

## Relationship between labour productivity and its remuneration. The case of agriculture

**Włodzimierz Rembisz**, Institute of Agricultural and Food Economics - National Research Institute (IAFE-NRI),  
Mathematics Application in Agricultural Economics Department, Świętokrzyska 20, Warsaw 00-002,  
Poland

**Agata Sielska \***, Institute of Agricultural and Food Economics - National Research Institute (IAFE-NRI),  
Mathematics Application in Agricultural Economics Department, Świętokrzyska 20, Warsaw 00-002,  
Poland

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### Abstract

The article aims at presenting the fundamental relationship between remuneration and productivity of labor factor. This relationship is explored analytically and empirically. It is investigated at the level of the agricultural sector, derived from the microeconomic level, i.e. an agricultural producer. Based on an optimal solution of the income maximisation problem, we derive the determinants of remuneration of the labour factor, i.e. income in agriculture. We explore analytically the improvement of labour productivity. We also take into consideration the issue of the importance of subsidies which can be referred to as the second potential source of agricultural producer's income. The empirical evidence is based on the FADN (Farm Accountancy Data Network) data for 2004-2012 for Member States that joined the European Union in 2004. We examine the statistical relationship between the indicators of developments in the productivity of the labour factor, income and the level of subsidies in selected countries.

Keywords: objective function of an agricultural producer, productivity of the labour factor, remuneration of the labour factor;

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\* ADDRESS FOR CORRESPONDENCE: **Agata Sielska**, Institute of Agricultural and Food Economics - National Research Institute (IAFE-NRI), Mathematics Application in Agricultural Economics Department, Świętokrzyska 20, Warsaw 00-002, Poland  
E-mail address: [Agata.Sielska@ierigz.waw.pl](mailto:Agata.Sielska@ierigz.waw.pl)

## 1. Introduction

We show the relationship between the productivity and remuneration of the labour factor, assuming income maximization as the producer's objective function. A producer maximises its objective function, when the marginal productivities of used production factors equate their remuneration. It is an endogenous basis to determine the level of remuneration of the labour factor. At the same time the producer is price taker and has no impact on the prices of production factors. All that affects the relationship between the productivity of the labour factor and its remuneration. We develop simple analytical formulae, which reflect relationships most relevant in this regard. We first define producer's objective function, which forms grounds for the relationship of labour productivity and its remuneration. Then, we consider the issue of improving the productivity of the labour factor in analytical terms, referring it to the agricultural sector. Afterwards, we show some empirical evidence of the relationship in question on the basis of the FADN (Farm Accountancy Data Network) data for 2004-2012.

In the literature, issues of productivity of the labour factor in agriculture are most frequently considered in terms of measurement, differences in relation to other sectors (Tamasauskiene, & Stankaityte, 2013) or productivity differentiation between countries (Gutierrez, 2002) or cross-section papers (Mahmood, 2012). The relation between wages and productivity is considered as an important factor which underlies the distribution of income between capital and labour (Feldstein, 2008). Labour productivity increase in the agricultural sector is considered as one of the determinants of overall economic growth (Dorward, 2013). Gollin (2010) discusses both theoretical arguments and empirical evidence for the hypothesis that in the developing countries rise in the agricultural productivity is the ground for the economic growth. Agricultural productivity is considered a key factor contributing to the structural change by Gollin, Parente, Rogerson (2002, 2007). The role of agriculture and productivity in the international differences in output per worker is analysed by Restuccia, Yang, Zhu (2008). Relationships between wages and productivity are analyzed by Narayan, Smyth (2009) and Verbic, Kuzmin (2009). The data evidences a relation between those variables (Nayak, & Patra, 2013; Bilidirici, Alp, 2008; Goschin, 2013). The articles address the sources and limits of productivity gains (Ruttan, 2002), as well as issues of the relationship between increased labour productivity and income distribution (Willis, & Wroblewski, 2007).

## 2. Producer's objective function

In accordance with the microeconomic approach, a producer maximises its objective function. We assume that this function is income defined as the difference between revenue and the costs of using production factors. The maximised objective function can be expressed as:

$$I_A = Y \cdot p_A - (K \cdot \rho + L \cdot \omega) \Rightarrow \max \quad (1)$$

where:  $I_A$  - income of an agricultural producer as a function of generated production;  $p_A$  - obtained price;  $K$  - use of the capital factor;  $\rho$  - remuneration of the capital factor;  $L$  - inputs of the labour factor;  $\omega$  - remuneration of the labour factor;  $Y$  - production.

The level of production  $Y$  with income  $I_A$  maximum for certain costs of using production factors  $K$ ,  $L$  is a producer's optimal choice. To meet this condition, the first derivative of the income function must equal zero. Assuming that the revenue function is continuous and differentiable, product prices are exogenous and with the total cost function (expenditure of funds for using production factors  $K \cdot \rho + L \cdot \omega$ ), the optimality condition can be expressed by Formula (2). A producer increases its costs of using factors until they equal resulting revenue growth:

$$\partial Y \cdot p_A = \partial K \cdot \rho + \partial L \cdot \omega \quad (2)$$

where:  $\partial Y \cdot p_A$  - derivative of total revenue (marginal revenue),  $\partial K \cdot \rho, \partial L \cdot \omega$  - derivatives of total cost (total marginal costs of capital and labour).

Under conditions of a competitive equilibrium, marginal revenue equals the price of a product (3). This corresponds to the real situation of an individual producer (in terms of the sector, it refers to marginal producers with the lowest marginal productivity). An individual producer does not affect the state of the market with its behavior, including the price of the product offered (Varian, 2005). Thus, we have:

$$\partial Y \cdot p_A = p_A \quad (3)$$

Assuming that one of the factors is constant:  $\partial K \cdot \rho = 0$  or  $\partial L \cdot \omega = 0$ , we obtain:  $\partial Y \cdot p_A = \partial L \cdot \omega$  or  $\partial Y \cdot p_A = \partial K \cdot \rho$ . This means that the optimal use of production factors maximising income is determined by the equalisation of growth in the costs of increased use of a certain factor with the resulting increase in revenue. Dividing  $\partial Y \cdot p_A = \partial L \cdot \omega$  by the marginal physical productivity of labour  $\partial Y / \partial L$ , we obtain a formula describing developments in the remuneration of the labour factor:

$$\frac{\partial Y}{\partial L} \cdot p_A = \frac{\partial Y \cdot p_A}{\partial L} \Rightarrow \omega \quad (4)$$

It is determined by the marginal productivity of the labour factor and product prices (obtained prices). The remuneration of labour may increase due to the rise in the volume of production or a decline in employment:

$$\frac{\partial Y \uparrow p_A}{\partial L \downarrow} \Rightarrow \omega \uparrow \leftarrow \varpi \uparrow \quad (5)$$

where:  $\uparrow$  means increase and  $\downarrow$  – decline.

### 3. Determinants of the labour factor productivity in the case of agricultural producer

In the case of agricultural producer, the problem is whether such endogenously determined remuneration of the labour factor will equal or be close to its price developed on the labour market, or more precisely – to the remuneration of this factor in its non-agricultural applications ( $\varpi$ ). This can be illustrated by Formula (5):

$$\frac{\partial Y}{\partial L} \cdot p_A \Rightarrow \omega \approx \varpi \quad (6)$$

Of course, if the price of the labour factor in non-agricultural applications increases, the remuneration of the labour factor in agriculture should increase as well, in order to maintain parity conditions. If such an increase in remuneration is to result from labour productivity, a decline in employment (in terms of the sector) or an increase in the volume of production (concentration in terms of a single producer) must occur, which can be schematically illustrated as:

$$\frac{\partial Y \uparrow p_A}{\partial L \downarrow} \Rightarrow \omega \uparrow \leftarrow \varpi \uparrow \quad (7)$$

where:  $\uparrow$  means increase and  $\downarrow$  – decline.

An alternative is an increase in the prices of agricultural products, as a source of growth in the remuneration of the labour factor, in order to maintain the parity relationship. Then, of course, the productivity of this factor needs to be improved (7).

$$\frac{\partial Y \cdot p_A \uparrow}{\partial L} \Rightarrow \omega \uparrow \leftarrow \varpi \uparrow \quad (8)$$

If these conditions are not met, subsidies, e.g. direct payments, as is known, are used to compensate for this income disparity, as they are now under the CAP (Common Agricultural Policy):

$$\frac{\partial Y \cdot p_A}{\partial L} \Rightarrow \omega + B \approx \pi \quad (9)$$

Where:  $B$  - direct payments and other forms of support under the CAP, which is assumed to restore income parity.

#### 4. Improving the productivity of the labour factor

An increase in the remuneration of the labour factor, using (4), can be illustrated by the following formula:

$$\frac{\partial \omega}{\omega} = \left( \frac{\partial Y}{Y} - \frac{\partial L}{L} \right) + \frac{\partial p_A}{p_A} = \frac{\partial P_L}{P_L} + \frac{\partial p_A}{p_A} \quad (10)$$

The above formula makes it clear that an increase in the remuneration of the labour factor, i.e. the income of producers (both in general, as well as agricultural producers) results from: firstly, improving the productivity of the labour factor  $P_L$  and, secondly, increasing the prices of products  $p_A$ . Between these two sources of income growth, complementary and substitutable relations can occur, which can be illustrated as:

$$\uparrow \frac{\partial \omega}{\omega} \approx \uparrow \frac{\partial P_L}{P_L} + \frac{\partial p_A}{p_A} \downarrow \approx \uparrow \frac{\partial P_L}{P_L} + \frac{\partial p_A}{p_A} \downarrow \quad (11)$$

Additionally, the last part of the right side of the above formula can be written as:

$$\uparrow \frac{\partial P_L}{P_L} \geq \frac{\partial p_A}{p_A} \downarrow \quad (12)$$

This situation is a challenge for agriculture and may entail a tough efficiency selection and a swift concentration process. Of course, it can occur in the absence of support from the agricultural policy. However, it indicates that – on realistic grounds of no opportunities to raise the prices of agricultural products – improving the productivity of the labour factor is a major factor in increasing the income of agricultural producers:

$$\uparrow \frac{\partial \omega}{\omega} \approx \uparrow \frac{\partial P_L}{P_L} + \frac{\partial p_A}{p_A} \rightarrow \quad (13)$$

Thus, improving labour productivity is a condition to achieve income growth for:  $\partial p_A / p_A \approx 0$ :

$$\frac{\partial P_L}{P_L} \uparrow \Rightarrow \frac{\partial \omega}{\omega} \uparrow \quad (14)$$

However, a method to improve the productivity of the labour factor is important. It may be achieved through an increase in production associated with a decline in employment, which seems to be the most desirable method, though of course difficult to implement:

$$\uparrow \frac{\partial Y}{Y} - \frac{\partial L}{L} \downarrow = \frac{\partial P_L}{P_L} \uparrow \Rightarrow \frac{\partial \omega}{\omega} \uparrow \quad (15)$$

Obviously, requirements for the rate of growth in the remuneration of the labour factor, and thus for the loss of its employment in agriculture (structural changes), result from macroeconomic conditions and are mainly related to the rate of growth in the remuneration of the labour factor in other segments and sectors of the national economy. We are not to refer to this issue; however, we would like only to notice that the conditions of substitution of the labour factor by the capital factor are currently fully satisfied and progress embodied in new machines, equipment and technologies is

enormous. Moreover, this factor becomes increasingly cheaper than the labour factor both in terms of price and efficiency relations:

$$\frac{\partial Y}{\partial K} \uparrow \cdot \rho \downarrow \geq \frac{\partial Y}{\partial L} \uparrow \cdot \omega \uparrow \quad (16)$$

The process of substitution becomes cost-effective, especially if the remuneration of the labour factor is recognised as parity. On the other hand, this process of substitution of the labour factor by the capital factor is mitigated by income subsidies (direct payments). In fact, we have:

$$\frac{\partial Y}{\partial K} \uparrow \cdot \rho \downarrow \geq \frac{\partial Y}{\partial L} \uparrow \cdot (\omega \downarrow + B \uparrow) \quad (17)$$

We do not analyse the determinants of decreasing employment.

## 5. Empirical illustration in terms of the agricultural sector

Empirical illustration is based on the FADN data for 2004-2012\*.

Figures 1-3 present the dynamics (average rate of change) of support  $B$ , labour productivity  $P_L$  and income per labour unit  $\omega$  in ten Member States that joined the European Union in 2004. In each of the countries concerned, average annual gains in the productivity of the labour factor occurred, while the highest rate of growth was recorded in case of Lithuania and Estonia. Also, the high rate of gains in the productivity of the labour factor, especially in relation to the rate of subsidies and income was observed in case of Slovenia. This may indicate increasing agricultural competitiveness in this country. As for Poland, the high rate of growth in subsidies is not reflected in the rate of gains in labour productivity and income, i.e. they covered an increase in other costs in accordance with the earlier observation.

Out of the 27 EU Member States in total, 24 of them (i.e. 88.89%) reported both the positive rate of income and labour productivity developments (c.f. formula 13). A decline in the employment of the labour factor did not serve as a primary source of income growth. Nevertheless, an increase in income combined with an average annual decline in the employment of the labour factor occurred in 15 Member States. As for subsidies, their increase coupled with a rise in income was recorded in case of 22 analysed Member States (81.48%). It is comforting that no Member State achieved the positive rate of income and the negative average rate of productivity at the same time. The obtained results confirm the role of labour productivity developments in the development of income.

Figure 1 presents the relationship between the average growth rates of subsidies  $B$  and income  $\omega$  for the 27 EU Member States in relation to Formulas 9 and 17. The linear regression analysis indicates the not-so-obvious existence of a positive relationship between these two variables. More importantly, a positive linear relationship can be observed in case of the average rate of labour productivity  $P_L$  and income  $\omega$  developments (Figure 3). On the other hand, the results are not clear for a relationship of the average rate of labour factor employment and income developments (Figure 3). It seems that the analysed EU Member States can be divided into two groups in this respect. In the first one, the relationship between these variables seems to be positive, i.e. higher growth in labour factor inputs is associated with higher income growth. In view of the above theoretical reasoning, the approach is illogical, which may also be proved by the fact that linear mapping is not of high quality measured by determination coefficients. In the second group of Member States, the relationship between these variables is non-linear. With an increase in the average rate of decline in employment, the rate of income developments increases. It is worth noting that this group comprises both Member States that joined the EU in 2004, as well as certain "old" Member States (e.g. Finland).

\* European Commission - EU FADN. [http://ec.europa.eu/agriculture/rica/database/database\\_en.cfm](http://ec.europa.eu/agriculture/rica/database/database_en.cfm)

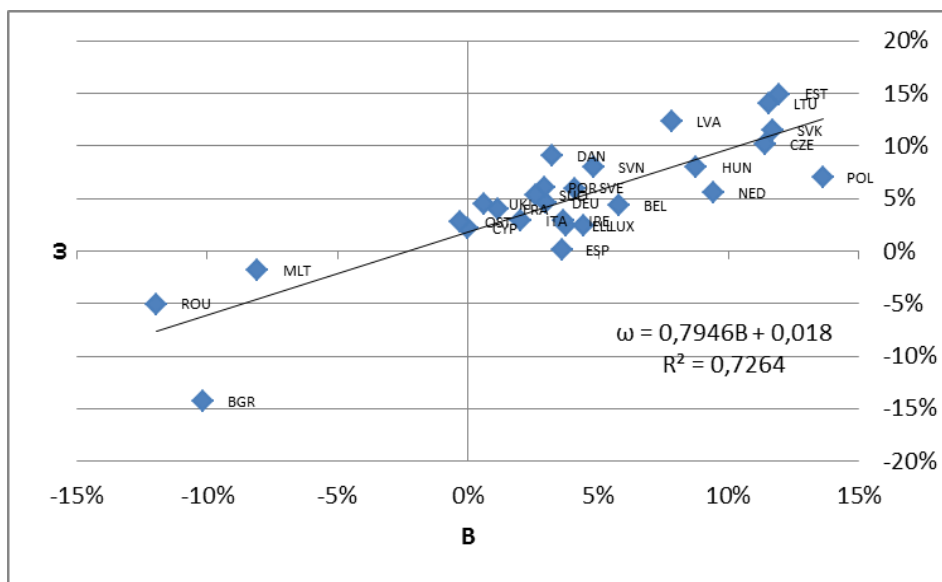


Figure 1. Average rates of subsidy  $B$  and income  $\omega$  developments. Source: own elaboration based on the FADN public database ([http://ec.europa.eu/agriculture/rica/database/database\\_en.cfm](http://ec.europa.eu/agriculture/rica/database/database_en.cfm))

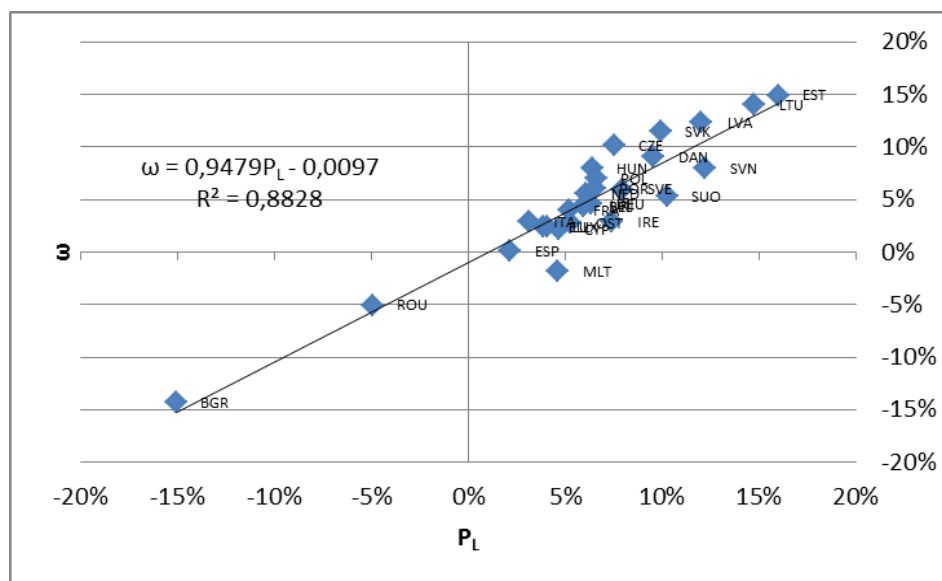


Figure 2. Average rates of labour productivity  $P_L$  and income  $\omega$  developments. Source: own elaboration based on the FADN public database ([http://ec.europa.eu/agriculture/rica/database/database\\_en.cfm](http://ec.europa.eu/agriculture/rica/database/database_en.cfm))

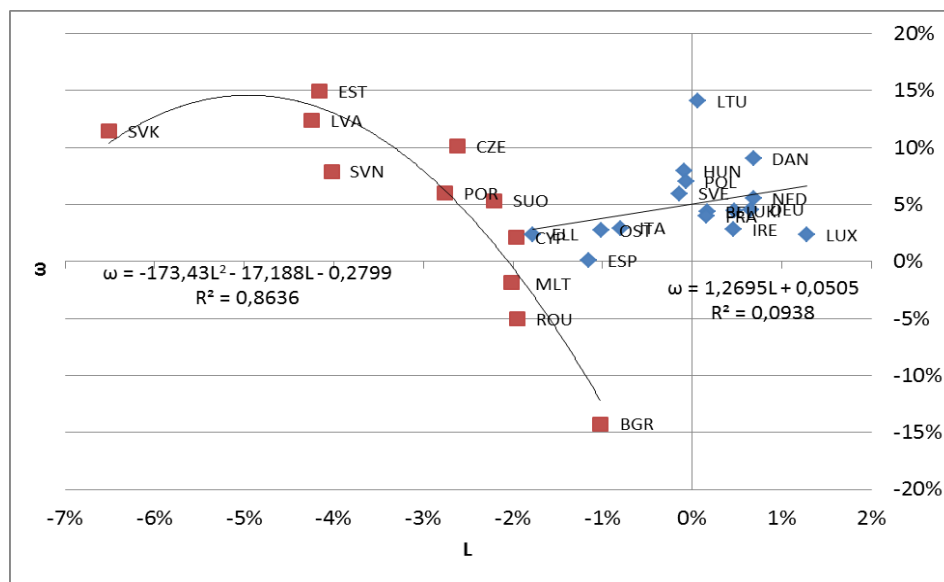


Figure 3. Average rates of labour input  $L$  and income  $\omega$  developments. Source: own elaboration based on the FADN public database ([http://ec.europa.eu/agriculture/rica/database/database\\_en.cfm](http://ec.europa.eu/agriculture/rica/database/database_en.cfm))

## 6. Conclusion

The paper addressed the issue of remuneration of the labour factor in view of the objective function of an agricultural producer. Based on an optimal solution to maximise income in analytical terms, we derived the determinants of remuneration of the labour factor, i.e. income in agriculture. In particular, we focused on the relationship between the productivity of the labour factor with its remuneration in terms of certain product prices, which satisfies competitive balance conditions. Furthermore, we took into account direct payments. This issue was considered in theoretical and cognitive terms, but it has fundamental practical implications for agricultural policy.

The derived relationships were illustrated empirically based on data from the FADN database. Mainly, we analysed the fit of the derived relationships to the actual situation, examining the statistical relationship between the indicators of developments in the productivity of the labour factor, income and the level of subsidies in selected EU Member States in 2004-2012. Most importantly, a positive relationship between developments in the productivity of the labour factor  $P_L$  and its remuneration  $\omega$  can be observed. Of course, the rate of subsidy developments  $B$  indicated a positive relationship with income; however, these phenomena are somewhat parallel. Moreover, the relationship of an increase in income due to employment decline was observed. The obtained results confirm suggestions arising from the theoretical analysis, which proves its correctness. At the same time, they indicate the rationality of growth processes in the agriculture of the Member States analysed.

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