding to the form in which the product is ready for consumption and expanding the variety of products offered to the consumer from agricultural raw materials. Generally, it is associated with changes in the consumer utility function"[22].

Changes in the share of individual links in the prices of products offered to the consumer results from the increased investment commitment of production factors in indirect links of the food chain between the producer and the consumer. P. Timmer pointed out the relationship between economic growth and changes in the share of each link of the marketing chain in the retail price of the product. At higher levels of development, when *"the share of agriculture in employment is less than 20% and expenditure on food in total expenditure is lower than 30% (...) the share of agriculture in the value of the basket of food goods is very low due to the importance of processing and commercial services"*[23]. Therefore, it is important to ask about the share of processing, trade and services in the value of finished food products purchased by consumers[24].

The data contained in Table 1.10 allow us to conclude that all countries considered in the present work are characterised by appropriate low levels of employment in the agricultural sector in relation to total employment, and lower expenditure on food in relation to spending on other consumer goods. The approximate empirical illustration of the issues raised above can be found in Table 1.11 in growth indices calculated for the size (in thousand tons) of selected transported food articles. Transportation was chosen as one of the services used in the food chain. In addition to the time series of indices we also present estimates of relevant trends functions describing the present upward trends.

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[21] English agricultural economist expressed it like this: *"in relation to the vast majority of agricultural products in developed countries, traditional relationships of farmers and consumers have been severed. Agriculture is now nothing more than a supplier of raw materials for processing and shopping centres"* C. Riston, *Agricultural Economics Principles and Policy,* Westview, Denver, 1992, p. 149.

[22] W. Rembisz, *Mikro- i makroekonomiczne…,* op. cit., p. 77.

[23] P. Timmer, *The Agricultural Transformation – Handbook of Development Economics*, New York 1987, p. 32.

[24] S. Stańko, M. Włodarczyk, *Ceny detaliczne żywności a ceny surowców rolniczych (na przykładzie cen skupu pszenicy i cen chleba pszennego*), Biuletyn informacyjny ARR No. 10, 2006, p. 4.

Table 1.10. Percentage share of agricultural employment in total employment and expenditure on food in total expenditure in 2003-2008 for selected countries

Year / Country	2003		2004		2005		2006		2007		2008	
	Share of agriculture in employment	Share of expenditure on food in total expenditure	Share of agriculture in employment	Share of expenditure on food in total expenditure	Share of agriculture in employment	Share of expenditure on food in total expenditure	Share of agriculture in employment	Share of expenditure on food in total expenditure	Share of agriculture in employment	Share of expenditure on food in total expenditure	Share of agriculture in employment	Share of expenditure on food in total expenditure
United Kingdom	1.25%	8.99%	1.29%	8.83%	1.35%	8.69%	1.29%	8.62%	1.37%	8.73%	1.47%	9.14%
Germany	2.47%	11.30%	2.33%	11.18%	2.37%	11.01%	2.26%	10.99%	2.25%	11.21%	2.25%	11.36%
Netherlands	3.22%	11.21%	3.25%	11.04%	3.43%	10.60%	3.32%	10.89%	3.03%	10.98%	2.70%	11.42%
Sweden	2.10%	12.47%	2.14%	12.24%	2.02%	11.98%	1.98%	12.04%	2.25%	12.02%	2.20%	12.36%
Belgium	1.77%	13.90%	1.98%	13.71%	2.02%	13.36%	1.95%	12.84%	1.86%	12.83%	1.81%	12.77%
Spain	5.73%	14.59%	5.50%	14.18%	5.27%	14.10%	4.78%	13.87%	4.55%	13.61%	4.34%	13.40%
France	4.18%	14.42%	3.85%	14.08%	3.63%	13.73%	3.71%	13.44%	3.43%	13.22%	3.05%	13.47%
Italy	4.86%	15.07%	4.42%	14.93%	4.20%	14.79%	4.27%	14.69%	3.97%	14.54%	3.82%	14.66%
Czech Republic	4.50%	16.99%	4.29%	16.72%	3.97%	16.06%	3.77%	15.48%	3.58%	15.67%	3.32%	16.32%
Greece	15.29%	18.36%	12.60%	17.84%	12.43%	16.63%	12.04%	16.52%	11.56%	16.57%	11.71%	16.42%
Hungary	5.49%	17.71%	5.25%	17.30%	4.97%	16.72%	4.85%	16.83%	4.66%	17.28%	4.49%	17.49%
Poland	18.42%	21.09%	18.01%	21.22%	17.37%	21.05%	15.79%	20.88%	14.74%	20.59%	15.44%	20.43%

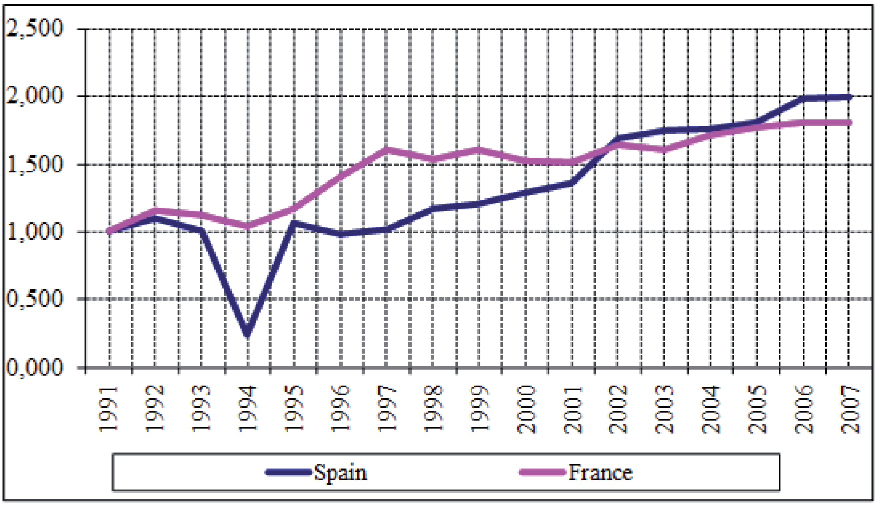
Source: Authors' own calculation according to the LABOURSTA and USDA data.

Table 1.11. Estimates of the trend function describing the increase in transport (in thousand tons of transported products) of food products for Spain and France

Country	Slope	Constant	R^2
Spain	0.079	0.605	0.755
France	0.05	1.018	0.866

Source: Own calculations based on the Eurostat data.

Figure 1.12. Rate of changes calculated for the transport of food products for Spain and France in 1991-2007 (1991=100)



Source: Author's own compilation based on the Eurostat data.

In light of the foregoing, the growth of the processing sector creates the so-called "price gap", which is the source of financing activity in the food chain, including funding of services related to the purchase of agricultural products, storage, processing and enrichment of value in use, primary, wholesale and secondary trade, distribution, retail trade, advertising, etc. According to D. Dahl, J. H. Hammond it can be assumed that *"one of the ways to determine the added value in the processing and trade is to include inputs of production factors used in the processing, transport, trade, taking place between the farm and the consumer, in the payment (return) categories. We would then include such categories as wages, as a return on investment of labour in the processing, trading, transportation, etc.; interest on loan capital and capital factor used in the process; pensions, as fees for use of land and buildings; and profit, as a reward for entrepreneurship and risks. Thus we can adopt the name of market costs associated with the movement of the product from the farm to the consumer. Another way to define this gap is the term of return on inputs borne by individual participants in the process of processing, transport and trade, in particular the* *fees charged by retailers, wholesalers, food industry, transports and others. Hence, one can adopt the name of market fees"*[25].

The increased role of processing is also reflected in the diversity of values of income and price elasticity of demand for food in comparison to the same ratios calculated for agricultural products[26]. They are, in fact referred to the two levels of the same agri-food market on the basis of the rolling principle, or one can adopt that they pertain to two separate markets.

In the light of these assumptions, for it is the agri-food processor that determines demand conditions for the agricultural producer. The producer should adapt to these conditions. Referring to the terminology used in management sciences, the processor can be classified to the nearest market environment of the producer as the most important business partner. The processor creates a market for the agricultural producer[27].

Agri-food processor is responsible for the demand side on the market of agricultural raw materials and the market of inputs associated with the processing of agricultural products. He is also responsible for the supply side on the market for food products. Thus, a system of relationships is created, which should be in general and partial equilibrium. This system can be written as follows:

$$\dot{Z}^S = f_{\dot{Z}}^S(C_{\dot{Z}}, C_R, C_W) \quad (1.20)$$

$$R = f_R^D(C_{\dot{Z}}, C_R, C_W) \quad (1.21)$$

$$W = f_W^D(C_{\dot{Z}}, C_R, C_W) \quad (1.22)$$

where: $f_{\dot{Z}}^S$ – function of the supply of food products; f_R^D – function of the demand for agricultural products as raw materials; f_W^D - function of demand for inputs related to the processing of agricultural products; $C_{\dot{Z}}$ – price of food product; C_R – price of agricultural raw material; C_W – price of inputs associated with the processing of agricultural raw material.

The agri-food processor, by making decisions regarding the use of inputs, in particular regarding the relationship of raw material and its processing, takes into account not only the level of prices of these mutually substitutable inputs[28], but also other factors (quality norms and standards, health requirements, which are included in

[25] D. Dahl, J.H. Hammond, *Market and Price Analysis, The Agricultural Industries*, Minneapolis, 1982, p. 140.
[26] W.W. Cochrane, *Farm Prices,* Minneapolis, University of Minnesota Press, 1986, p. 63.
[27] Ibidem, p. 72. We do not include here the importance of direct markets: agricultural producer-consumer.
[28] From the micro-economic point of view, the behaviour of the agri-food processor is recognised in terms of the choice of the producer for maximization of his profit function. Inputs, which he uses in operations are, in addition to agricultural raw materials (agricultural products), also the inputs associated with the processing of agricultural raw materials. We assume that the processor acts rationally and has rational expectations. Thus, in a situation in which he anticipates an increase in agricultural prices he will intensify its processing, to obtain the maximum effect from the same individual effort (objective functions). The prices of these inputs, i.e. of agricultural raw material and its processing with a given financial limit are components of the budget constraint, i.e. isocosts. This sets pricing terms for agricultural raw materials.

costs associated with the processing of agricultural raw materials). Let us then analyse the choice of the agri-food processors. The objective function of the processor is to maximize profit, expressed by the formula:

$$[C_{\dot{Z}} \cdot g(R,W) - (C_R \cdot R + C_W \cdot W)] \rightarrow \max \tag{1.23}$$

where: $g(R,W)$ – supply of food products; R – agricultural products (agricultural raw material); W – inputs related to the processing of agricultural raw materials.

Decision variables in this approach are the inputs associated with the processing of agricultural products used by the processor as raw materials and the agricultural products. In the latter case, of course, the most important is the buying price of the agricultural product as a raw material. The processor can maximize the objective function for a given production – the maximum effect from given inputs or minimum inputs for a given production.

In order to reduce the demand, the processor's decision problem can be shown using conditional optimization. Using the Lagrangian function, it is assumed that the objective function of the processor is to minimize the cost incurred to obtain food product for a given amount of production (demand) thus:

$$C_R \cdot R + C_W \cdot W \rightarrow \min \tag{1.24}$$

While maintaining the condition:

$$\dot{Z} = f(R,W) \tag{1.25}$$

Which leads to the Lagrange function:

$$\Psi(R,W,\lambda) = C_R \cdot R + C_W \cdot W + \lambda(\dot{Z} - f(R,W)) \tag{1.26}$$

By solving this problem we can derive equilibrium conditions for the agri-food processor. Prices (pay) for each input must be equal to their marginal productivities, which is the canon for the producer in terms of competitive balance. Then, only the processor has endogenous sources of funding, because the assumption that the price of the product of the processor is fixed is implicitly held. It is assumed, therefore, that - particularly in the short term - the prices of agricultural raw materials depend on their marginal utility for processors. This is also determined by the purchase price of the agricultural producer, i.e. the maximum price the processor can pay to the agricultural producer.

Therefore, as we pointed out, the processor is crucial to the sustainability of growth in the agri-food sector, because by seeking to maximize his objective function he determines the price level of agricultural products produced by the producers, under the assumption that the price of agricultural raw materials is determined by their marginal utility for the processor. It is also the basis for isolating the intermediate demand, which is reported by the agri-food processor for agricultural raw materials and direct (final) demand reported by the consumer.

1.3. Agricultural producer

From the above and from the literature it follows that increasing agricultural production “meets inelastic demand, causing a fall in real prices of agricultural products. As a result, farmers' incomes are not growing in proportion to the rate of growth of production"[29]. In fact, this also depends on the growth rate of production efficiency. However, agricultural producers cannot rely "on the increase in prices of products as the source of increase in their income"[30]. Due to the increasing role of the processors as discussed above, and the recessive nature of the market, agricultural producers who seek to improve their income are forced to use the possibilities in the field of productivity of production factors. This also applies to the labour factor[31]. The growth models used in agriculture include, in particular, the indicators of labour productivity and productivity of the land. This is also the essence of the developed model in relation to agricultural production and agricultural producer. Development of these values and their empirical illustration are contained in chapter 3.

Considering the agricultural producer, it is assumed that the maximized objective function is his income. The essence of this objective function (income) is reflected best by the difference between the revenue (price multiplied by the volume of production sold) and the costs of the use of production factors (product of the size of the factors used and their prices). This can be rewritten as follows:

$$C_R \cdot R - (C_K \cdot K + C_L \cdot L) \rightarrow \max \tag{1.27}$$

where: C_K – price (pay) of material production factor (capital); C_K – price (pay) of labour; K – material factor (production assets, fixed assets, including the land and current assets, both in quantitative and qualitative terms) ; L – labour factor (number of employees, both in quantitative and qualitative terms).

In competitive equilibrium, it is assumed that the level of price received for the product is constant, and the volume of production, which a (single) producer can sell does not meet demand constraints. However, in sectoral terms, due to the homogeneous nature of the agricultural product, agricultural producers aggregated in the scale of the whole agriculture, face demand constraints. Then the buying price responds to changes in the volume of production and the resulting supply. Supply growth usually leads to a decrease in buying prices and vice versa. This is also expressed in the conditional demand of the developed model.

In terms of the microeconomic approach, if we assume demand restrictions, the decision problem of the agricultural producer can be written in the form of the following conditional optimization task:

$$(C_K \cdot K + C_L \cdot L) \rightarrow \min \tag{1.28}$$

where:

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[29] A. Woś, *W poszukiwaniu modelu rozwoju polskiego rolnictwa,* IAFE-NRI, Warsaw 2004.

[30] W. Rembisz, *Mikroekonomiczne podstawy wzrostu dochodów producentów rolnych,* VIZJA PRESS&IT, Warsaw 2007, p. 26.

[31]But here, because of the many support programs of the CAP, this pressure on the increase in labour efficiency, as the main source of income, is weakening.

$$R = f(K, L) \tag{1.29}$$

where: $R = f(K, L)$ – production function of the agricultural producer.

Analysis of the producer's situation in microeconomic terms requires consideration of the behavioural traits of agricultural producers (farms) for the prices of production factors (price paid) and produced agricultural products (prices received). Models determining sensitivity of the producer to changes in relative prices are essential in such considerations. In this approach, there is often a need to define the production function describing the production process, which results in the conversion of production factors into the product[32].

[32]Empirical illustration of the producer's issue is in this approach often associated with the estimation of parameters of the corresponding functions. In this paper we abandoned this type of modelling which requires the direct application of the production function with a fixed analytical form for several reasons. The first is the disagreement among economists as to the classification of production factors and measuring of their costs. As a manifestation of this absence of an agreement, we can indicate for example a dispute between Cambridge vs. Cambridge, originating from the unclear treatment of the capital factor. Moreover, when studying the agricultural sector functioning in a given economy as a whole, without distinguishing between the producers of particular products, there may be significant differences between the factors of production and the analytical forms of production functions. In addition, some of the costs incurred by agricultural producers are in practice difficult to estimate. This applies especially to farmer's own labour or labour of his family, for which they do not receive wages.

2. Role of the processor in the growth model of agri-food production

Agricultural producer, as indicated above, operates in conditions shaped by other market participants, i.e. the consumer and the agri-food processor. Influence on the part of the consumer results from the increased demand for processed products, which in turn entails the increasing role of the processor. The increasing importance of the latter is associated with the role of prices of agricultural products, which are used by the processor as raw materials.

As indicated above, the agri-food processor seeking to maximize the profit replaces relatively more expensive input by the relatively cheaper one. This has implications for the agricultural producer. The processor, in fact, seeks to use agricultural raw materials in a most rational way in order to maximize profit. He processes them more completely adding value in use. This creates demand and limits increase in prices of agricultural products.

With a given formula of revenue of the agri-food processor (2.1), we can determine demand for agricultural products and inputs related to their processing:

$$C_{\dot{Z}} \cdot \dot{Z} = C_R \cdot R + C_W \cdot W \qquad (2.1)$$

The demand for agricultural raw material is as follows:

$$R = \frac{C_{\dot{Z}} \cdot \dot{Z}}{C_R} \qquad (2.2)$$

The demand for other inputs related to the processing, transport and trade in food:

$$W = \frac{C_{\dot{Z}} \cdot \dot{Z}}{C_W} \qquad (2.3)$$

Using (2.2) and keeping the assumption of a constant price level of food products ($C_{\dot{Z}}$), we get the following formula:

$$\frac{\Delta C_R}{C_R} = \frac{\Delta \dot{Z}}{\dot{Z}} - \frac{\Delta R}{R} \qquad (2.4)$$

The right side of equation (2.4) is the rate of change in the gap, which reflects the change in the degree of use of agricultural raw materials by the processor. This determines the increase in prices of agricultural products.

Tables 2.1 and 2.2[33] illustrate the above considerations concerning the rate of changes by including indexes calculated for the following variables: pork prices to the producer (C_R), production volume of meat produced by producers (R) and food production (from pork – $\dot{Z}$), while Table 2.3 presents estimates of linear trend functions for the respective indices and coefficients of determination. The results lead to the conclusion that the price of raw material (C_R) increased significantly in Belgium. In turn, the variable R was characterised by a growing trend, *inter alia,* in Italy, Spain and Germany, and a decreasing trend in Hungary, the Netherlands and the UK. The variable $\dot{Z}$ was characterised by a growing trend in the UK, Germany and Sweden, and a decreasing trend in the Netherlands.

[33] In tables 2.2 and 2.5 Belgium is recognised together with Luxembourg.

Comparing the development of the indices calculated for variables $\dot{Z}$ and R in the countries concerned, it can be seen that in most cases, these values were similar (e.g. for the Netherlands, Poland, Hungary, Germany and Sweden - although for the latter two countries we can see the increasing difference between R and $\dot{Z}$). The results obtained for the United Kingdom and Greece are different - the volume of production of agricultural raw materials is decreasing, while the food supply is at a significantly higher level.

Table 2.1. Rate of changes in the prices of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (1993=100) (a)

Country / Year	United Kingdom			Germany			Netherlands		
	C_R	R	Ż	C_R	R	Ż	C_R	R	Ż
1993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.985	1.037	1.028	1.065	0.989	1.003	1.073	0.958	0.716
1995	1.235	0.994	0.987	1.408	0.988	0.970	1.298	0.929	0.868
1996	1.411	0.981	1.020	1.540	0.997	0.994	1.433	0.930	0.892
1997	1.137	1.066	1.001	1.389	0.978	0.968	1.292	0.787	0.839
1998	0.818	1.109	1.032	0.926	1.052	1.035	0.822	0.987	0.925
1999	0.819	1.019	1.054	0.835	1.125	1.032	0.733	0.979	0.905
2000	0.943	0.879	1.023	0.926	1.092	1.004	0.844	0.929	0.933
2001	0.944	0.760	1.074	1.067	1.118	0.976	0.886	0.820	0.843
2002	0.863	0.757	1.064	0.898	1.127	0.994	0.775	0.788	0.839
2003	1.111	0.700	1.114	0.960	1.163	1.015	1.065	0.717	0.660
2004	1.240	0.692	1.115	1.210	1.186	1.022	1.089	0.738	0.602
2005	1.290	0.690	1.123	1.222	1.234	1.015	1.143	0.743	0.653
2006	1.266	0.681	1.180	1.293	1.279	1.022	1.223	0.724	0.693
2007	1.274	0.722	1.204	1.493	1.367	1.043	1.209	0.738	0.606

Source: Author's own compilation based on the FAO data.

Table 2.2. Rate of changes in the prices of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (1993=100) (b)

Country / Year	Belgium			Spain			France		
	C_R	R	Ż	C_R	R	Ż	C_R	R	Ż
1993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	1.068	1.018	0.786	1.040	1.017	0.983	1.047	1.041	1.002
1995	1.232	1.042	0.742	1.255	1.041	0.996	1.237	1.054	1.009
1996	1.350	1.069	0.729	1.351	1.128	1.042	1.322	1.062	1.001
1997	1.232	1.032	0.650	1.224	1.150	1.057	1.160	1.091	1.010
1998	0.853	1.084	0.631	0.867	1.314	1.204	0.844	1.145	1.061
1999	0.691	1.004	0.740	0.761	1.385	1.241	0.760	1.157	1.080
2000	1.726	1.054	0.751	0.848	1.391	1.233	0.807	1.137	1.093
2001	1.900	1.073	0.761	1.020	1.431	1.248	0.931	1.138	1.092
2002	1.622	1.051	0.691	0.832	1.470	1.264	0.767	1.153	1.056
2003	1.789	1.037	0.699	0.946	1.527	1.284	0.872	1.150	1.116
2004	2.190	1.065	0.660	1.121	1.473	1.173	1.027	1.127	1.005
2005	2.208	1.023	0.678	1.151	1.517	1.178	1.057	1.118	1.036
2006	2.284	1.010	0.647	0.866	1.549	1.217	1.118	0.989	0.934
2007	2.285	1.070	0.683	0.859	1.647	1.293	1.102	0.999	0.951

Source: Author's own compilation based on the FAO data.

Table 2.3. Rate of changes in the prices of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (1993=100) (c)

Country / Year	Czech Republic			Greece			Poland		
	C_R	R	Ż	C_R	R	Ż	C_R	R	Ż
1993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	1.215	0.765	0.795	0.989	1.005	1.069	1.246	0.883	0.935
1995	1.429	0.817	0.849	0.942	1.005	1.338	1.177	1.031	0.961
1996	1.441	0.817	0.850	1.010	0.995	1.164	1.233	1.084	0.981
1997	1.235	0.754	0.761	0.927	0.980	1.417	1.276	0.994	0.859
1998	1.163	0.774	0.799	0.802	0.987	1.309	1.098	1.065	0.926
1999	0.972	0.734	0.776	0.720	1.016	1.499	0.845	1.074	0.970
2000	1.011	0.677	0.717	0.743	1.038	1.611	0.937	1.011	0.948
2001	1.266	0.674	0.706	0.828	1.003	1.698	1.173	0.972	0.932
2002	1.128	0.676	0.716	0.683	0.805	1.498	0.968	1.063	0.953
2003	1.169	0.669	0.735	0.866	0.816	1.288	0.906	1.151	0.989
2004	1.413	0.692	0.803	0.921	0.790	1.279	1.268	1.028	0.946
2005	1.553	0.618	0.812	0.985	0.803	1.391	1.306	1.028	0.944
2006	1.619	0.583	0.778	1.046	0.797	1.523	1.268	1.102	0.999
2007	1.625	0.586	0.796	1.163	0.748	1.383	1.387	1.130	1.011

Source: Author's own compilation based on the FAO data.

Table 2.4. Rate of changes in the prices of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (1993=100) (d)

Country / Year	Hungary			Italy			Sweden		
	C_R	R	Ż	C_R	R	Ż	C_R	R	Ż
1993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	1.145	0.905	0.919	0.959	1.018	0.991	1.014	1.057	1.039
1995	1.375	0.86	0.856	1.17	1	0.958	0.984	1.061	1.089
1996	1.141	0.997	0.856	1.268	1.048	1.044	0.996	1.095	1.079
1997	1.207	0.864	0.81	1.173	1.037	1.029	0.916	1.131	1.109
1998	1.088	0.848	0.793	0.959	1.05	1.106	0.683	1.135	1.161
1999	0.834	0.931	0.812	0.805	1.094	1.164	0.613	1.118	1.138
2000	0.864	0.912	0.793	0.839	1.099	1.176	0.635	0.951	1.091
2001	1.194	0.827	0.749	0.997	1.122	1.25	0.665	0.948	1.075
2002	1.095	0.863	0.833	0.745	1.141	1.26	0.61	0.975	1.118
2003	1.046	0.759	0.712	0.857	1.182	1.281	0.638	0.988	1.131
2004	1.332	0.802	0.813	0.913	1.182	1.285	1.485	1.012	1.153
2005	1.419	0.675	0.744	1.028	1.126	1.266	1.528	0.945	1.125
2006	1.431	0.727	0.785	1.054	1.159	1.325	1.574	0.908	1.121
2007	1.459	0.743	0.8	0.984	1.192	1.36	1.957	0.91	1.148

Source: Author's own compilation based on the FAO data.

Table 2.5. Estimates of coefficients of the trend function for price changes of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (a)

Country	Description	C_R	R	$\dot{Z}$
United Kingdom	Slope	0.0119	-0.0315	0.0136
	Constant	0.9936	1.1246	0.9588
	R^2	0.0773	0.7591	0.8482
Germany	Slope	0.0052	0.025	0.0027
	Constant	1.1073	0.913	0.9849
	R^2	0.0099	0.8975	0.2648
Netherlands	Slope	-0.0015	-0.0204	-0.0211
	Constant	1.0706	1.014	0.9668
	R^2	0.0009	0.694	0.5212
Sweden	Slope	0.0493	-0.012	0.0069
	Constant	0.6254	1.1114	1.0501
	R^2	0.2682	0.4611	0.483
Belgium	Slope	0.1034	0.0012	-0.012
	Constant	0.7348	1.0324	0.8192
	R^2	0.7236	0.041	0.3591
Spain	Slope	-0.0147	0.0463	0.0203
	Constant	1.127	0.9654	0.9982
	R^2	0.1369	0.9349	0.6532

Source: Authors' own calculation according to the FAO data.

Table 2.6. Estimates of coefficients of the trend function for price changes of agricultural raw materials (C_R), agricultural raw materials (R) and food products ($\dot{Z}$) for selected countries of the European Union in 1993-2007 (b)

Country	Description	C_R	R	$\dot{Z}$
France	Slope	-0.0064	0.0015	-0.001
	Constant	1.0543	1.0783	1.0377
	R^2	0.0275	0.0127	0.0073
Italy	Slope	-0.0102	0.0143	0.0292
	Constant	1.065	0.9824	0.9328
	R^2	0.1	0.8932	0.9364
Czech Republic	Slope	0.0262	-0.0214	-0.0079
	Constant	1.0732	0.8937	0.856
	R^2	0.2842	0.8037	0.2368
Greece	Slope	0.0037	-0.0204	0.0226
	Constant	0.8788	1.0824	1.1839
	R^2	0.0152	0.7103	0.2773
Poland	Slope	0.0092	0.0084	0.0023
	Constant	1.0653	0.974	0.9387
	R^2	0.0602	0.3134	0.0725
Hungary	Slope	0.0207	-0.0177	-0.0115
	Constant	1.0096	0.9891	0.9102
	R^2	0.2197	0.6953	0.5216

Source: Authors' own calculation according to the FAO data.

Maximizing the objective function of the agri-food processor given by the formula (1.23) and determining its extreme, allows for obtaining expressions determining the level of input prices from the demand side shaped by the processors. This also encompasses the prices of agricultural raw materials (C_R), the level of which depends on the price of the food product ($C_{\dot{Z}}$). One can observe an increase in the gap between the growth in demand for finished food products and the growth in demand for agricultural products as raw materials for the manufacture of food products. There is also an increase in the gap between the price of agricultural raw material and the price of already processed food product.

Table 2.7 contains estimates of the coefficients of linear trend function (with error estimates) describing changes in the price gap S_R calculated according to the formula (2.5) for food products in selected countries of the European Union.

$$S_R = \frac{C_{\dot{Z}}}{C_R} \quad (2.5)$$

It may be noted that in some countries this Figure followed the rising trend. On the basis of a sample drawings 2.1. and 2.2 made for selected countries, it can be concluded that the price gap is not constant. This means that the agri-food processor does not earn the income from the gap at a constant level, at the expense of the agricultural producer to some extent. There are many indications that it absorbs or neutralizes the effects of the natural volatility in prices of agricultural products in relation to the finished food products.

* * *

As emphasised in accordance with the principles of sound management, the processor must either maximize the utility effect in the form of food goods from purchased raw materials, or minimize the consumption of raw materials for the given utility effect. It comes down to the cost of obtaining unit utility – the food goods. At a given time, the level of isocost straight for the processor mostly results from the price level of agricultural products purchased as food raw materials. This also affects the market-shaped part of the value of agricultural product in the food product. This process is done on the basis of mutual influence. In fact, it is the market settlement of conflicting interests of the agricultural producer, as a supplier of raw materials and the interests of agri-food processor, as a producer of finished food goods. The question is only whether or not, the market where these contradictions are settled has the characteristics of a market with competitive balance. This is the mechanism explaining the decrease in the share of the agricultural producer in the final price of the food goods. This results from the consumer choices. The consumer, maximizing its objective function at increasingly higher income and time restrictions, prefers more and more the finished processed food product. We have outlined this in the first chapter. In fact, the consumer selects agri-food processors' services that are more advanced and more diverse. Thus, it is the consumer who finally accepts or verifies these services, which are financed from the gap between the price of the finished food product and the price of agricultural raw material.

With this in mind, we can show the role of processing in the growth model of agri-food production, starting from the pre-established objective function of the processor (1,123-1.26), i.e.

$$\dot{Z} = f(R,W) \tag{2.6}$$

After transformations of the function 2.6 according to W. Rembisz we get the following:

$$\dot{z}^S = S_R r + (1 - S_R)w \tag{2.7}$$

where: $\dot{z}$ – growth in the supply of food products; S_R – share of agriculture in the value of the food product; $(1 - S_R)$ - share of processing services in the value of the food product; r – rate of growth of agricultural production, w – rate of growth in the supply of services relating to the processing of raw materials and trade in food products.

According to equation 2.7, the rate of growth in the supply of food products is a weighted average of the rate of growth of agricultural production (r) and the rate of growth in the supply of services related to processing, distribution and consumption (w). Weights are the discussed share of agricultural raw material in the price of the product or in the supply of food products, or in consumer spending in macro-economic terms. Therefore, the increase in demand for finished food products is not transmitted directly to the increase in demand for agricultural raw materials, and thus the possibility of increasing agricultural production and procurement prices[34]. From the above it follows that the share

[34] W. Rembisz, *Mikro- i makroekonomiczne…*, op. cit., p. 138.

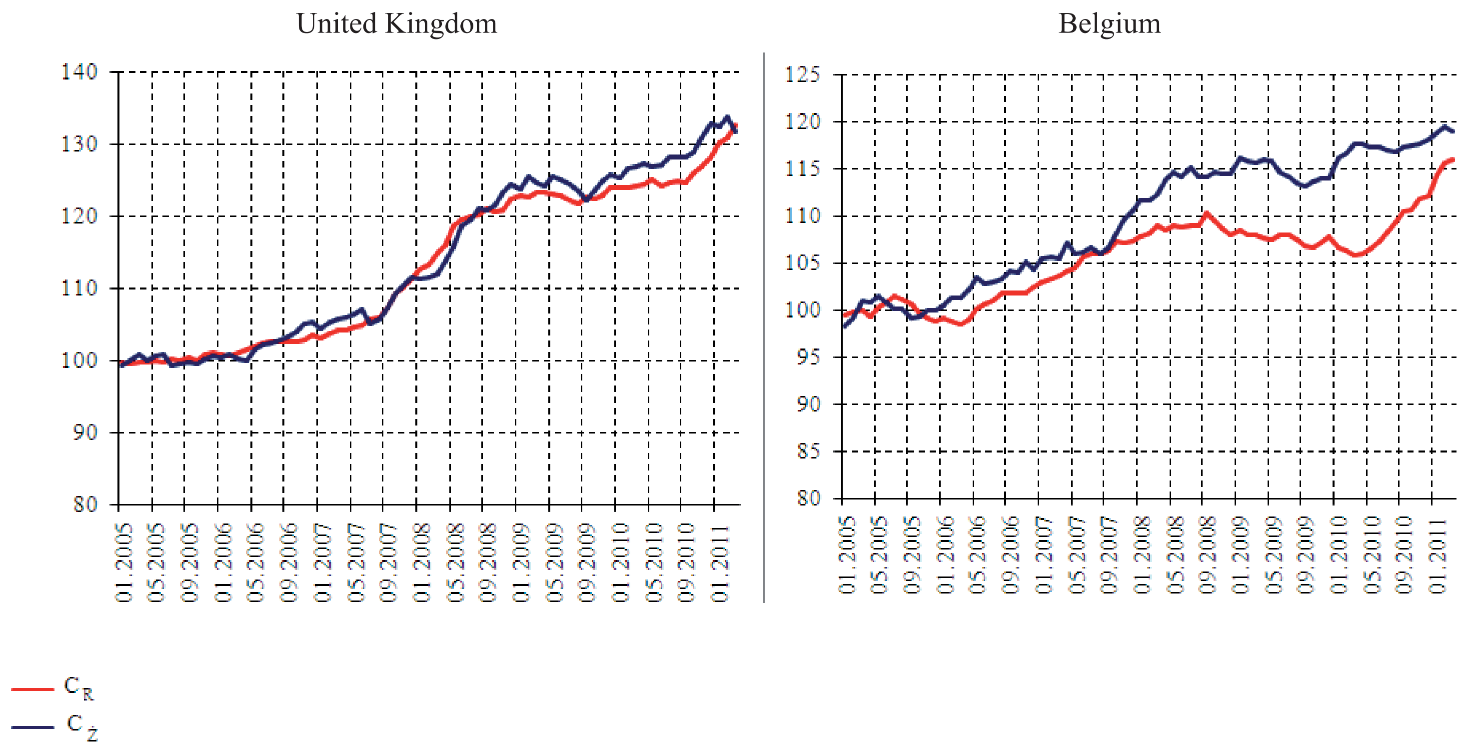
of agricultural income from the final consumer expenditure on food decreases. These are sums counted in billions of consumer spending as a source of income for agricultural producers, which creates certain political and propaganda friction.

Table 2.7. Estimates of the trend function coefficients for price gap (S_R) of food products in selected countries of the European Union in the period from 01.2005 to 03.2011 (01.2005=100)

Country	Slope	Constant	R^2
United Kingdom	0.0003 (0.0001)	0.9951 (0.0027)	0.2644
Germany	-0.0001 (0.0001)	0.9979 (0.0042)	0.0119
Netherlands	-0.0013 (0.0002)	0.9997 (0.0083)	0.4071
Sweden	-0.0002 (0.0001)	0.9942 (0.0044)	0.0649
Belgium	0.0011 (0.0001)	0.9960 (0.0043)	0.6360
Spain	0.0002 (0.0001)	0.9984 (0.0036)	0.0578
France	0.0009 (0.0002)	0.9728 (0.0083)	0.2450
Italy	-0.0004 (0.0001)	0.9939 (0.0057)	0.1031
Czech Republic	0.0014 (0.0001)	0.9888 (0.0045)	0.7091
Greece	0.0003 (0.0001)	0.9785 (0.0051)	0.0881
Poland	0.0020 (0.0001)	0.9804 (0.0048)	0.8203

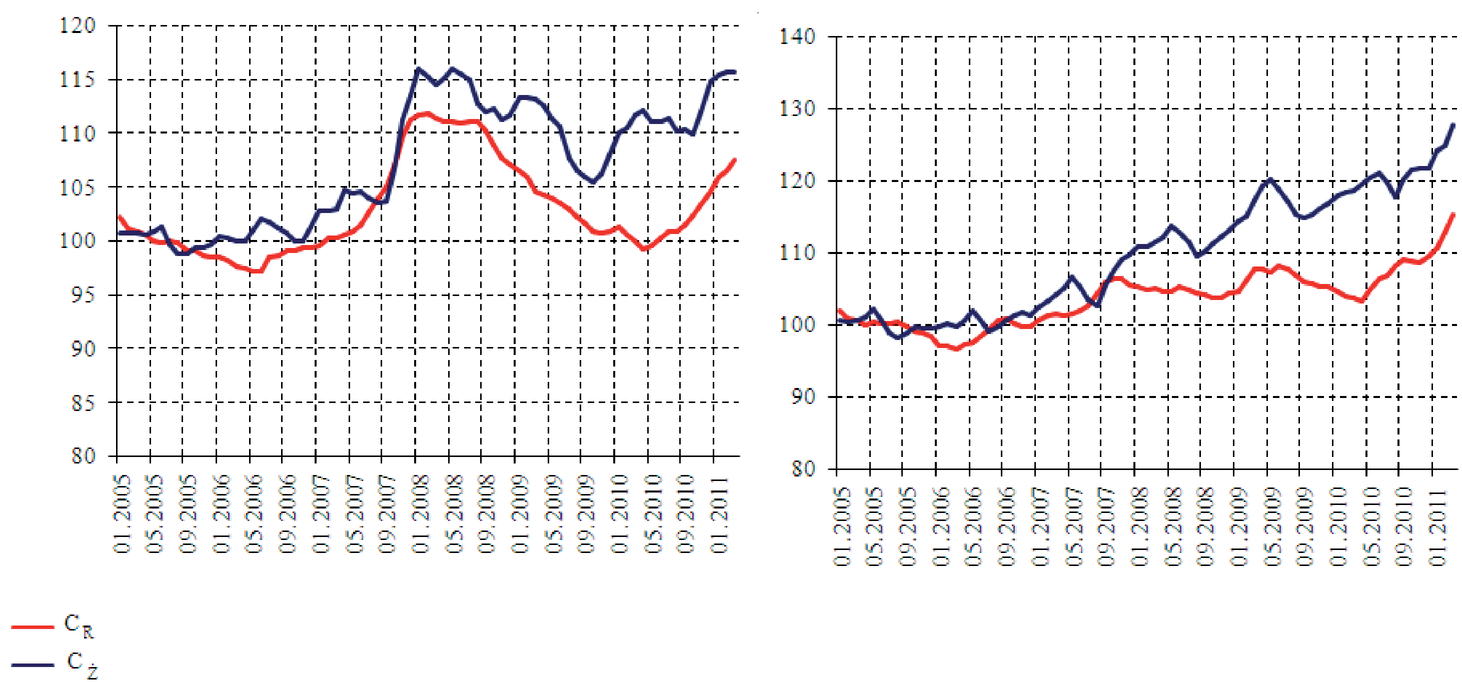
Source: Own calculations based on the Eurostat data.

Figure 2.1. Comparison of changes in prices of agricultural raw materials (C_R) and retail prices ($C_{\dot{Z}}$) of food products in the UK and Belgium from 01.2005 to 03.2011 (01.2005=100) (a)



Source: Own compilation based on the Eurostat data.

Figure 2.2. Comparison of changes in prices of agricultural raw materials (C_R) and retail prices ($C_Ż$) of food products in the Czech Republic and Poland from 01.2005 to 03.2011 (01.2005=100) (b)



Source: Own compilation based on the Eurostat data.

3. Growth factors of agricultural production in the developed model

We assume, in accordance with the facts, that the rate of growth of agricultural production (or more accurately the supply of agricultural products) is essential in shaping the growth of the supply of food products. This indicator, which is (r), is referred to in the developed model of growth in agri-food production. We focus on the rate of growth of agricultural production and the factors that shape this rate.

Analysis of the growth factors of agricultural production can be conducted in macroeconomic or microeconomic perspective, and in the long- and short-term (in economic terms). In the case of microeconomic approach in the short-term (static, because technical changes are not possible) special importance is given to the behavioural characteristics of agricultural producers. The above takes into account the variables that directly affect the objective function of the agricultural producer, i.e. prices (received and paid) as well as regulations and support policy. However, in the macroeconomic approach, the main point of the analysis is to determine the effect of changes in the use of production factors and their productivity, i.e. the effect of efficiency of production on the growth rate of production. This also provides for the impact of individual changes in productivity of labour and capital on the growth of production.

3.1. Changes in agricultural land resources and their productivity

Characteristic primary variables of the agricultural sector, which - intuitively speaking - determine the volume of the production are: the value of the land factor and its productivity. The specificity of the agricultural function of production has been highlighted, *inter alia,* by Timmer. He writes that *"agriculture is the only sector of the national economy, in which land, as the soil, is a key productive factor of production, which is part of its production function"*[35]. Thus, when determining the level of agricultural production[36], both in the whole country, as well as in individual farms, we adopt the two variables characteristic for this sector, i.e. the area of agricultural land (land element)[37] and the average productivity of the agricultural area unit[38]. This relationship is written as:

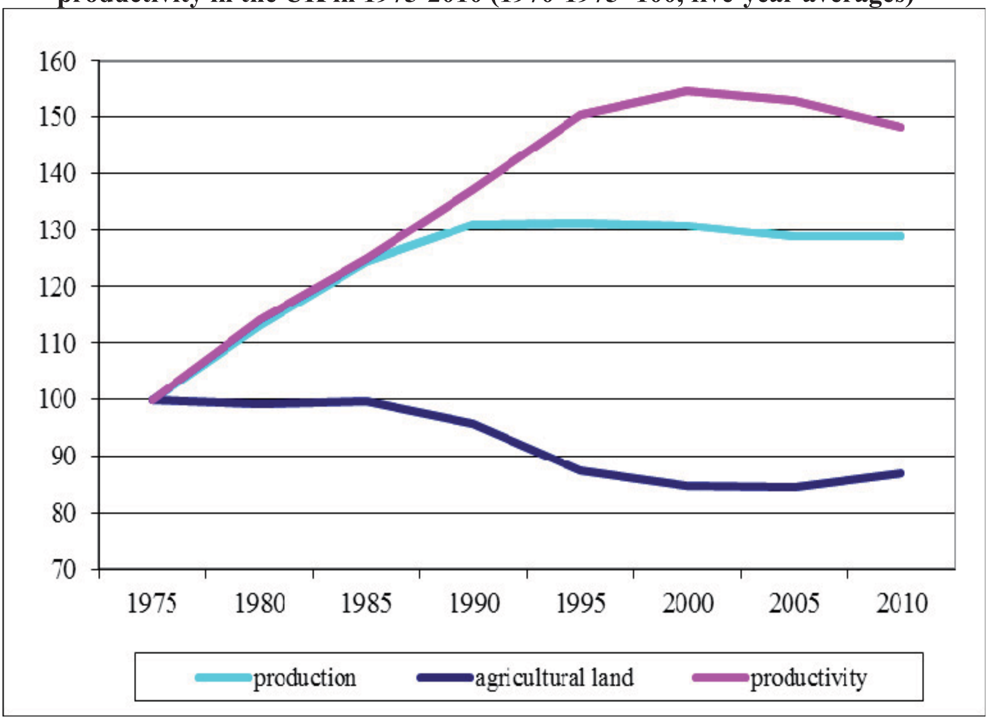
$$R = Z \cdot \frac{R}{Z} = Z \cdot Q \tag{3.0}$$

[35] P. Timmer, *Getting Process…,* op. cit., pp. 81-82.
[36] Assuming that final production is equal to the commodity production, i.e. the production intended for the market.
[37] Defined by the involved land factor, W. Rembisz, *Mikro- i makroekonomiczne…*, op. cit., p. 161.
[38] This is a unit productivity of the land factor , W. Rembisz, *Mikro- i makroekonomiczne…*, op. cit., p. 161.

where: R – volume of agricultural production (we assume that this is the final production in constant prices); Z –area in equivalent hectares of agricultural land; $\frac{R}{Z} = Q$ – average productivity per hectare of agricultural land.

When we assume that in a given time the increase in the land factor is not possible (or the decrease in this resource), the condition for the increase in agricultural production (R) is the increase in productivity of the land ($\frac{R}{Z}$).[39] The empirical illustration of this relationship for the UK is illustrated in Figure 3.1. As shown in Figure 3.1, the size of land resources in the UK declined in the 1970-2010 period by almost 20% compared to the average of the 1970-1975 period, but there has been a growth of agricultural production by about 30%. This means, of course, an increase in the productivity of this production factor.

Figure 3.1. Volume of agricultural production, agricultural land area and productivity in the UK in 1975-2010 (1970-1975=100, five-year averages)



Source: Own calculations based on the FAO and EUROSTAT data

To express the growth of agricultural production in one year we expand the formula 3.0 with incremental value, obtaining:

[39] Due to the biological nature of agricultural production and the associated climate impacts, productivity of land is expressed by the size of the crop.

$$R_0 + \Delta R = (Z_0 + \Delta Z) \cdot (Q_0 + \Delta Q) \qquad (3.1)$$

We obtain the increase in agricultural production in a given year by subtracting it from the base year ($R_0 = Z_0 Q_0$), so we have:

$$\Delta R = \Delta Q \cdot Z_0 + \Delta Z \cdot Q_0 + \Delta Z \cdot \Delta Q \qquad (3.2)$$

Therefore, the growth of agricultural production is determined by three factors:

a. increase in productivity of initial resources of agricultural land ($\Delta Q \cdot Z_0$);
b. the effect of changes in agricultural land resource, which achieved the average level of productivity of the land in the initial period ($\Delta Z \cdot Q_0$)[40];
c. product of land productivity gains and changes in the land use ($\Delta Z \cdot \Delta Q$). This product approaches zero[41].

Tables 3.1 to 3.3 present the values of these three factors for selected EU countries. [42]Table 3.1 shows the values ±f the product $\Delta Q \cdot Z_0$, Table 3.2 – values of the product $\Delta Z \cdot Q_0$, and Table 3.3 – values of the product $\Delta Z \cdot \Delta Q$. Productivity Q (and its growth ΔQ) were measured on the basis of the ratio ($\frac{R}{Z}$). As shown in Table 3.1, in the majority of the analysed European Union countries the productivity of the land in relation to the resources of agricultural land in 2000 increased in the 2000-2009 period. The trend can be observed in the case of Poland, Italy and Hungary. The negative value of the product: $Z_0 \cdot \Delta Q$ was recorded in the case of Greece and the Netherlands. Considerable stability in the productivity of agricultural land resources was observed in Sweden. Table 3.2 presents the value of the product $\Delta Z \cdot Q_0$. On the basis of the data, it can be concluded that in most of the EU countries in the 2000-2009 period there was a reduction in the area of agricultural land[43]. The strongest effect of reducing the area of agricultural land could be seen in Italy, Greece and Spain. In other countries, we can see a slight variation of this value.

The value of the product of the increase in productivity of land and changes in its use ($\Delta Z \cdot \Delta Q$) was juxtaposed for selected EU countries in Table 3.3. This product demonstrates values close to zero for most countries. The exceptions are countries like Greece, Spain and Italy, which indicates that there were positive effects of the two sources of growth of agricultural production in these countries.

[40]This ratio can be regarded as an indicator of structural change (growth of farm area) on their production.
[41]Assuming the loss of land in macroeconomic terms or occurrence of substitution dependence between these values in microeconomic terms.
[42] We have chosen the same group of the EU countries, which has been used for the analysis in the previous chapters of the study.
[43]Where an average level of land productivity was achieved in relation to the initial period (2000).

Table 3.1. Increase in productivity of the initial (2000 = 100) agricultural land resource ($Z_0 \cdot \Delta Q$)

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	35	155	191	261	148	93	45	-35	7	-60
Czech Republic	10	-68	-80	47	70	91	-27	80	85	58
France	-826	-287	-1844	1029	-325	1050	-871	378	821	564
Germany	106	-372	-295	851	851	897	-436	344	38	211
Greece	-33	-72	817	165	1324	-889	392	-1417	-134	-709
Hungary	174	43	-28	208	194	231	-425	182	30	369
Italy	71	-270	-73	1128	1287	1764	807	562	904	80
Netherlands	-219	-297	-270	-976	-814	-739	371	390	404	161
Poland	283	419	638	975	965	704	256	107	581	193
Spain	1042	2467	1646	1250	-1242	-916	634	1960	1395	-272
Sweden	31	36	-19	14	10	20	0	8	18	-8
United Kingdom	-153	22	123	104	77	-530	-463	-252	51	257

Source: Own calculations based on the FAO and EUROSTAT data

Table 3.2. Effect of change in the area of ˚gricultural land from the initial (2000 = 100) level of productivity of the land ($\Delta Z \cdot Q_0$)

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	15	38	-61	-11	25	16	0	4	-4	6
Czech Republic	-4	-9	-7	-7	-7	-7	-7	-7	-7	-4
France	49	94	20	15	73	25	-30	-194	-147	-99
Germany	0	-31	23	85	113	39	-21	29	79	62
Greece	-43	-61	-955	-123	-892	743	-691	695	-45	599
Hungary	-37	-76	-2	-3	-2	0	-2	-6	-4	-3
Italy	-275	-410	-827	-572	-806	-927	-1285	-541	-789	-17
Netherlands	-47	13	-27	1,497	1,312	1,102	-455	-299	-102	6
Poland	-135	-321	-425	-294	-263	-66	-33	130	52	16
Spain	-351	-529	-366	-37	4	-284	-419	-406	-213	-89
Sweden	-15	-31	-17	-16	8	-7	-8	-32	-8	-4
United Kingdom	-266	-142	-235	182	-62	471	288	299	-49	-63

Source: Own calculations based on the FAO and EUROSTAT data

Table 3.3 Product of the increase in productivity of land and changes in agricultural area ($\Delta Z \cdot \Delta Q$)

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	0,1	1,0	-2,0	-0,5	0,6	0,3	0,0	0,0	0,0	-0,1
Czech Republic	0,0	0,2	0,2	-0,1	-0,1	-0,2	0,1	-0,2	-0,2	-0,1
France	-0,7	-0,5	-0,6	0,3	-0,4	0,4	0,4	-1,2	-2,0	-0,9
Germany	0,0	0,3	-0,2	2,0	2,7	1,0	0,3	0,3	0,1	0,4
Greece	0,1	0,4	-70,2	-1,8	-106,1	-59,4	-24,3	-88,5	0,5	-38,2
Hungary	-1,3	-0,6	0,0	-0,1	-0,1	0,0	0,2	-0,2	0,0	-0,2
Italy	-0,5	2,7	1,5	-16,0	-25,7	-40,6	-25,7	-7,5	-17,7	0,0
Netherlands	0,6	-0,2	0,4	-79,6	-58,2	-44,4	-9,2	-6,3	-2,2	0,1
Poland	-3,0	-10,7	-21,5	-22,8	-20,1	-3,7	-0,7	1,1	2,4	0,2
Spain	-9,6	-34,2	-15,8	-1,2	-0,1	6,8	-7,0	-20,9	-7,8	0,6
Sweden	-0,1	-0,3	0,1	-0,1	0,0	0,0	0,0	-0,1	0,0	0,0
United Kingdom	2,2	-0,2	-1,5	1,0	-0,3	-13,2	-7,1	-4,0	-0,1	-0,9

Source: Own calculations based on the FAO and EUROSTAT data

As is well known due to the increasing competition for land use and urbanisation development of industry, services, etc., which takes place in the European Union, we observe a decrease in the area of agricultural land (in macro-economic terms). [44] These processes imply that the value of the relationship of : $\Delta Z \cdot Q_0$ is negative, which is confirmed by the data in Table 3.2. In contrast, as mentioned in the discussion on the formula (3.2), it is different when it comes to the relationship: $\Delta Z \cdot \Delta Q$, the value of which is summarized in Table 3.3.

In terms of decrease in agricultural land, which usually refers to the agricultural sector, we have : $\Delta Z \cdot Q < 0$ and: $\Delta Q \cdot Z > \Delta R$, and thus increase in the average productivity of agricultural land is higher than the growth of total agricultural production[45]. Of course, the increase in productivity of the land factor must substitute the effects of the decrease in the land factor. It takes place in a macroeconomic sense, when we are dealing with the real absolute loss of agricultural land[46]. However, from the microeconomic point of view, these expressions mostly have positive values. This follows directly from the concentration processes occurring in farms (expansion of the land factor resource per farm) or in the absence of concentration – substitution by increasing the productivity of the land. However, these relationships in microeconomic terms were not the subject of our interest[47].

It can be assumed that in the micro- and macro-economic context the expression $\Delta Z = 0$, therefore, equation (3.2) takes the form:

$$\Delta R = \Delta Q \cdot Z_0 \qquad (3.3)$$

Interpretation of the formula (3.3) may be that with given resources of the land factor the increase in agricultural production on the farm as well as in the sector is determined by the average productivity of agricultural land.

In addition to the productivity of the land, the factor that also affects the level of agricultural production is the labour factor. The inclusion of labour in growth analysis of agricultural production refers to the classical analysis of economic growth factors. To the equation (3.0) we introduce the level of employment in agriculture, obtaining the relationship:

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[44] Given the ever-increasing price of land, including arable land, the land is a very attractive means of thesaurisation. However, despite the significant increase in land prices, its supply decreases (due to the obvious fact of resource limitations) with the increasing demand, T. Czekaj, *Dochodowość materialnych czynników produkcji w gospodarstwach osób fizycznych w 2005 roku*, [in:] W. Józwiak (ed.), *Sytuacja ekonomiczna i aktywność inwestycyjna różnych grup gospodarstw rolniczych w Polsce i innych krajach unijnych w latach 2004-2005*, Multi-Annual Programme, Report No. 68, IAFE-NRI, Warsaw 2007, p. 61.

[45] W. Rembisz, *Mikro- i makroekonomiczne…*, op. cit., p. 177.

[46] In the discussion on the role of the land factor in the potential growth of agricultural production (defined by the rate of change in arable area and land productivity), one should not forget about the agricultural policy of setting aside land or maintaining it in readiness for production (fallowing).

[47] W. Józwiak, Z. Mirkowska, *Ekonomiczne przesłanki zdolności konkurencyjnej polskich gospodarstwa rolnych*, [in:] W. Józwiak (ed.), *Sytuacja ekonomiczna i aktywność inwestycyjna różnych grup gospodarstw rolniczych w Polsce i innych krajach unijnych w latach 2004-2005*, Multi-Annual Programme, Report No. 68, IAFE-NRI, Warsaw 2007, p. 19.

$$\frac{R}{L} = \frac{Z}{L} \cdot \frac{R}{Z} \tag{3.4}$$

where: $\frac{R}{L}$ – labour productivity per person employed; $\frac{Z}{L}$ – size of agricultural land per employee; $\frac{R}{Z}$ – average productivity of agricultural land.

This equation, also after transformation into a dynamic form, indicates two factors of increase in labour productivity. These are: productivity of the land factor and the amount of land factor per labour factor (the average farm size). It is a formula from the theory of agricultural economics related to Hayami-Ruttan for the developed model of increase in agri-food production. In particular, it shows a simple relationship between the productivity of land and labour productivity. As one can see, labour productivity ($\frac{R}{L}$) increases when with a given relationship ($\frac{Z}{L}$) the productivity of the land ($\frac{R}{Z}$) increases or with the relationship ($\frac{R}{Z}$) the area of agricultural land per employee increases. Table 3.4 shows the resulting values of labour productivity and land productivity in selected countries of the European Union in 2000-2008.

Table 3.4. Average (for 2000-2008) labour productivity, agricultural land productivity and average size of arable land per person employed in selected countries of the European Union

Country	Labour productivity ($\frac{R}{L}$)	Productivity of agricultural land ($\frac{R}{Z}$)	Size of agricultural land per employee
Belgium	83	7.45	11
Czech Republic	16	1.00	16
France	66	3.18	21
Germany	41	3.06	13
Greece	18	4.36	4
Hungary	26	1.15	22
Italy	41	5.05	8
Netherlands	73	18.35	4
Poland	6	1.09	5
Spain	45	3.18	14
Sweden	42	1.41	29
United Kingdom	50	3.21	16

Source: Own calculations based on the FAO, EUROSTAT and LABOURSTA data.

3.2. Growth rate of agricultural production

For the needs of the growth of agricultural production as a component of the developed growth model, we divide both sides of the equation (3.2) by equation (3.0). After simplification we get:

$$\frac{\Delta R}{R} = \frac{\Delta Q}{Q} + \frac{\Delta Z}{Z} + \frac{\Delta Z \cdot \Delta Q}{Z \cdot Q} \tag{3.5}$$

Taking the appropriate symbols to denote growth rates, we have the following formula (3.5):

$$r = q + z + z \cdot q \tag{3.6}$$

where: $\frac{\Delta R}{R} = r$ – growth rate of agricultural production[48]; $\frac{\Delta Q}{Q} = q$ – the growth rate of productivity of land ; $\frac{\Delta Z}{Z} = z$ – rate of change of agricultural land resources.

The product of growth rates ($z \cdot q$) due to the substitutability of the processes is close to zero, as already pointed out above, and therefore the equation (3.6) can be reduced to the following form: [49]

$$r = z + q \tag{3.7}$$

The same result will be achieved by taking logs of the equation (3.6) to the following form:

$$\ln R = \ln Z + \ln Q \tag{3.8}$$

After differentiating it with respect to time the equation can be written as follows[50]:

$$\frac{\partial R / \partial t}{R} = \frac{\partial Z / \partial t}{Z} + \frac{\partial Q / \partial t}{Q} \tag{3.9}$$

The growth rate of agricultural production (r) is determined by the rate of change of agricultural land and the growth rate of land productivity (q). Conclusions from the equation (3.7) result from the regularity formulated, *inter alia*, by Hayami and Ruttan, who stated that *"the increase in productivity of land has the same effect on the growth of agricultural production as the expansion of crops"*[51]. These issues have been outlined above in general for the equation (3.1). Accordingly, at the macroeconomic level, based on the equation (3.7), we can only repeat the previously established observations and regularities, but in dynamic terms. Under normal conditions, the de-

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[48]Some agricultural products are consumed on the spot, i.e. there is natural consumption. In this analysis, we assume that the growth rate of agricultural production (r), except for changes in inventory, contains an element of the dynamics of change in production for own consumption (r_N);

[49] Based on W.H. Branson, *Macroeconomic theory and policy*, 2. Edition, Harper & Row Publishers, New York, 1979.

[50]Where:

$$\frac{\partial R / \partial t}{R} = \frac{\Delta R}{R} = r \quad \frac{\partial Z / \partial t}{Z} = \frac{\Delta Z}{Z} = z \quad \frac{\partial Q / \partial t}{Q} = \frac{\Delta Q}{Q} = q$$

[51] Y. Hayami, V. Ruttan, *Agricultural Development…,* op. cit., p. 310.

velopment of agriculture in the EU countries is : $z < 0$, i.e. the use of land factor in agricultural production is reducing. This is confirmed by the results for selected EU countries (Table 3.5). In most countries, the rate of change of agricultural land resources is negative or close to zero (in few cases the value of *z* was positive). The rate of this loss or the accepted rate of loss of land use factor in agriculture is an economic and regulatory issue[52].

It can be assumed that the loss of agricultural land in the economy is inevitable, which can be recognised as:

$$Z_t = Z_0 e^{z_t} \tag{3.10}$$

where: $0 < z < 1$, is an exogenous variable for the CAP[53].

[52]Causes of reduction in the use of the land factor are known in theory, which we have already pointed out above. Firstly, these are associated in particular with (3.7) and are explained by the analytical model developed in the study. The positive rate: $q > 0$ exceeding the effects $z < 0$ is the process of intensification known in the economics. At present "barrier" of demand, and in fact the insufficient growth in demand for final agri-food products and for agricultural raw materials, there is no need for the two variables included in the equation (3.7) to be positive. Scope of substitution between the two growth factors is quite large, as we show in the formula (3.12). These are somewhat endogenous factors. Secondly, the decline in agricultural land resources, or more precisely the agricultural land, is due to the processes of urbanization, industrialization, servicisation and development of technical and transport infrastructure and environmental issues.

[53] W. Rembisz, *Mikro- i makroekonomiczne…*, op. cit., p. 169.

Table 3.5. Rate of change of agricultural land resources (*z* in %) in selected countries of the European Union in 2000-2009

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	0.3	0.7	-1.1	-0.2	0.4	0.3	0.0	0.1	-0.1	0.1
Czech Republic	-0.1	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
France	0.1	0.2	0.0	0.0	0.1	0.0	-0.1	-0.3	-0.2	-0.2
Germany	0.0	-0.1	0.1	0.2	0.3	0.1	-0.1	0.1	0.2	0.2
Greece	-0.4	-0.6	-9.4	-1.2	-9.8	7.5	-7.5	7.1	-0.5	5.8
Hungary	-0.7	-1.5	0.0	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1
Italy	-0.7	-1.0	-2.1	-1.5	-2.1	-2.5	-3.6	-1.5	-2.3	-0.1
Netherlands	-0.3	0.1	-0.1	7.5	6.2	5.0	-2.1	-1.4	-0.5	0.0
Poland	-1.1	-2.6	-3.6	-2.5	-2.3	-0.6	-0.3	1.1	0.5	0.1
Spain	-0.9	-1.4	-1.0	-0.1	0.0	-0.8	-1.1	-1.1	-0.6	-0.2
Sweden	-0.4	-0.8	-0.5	-0.4	0.2	-0.2	-0.2	-0.9	-0.2	-0.1
United Kingdom	-1.4	-0.8	-1.3	1.0	-0.3	2.5	1.5	1.5	-0.2	-0.3

Source: Own calculations based on the FAO and EUROSTAT data

With reference to equation (3.7) it can be seen that the condition for the growth of agricultural production, i.e.: $r > 0$, is the presence of a suitable substitution between factors of production growth, i.e. between rates of growth: (q) and (z). In order to illustrate this and conduct further analyses, Table 3.6 summarizes rates of change of land productivity in the selected countries of the European Union. In the 2000-2009 period most countries had a positive rate of change in the productivity of agricultural resources, although in some years there was a noticeable decline in the value. The occurrence of such a large negative rate of change in productivity of agricultural land, including in the Netherlands, Greece, the United Kingdom (Table 3.6), may be due to the fact that actions taken under the Common Agricultural Policy are focused on instruments that increasingly prefer non-agricultural rural development and reducing the intensity of agricultural production in farms.

Table 3.6. Rate of growth of land productivity (in %) in the selected countries of the European Union in 2000-2009

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	0.6	2.7	3.2	4.2	2.3	1.4	0.7	-0.5	0.1	-0.9	0.6
Czech Republic	0.3	-2.1	-2.6	1.5	2.2	2.7	-0.8	2.4	2.5	1.7	0.3
France	-1.4	-0.5	-3.2	1.8	-0.6	1.8	-1.5	0.6	1.4	0.9	-1.4
Germany	0.3	-1.1	-0.9	2.4	2.3	2.4	-1.2	0.9	0.1	0.6	0.3
Greece	-0.3	-0.6	6.9	1.4	9.9	-7.1	3.0	-12.4	-1.2	-6.7	-0.3
Hungary	3.4	0.8	-0.6	3.9	3.5	4.0	-8.0	3.3	0.5	6.3	3.4
Italy	0.2	-0.7	-0.2	2.7	3.0	4.0	1.8	1.2	1.9	0.2	0.2
Netherlands	-1.2	-1.6	-1.5	-5.8	-5.1	-4.8	2.4	2.4	2.5	1.0	-1.2
Poland	2.2	3.2	4.7	6.7	6.2	4.3	1.5	0.6	3.4	1.1	2.2
Spain	2.7	6.1	3.9	2.9	-2.9	-2.2	1.5	4.5	3.1	-0.6	2.7
Sweden	0.8	0.9	-0.5	0.4	0.3	0.5	0.0	0.2	0.5	-0.2	0.8
United Kingdom	-0.8	0.1	0.6	0.5	0.4	-2.8	-2.5	-1.4	0.3	1.4	-0.8

Source: Own calculations based on the FAO and EUROSTAT data

In macroeconomic terms, in order to achieve a positive growth rate of agricultural production (r), it is necessary for (3.7) to meet the following condition:

$$q + z > 0 \qquad (3.11)$$

At the farm level, but also at the sector level there may be different cases. The most desirable case appears to be a relationship where both indicators (q) and (r) are positive, i.e. when there is $\frac{q}{r} > 0$. Typically, the demand constraints pertain to (r) as a macro-economic value, and not (r) as a micro-economic value referring to the farm. This is because the demand conditioning in the agricultural sector scale (macro-economic) is different from that in the scale of a single agricultural producer. These are completely different processes, despite the superficial similarity. Further dependencies refer to the scale of the agricultural sector. They can, however, also be analysed in the scale of a single producer and his farm, but as regards a different aspect. For an individual agricultural producer (of a farm) there are no restrictions on demand[54], equation (3.11) will be satisfied first when two growth factors will be positive, but it is possible to distinguish between:

$$q > z \text{ and } q < z.$$

Second, in analytical and accounting terms it is possible, if:

$$q > 0 \text{ and } z < 0.$$

but: $q > |z|$, that is, so that the increase in the productivity of the land substitutes the loss of production effect due to the reduction in the area of agricultural land.
Thirdly, where:

$$q < 0 \text{ and } z > 0.$$

where $|q| < z$, i.e. so that the increase in the size of agricultural resources substitutes for the loss of production due to the effect of reducing the productivity of the land.

Verification of these three cases was carried out by comparing the size of growth rates in Table 3.5 (z) and Table 3.6 (q). Results are shown in Table 3.7. One can see that not all countries in the analysed period had a positive rate of growth (r). This is especially true for Greece and Italy. In Poland, in all analysed years there has been a positive rate of growth of agricultural production. The data in Table 3.7 are characterised by different models of growth of production in agriculture in the light of dependencies contained in (3.4-3.6), which refer to the Hayami-Ruttan approach.

[54]Of course, in practice, in a given location, with a particular customer, etc., such a restriction exists, but the assumption of competitive conditions is waived in such situation.

Table 3.7. Comparison of *q* and *z* indicators for selected EU countries in 2000-2010

Countries / Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	q>z	q>z	1	1	q>z	q>z	q>z	0	1	0	q>z
Czech Republic	1	0	0	1	1	1	0	1	1	1	1
France	0	0	0	q>z	0	q>z	0	1	1	1	0
Germany	q>z	0	0	q>z	q>z	q>z	0	q>z	z>q	q>z	q>z
Greece	0	0	0	1	1	1	0	0	0	0	0
Hungary	1	0	0	1	1	q>z	0	1	1	1	1
Italy	0	0	0	1	1	1	0	0	0	1	0
Netherlands	0	0	0	1	1	1	1	1	1	q>z	0
Poland	1	1	1	1	1	1	1	z>q	q>z	q>z	1
Spain	1	1	1	1	0	0	1	1	1	0	1
Sweden	1	1	0	0	q>z	1	0	0	1	0	1
United Kingdom	0	0	0	z>q	1	0	0	1	1	1	0

Value of 1 indicates the presence of dependence $q > |z|$ or $|q| < z$ which implies that r> 0

Entries q> z and z> q occur when q> 0 and z> 0, which implies that r> 0

Value of 0 means that none of the above described cases are met, which indicates that r < 0

Source: Own calculations based on the FAO and EUROSTAT data

With reference to (3.4) and (3.7) and taking into account the demand conditions, it is possible to consider various options for production growth, as well as various approach to agricultural policy[55]. To determine the share of indicator (z) and (q) in the rate of growth of production (r), equation (3.1) was transformed. After dividing, we arrive at the following:

$$1 = \frac{z}{r} + \frac{q}{r} \qquad (3.12)$$

Relation: $\frac{z}{r}$ illustrates the impact of the loss of agricultural land on the rate of growth of agricultural production. Relation: $\frac{q}{r}$ shows the impact of growth of land productivity on the rate of growth of agricultural production. Note that the relationship ($\frac{q}{r}$) expresses the reciprocal of the elasticity of agricultural production towards growth in land productivity, namely:

$$1 : \frac{q}{r} = \frac{\Delta R}{R} \cdot \frac{Q}{\Delta Q} = \frac{\Delta R}{\Delta Q} \cdot \frac{Q}{R} \qquad (3.13)$$

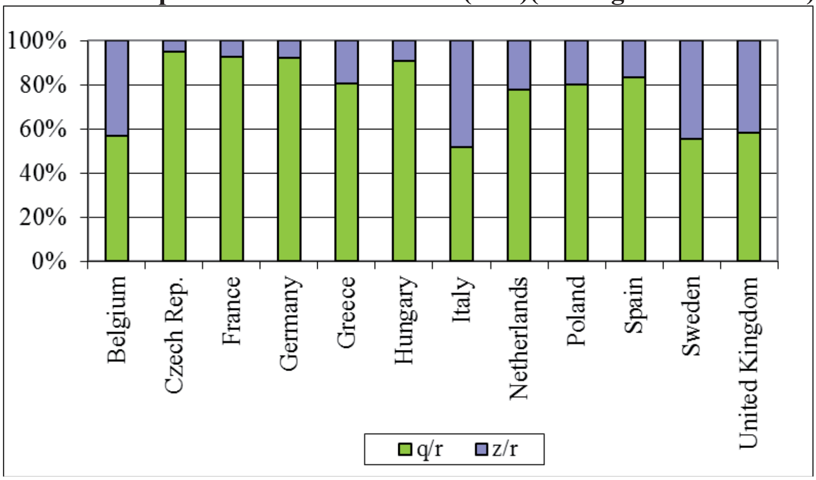
which can also be interpreted as the sensitivity of agricultural production to changes in land productivity.

Figure 3.2 shows the average values of the relationship: ($\frac{z}{r}$) and ($\frac{q}{r}$), designated for the selected countries of the European Union on the basis of the calculations for the 2000-2009 period. Based on the results listed in Figure 3.2 it can be seen that the changes in agricultural production to a greater extent can be attributed to changes in the land productivity than to the changes in agricultural land resources. The analysis confirms the view expressed in the 1980s by Halcrow that *"the growth in agricultural production is increasingly attributable to the growth in yields and animal productivity than to the growth of the agricultural land area"*.[56] For the majority of the analysed European Union countries the impact of the rate of growth of land productivity on the rate of growth of agricultural production is four times higher than that of the rate of change of agricultural land.

[55]In terms of demand constraints, there is of course no compulsion to increase land productivity or excessively limit the loss of land resources used in agriculture. It is different, of course, in conditions of demand pressure, as was the case in the centrally planned economy. One should also look differently at these sources of production growth in the conditions of implementing the concept of sustainable growth. There must be maintained an appropriate balance between these two sources of growth. We refer to it in further analysis of these formulas.

[56] H. Halcrow, *Economics of Agriculture,* McGraw-Hill, New York, 1980, p. 66.

Figure 3.2. Impact of changes in agricultural land resources and land productivity on agricultural production in selected countries of the European Union - exemplification of the formula (3.18)(Average for 2000-2009)



Source: Own calculations based on the FAO and EUROSTAT data

Having defined the necessary rate of growth of agricultural production resulting from the demand growth, in order to maintain steady growth we can, based on (3.7), determine the necessary rate of growth of land productivity (q):

$$q^* = r^* - z \tag{3.14}$$

where: $q*$ – desirable - resulting - growth rate of land productivity; $r*$ – desirable (due to market conditions) growth rate of agricultural production; z – rate of changes of agricultural land resources.

The factor which determines the essential rate of growth of land productivity (q^*), for a given rate of demand for food, is the increasing demand for non-agricultural use of land. Assuming the rate of growth of production (r^*) conditioned by demand, the necessary rate of growth of land productivity (q^*) must be higher, the higher is the rate of loss of agricultural land resources[57].

As mentioned earlier in this chapter, in addition to the land productivity, the factor that also affects the rate of change in agricultural production is the labour productivity (introduced for consideration in equation (3.10). After multiplying (3.10) by the labour factor (L), we arrive at the following:

[57]At the same time, it should be noted that the rate of land loss can be higher, the greater are the opportunities for increasing rate of land productivity. It is also clear, however, it points to the analytically documented choice, even before the introduction of the policy on the need to intensify agriculture.

$$R = L \cdot \frac{Z}{L} \cdot \frac{R}{Z} \tag{3.15}$$

After taking the logarithm of the formula (3.21) we have the following: [58]

$$\ln R = \ln L + \ln\frac{Z}{L} + \ln\frac{R}{Z} \tag{3.16}$$

After differentiating formula (3.16) we have the following: [59]

$$\frac{\partial R / \partial t}{R} = \frac{\partial L / \partial t}{L} + \frac{\partial \frac{Z}{L} / \partial t}{Z / L} + \frac{\partial \frac{R}{Z} / \partial t}{R / Z} \tag{3.17}$$

where: $\frac{\partial R / \partial t}{R} = \frac{\Delta R}{R} = r \; \frac{\partial L / \partial t}{L} = \frac{\Delta L}{L} = r_L$ – respectively growth of production and the rate of change of employment in agriculture ; $\frac{\partial \frac{Z}{L} / \partial t}{Z / L} = l_Z$ – rate of change in the relation of the area of agricultural land per employee, which can be expressed as $l_Z = z - r_L$ [60]; $\frac{\partial \frac{R}{Z} / \partial t}{R / Z} = \frac{\Delta \frac{R}{Z}}{R / Z} = \frac{\Delta Q}{Q} = q$ – growth rate of productivity of agricultural land.

On this basis, equation (3.17) can be written as the following:

$$r = r_L + l_Z + q \tag{3.18}$$

Thus, the rate of growth of agricultural production is influenced by: the rate of change in employment, rate of change in area of agricultural land per employee and growth of land productivity. Equation (3.18) combines the elements of the method of growth analysis of agricultural production based on changes in agricultural land resources and their productivity, with elements of analysis based on employment and average labour productivity. Both of these approaches reflect a significant dilemma in economics, what is more important, the increase in labour productivity or increase in land productivity.

The correctness of expressions in the formula (3.18) can be easily proved, showing, at the same time, their logic and economic substance. Development of labour and land (concentration ratio illustrating the agrarian structure) can be expressed as the following:

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[58] Using logarithm properties: $\ln(xyz) = \ln x + \ln y + \ln z$, for $x, y, z > 0$.

[59] Transforming equation (3.21) into (3.23) based on W.H. Branson, *Macroeconomic…,* op. cit.

[60] Based on Sz. Figiel, W. Rembisz, *Przesłanki…,* op. cit., p. 99.

$$\frac{Z}{L},$$

after taking logs[61] we have:

$$\ln(\frac{Z}{L}) = \ln Z - \ln L, \tag{3.19}$$

and

$$l_Z = z - r_L. \tag{3.20}$$

What is obvious is the fact that the concentration ratio is the result of changes in the use of agricultural land and changes in employment in agriculture.

With (3.18), we can analyse the impact of the loss of employment and the process of concentration in agriculture ($l_Z > 0$) on the rate of growth of agricultural production. Since we have the following:

$$1 = \frac{r_L}{r} + \frac{l_Z}{r} + \frac{q}{r} \tag{3.21}$$

The relationship ($\frac{r_L}{r}$) is the impact of the rate of loss of employment on the growth of agricultural production. Relation ($\frac{l_Z}{r}$) illustrates the impact of increase in the average area of the concentration process on the rate of agricultural production. Relationship ($\frac{q}{r}$) expresses the impact of the increase in land productivity on the rate of growth of agricultural production. These relationships are also, respectively: rates of flexibility of production growth in relation to employment and the changes in the average area and land productivity.

On the basis of equation (3.14) one can state that the growth of land productivity is a resulting variable defined in the conditions of dynamic equilibrium in the agri-food market for by rate of demand for agricultural products and the rate of land loss. At the same time, (r*) and (z) are influenced by macroeconomic factors, external to agriculture. The first one is conditioned by demand for agricultural products, and the other by demand for non-agricultural land use. Thus, for a relatively steady demand for agricultural products and with decreasing agricultural land resources (Figure 3.1 and Table 3.2 and Table 3.3) to achieve the required volume of agricultural production delineating the balance between the producer and the processor, it is necessary to enhance the productivity of the land factor. It is obvious that the best source of growth of land productivity is to improve the efficiency of production.

[61] (based on the logarithm properties: $\ln(\frac{x}{y}) = \ln x - \ln y$ for: $x, y > 0$)

Conclusion

In the study we made a preliminary attempt to build a demand conditioned growth model of agri-food production. The model is based on two principles. Firstly, the balancing of the dynamics of demand for agri-food products and agricultural raw materials with the dynamics of their production and supply. Secondly, explanation of the mechanism of behaviours or choices of the main actors in this model, i.e. the consumer, the agri-food processor and the agricultural producer, as the most important link in this model. It shows the specificity of demand determinants of increase in agri-food production. In fact, it involves a two-level demand, with two related, but separate markets. The first is the final market of consumer products, agri-food goods. The second market is the market for agricultural products as raw materials for the production of finished food products. In both markets, the elasticity of demand is relatively low and there is a price gap. This creates certain problems when it comes to the implementation of the objective function of agricultural producers. They cannot count on an increase in demand and, consequently, an increase in production and prices, as a source of growth of income. This source may be the improved production efficiency. Thus, in the model we emphasize the role and importance of production efficiency by introducing additional explanations and measurement methods, as well as identifications of the sources of improvement.

Developed model allows for analysing different variants of the growth of basic increase in production. These variants are associated with the share of land productivity factor and the changes (loss) as regards application of this factor in agricultural production to shape its dynamics, as well as in the development of labour productivity, which is also a growth factor. It is a macroeconomic perspective, to which we refer in the model. These figures are illustrated empirically, it was shown that agriculture of the EU countries, which are the subject of the analysis, is dominated by the growth option based on land productivity growth substituting effects of land loss, the loss associated with economic development. Depending on the demand conditions the relationship between the indicator of soil productivity and the effect of its loss are shaped differently. Additionally, we illustrated empirically the impact of changes in labour productivity, in accordance with developed formulas that comprise the model, on the growth of production in relation to other indicators.

The model based on microeconomic analytical formulas describing the choices of the consumer, the processor and the producer has been subjected to a preliminary empirical verification. The data collected from national and international statistics are mainly to illustrate regularities or conclusions derived from the model and the selected analytical formulas. In this sense, empirical analysis and graphical illustrations, as well as specific trend functions of indicators included in the model, verify positively or negatively the assumptions and reasoning. They also entitle to broader observations beyond reasoning tied closely to the model.

Empirical study results show the recessive nature of the agri-food market, which is confirmed by reasoning based on the model, in the sense that its growth rate is continuously decreasing. The rates of the share of food products in consumer spending are decreasing, the structure of consumption is changing to better in terms of health, but to worse from the perspective of agricultural producers, because it does not increase the demand for agricultural raw materials, e.g. as stability and relative decline in the share of meat in consumption and therefore the rate of demand.

Therefore demand can no longer be considered as a growth dynamization factor of agri-food production, at least the domestic demand. This places a greater requirement for efficiency, both in terms of the agri-food processor and the agricultural producer. The agri-food processor, maximizing its objective function, makes better use of agricultural raw materials, which relatively reduces the need for increased production of agricultural raw material and the possibility of an increase in its price. We pointed to the potential for improving the efficiency of agricultural producers by providing ownership of the DEA method. On the example of selected countries of the European Union we illustrated the key indicators of the model of growth of agricultural production and we made a comparison of the indicators between the analysed countries. In order to make generalizations, the development of indicators was aligned to the specific forms of trends.

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