

## LONG-TERM RELATIONSHIP BETWEEN WAGES AND LABOUR PRODUCTIVITY IN AGRICULTURAL AND MANUFACTURING SECTOR IN POLAND

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### ABSTRACT

This paper investigates the long-term relationship between labour productivity and real wages in agricultural and manufacturing sector in Poland in the years 1991–2016. In order to establish the long-run dynamics, autoregressive distributed lag framework (ARDL) is applied. Long run causality running from labour productivity to wages in both sectors is confirmed. The yearly speed of adjustment following change in labour productivity is smaller in agricultural than in manufacturing sector and amounts 24 and 37% respectively. Increase of 1% in labour productivity leads to 0.4% higher wages in agriculture, and to 0.64% higher wages in manufacture.

**Key words:** wages, labour productivity, ARDL model

### INTRODUCTION

The key issue in well-balanced economy is the relationship between production factors and their productivity. The productivity of labour factor is a measure of how well a country or enterprise uses its human resources in the production of goods and delivering the services. In the macroeconomic or sectoral perspective it is related to effective allocation and distribution of resources. Therefore, labour productivity is one of the factors determining the stable economic development, resulting in respective differences in the level of wealth among the sectors of the economy.

Changes in productivity are associated with movements of real wages. This relation has always been crucial economic and legal concern. The Convergence Report [ECB 2016] highlights that the increase of real wages in harmony with labour productivity is a necessary precondition for long macroeconomic stability. This link is a key determinant of the distribution of income between labor and capital [Feldstein 2008]. In the long perspective, raising productivity is the way to improve standard of living, with real wages being the most direct mechanism through which the benefits of productivity growth are transferred to employed population [Schwellnus et al. 2017]. Though, if wages increase faster than labour productivity, workforce gets greater part of national income and incentives to invest in capital decrease. In the aftermath, technological development in the sector slows down and in long-term both, labour productivity and wages, decrease.

The research problem that forms the basis for this study is the adjustment of wages to changes in labour productivity. I hypothesize that real wages and productivity are cointegrated, which means there is a statistically significant long-run relationship between them. This relation, however, differs depending on the economic sector.

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I focus on two distinctly different sectors, namely agriculture that represents primary sector<sup>1</sup>, and manufacture that denotes the secondary sector.

The aim of this paper is to reveal and quantify the long-term relationship between labour productivity and wages in Polish agricultural<sup>2</sup> and manufacturing<sup>3</sup> sector since the economic transition. The market economy and structural reforms started to be introduced in 1990, thus the research period of this study is 1991–2016. In order to establish the direction of causation between wages and productivity and then their long-run dynamics, I apply autoregressive distributed lag framework. All estimations were performed in EViews.

The remainder of the paper is organised as follows. Section 2 explains the theoretical background. Section 3 includes an overview of wage levels and labour productivity in Poland. Section 4 describes data and methodology. Section 5 presents empirical results. The paper ends up with conclusions.

## THEORETICAL BACKGROUND

In the literature, there is a consensus regarding a positive relationship between labour productivity and the level of real wages. There are few basic theories in this scope.

Standard microeconomic theory suggests that wages correspond to the marginal productivity of labour and can be derived from the profit-maximising behaviour of entrepreneurs. In the short term, if productivity per unit of labour increases, while labour supply remains constant, the increased labour demand would result in higher pay, until a new profit-maximising equilibrium is reached. In the long-run, enterprises can modify not only the employment levels, but also their capital stock. As a consequence, changes in the wages and/or the price of capital may lead to substitution of labour for capital or other way around. However, yet again, higher wages would result from labour productivity growth. Thus, the main implication from this theory is that wages follow the development of productivity [Meager and Speckesser 2011].

In contrast to the theory above, the efficiency wage theory argues that causality runs from wages to productivity. The idea of this approach is that companies may benefit from paying employees a wage higher than their marginal revenue product. Higher salary denotes a higher cost of potential job loss for workers. Thus, when employees earn more, they exert greater effort to avoid losing the job [Storm and Naastepad 2007], this in turn results in better productivity.

In the macroeconomic approach a major part of wage analysis are based on the Philips curve [Phillips 1958] or the wage curve [Blachower and Oswald 1994]. Therefore, in most studies wages are explained by unemployment. However, in case of Poland there are empirical evidences that the level of wages corresponds more to the changes in productivity than in unemployment [Nikulin 2015].

But in what proportion to each other wages and productivity move? In the Cobb–Douglas function, the marginal product of labor is proportional to the average product of labor, i.e. to productivity. In this case, the wage level is expected to rise at the same rate as the rise in productivity. Nevertheless, considering different technologies, the marginal product of labor is not necessarily proportional to productivity. If new invested capital causes a rise in productivity and the elasticity of substitution between capital and labor is greater than one, the marginal product of labor will rise proportionately less than productivity. This implies that the wages and productivity do not move proportional [Feldstein 2008]. It is also worth drawing attention to the fact, that the relation between wages and productivity is affected not only by changes in technology, but also

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<sup>1</sup> There-sectors theory developed by A. Fisher, C. Clark and J. Fourastie in the 1930s. divides economies into three sectors: primary: extraction of raw materials, secondary: manufacturing, tertiary: services.

<sup>2</sup> Section A of classification of business activities in Poland (PKD 2007) that includes agriculture, forestry and fishing and corresponds to primary sector.

<sup>3</sup> Section C, D, E of PKD 2007.

by different factors, such as the changing composition of the workforce, the changing cost of capital or wage negotiations.

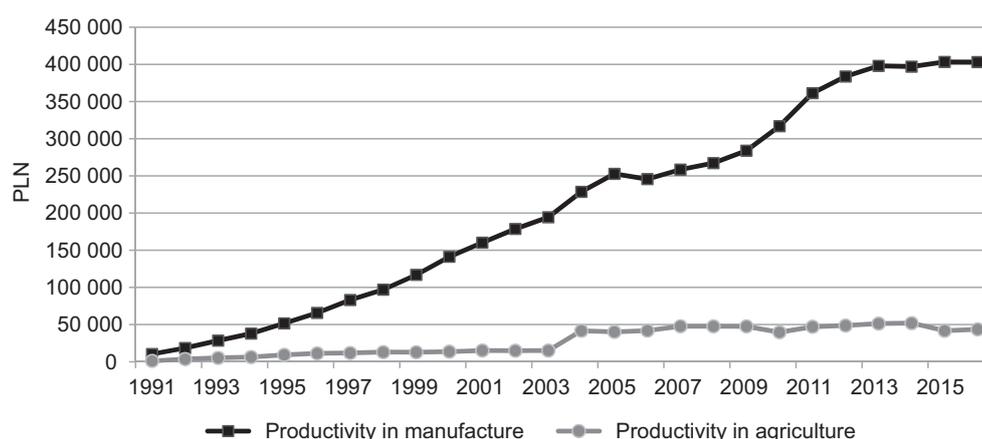
Since this study contains the comparative analysis of two sectors, it is relevant to point out several factors that generate differentials in the link productivity-wage among the sectors. A first factor is explained by differences in human capital [Haltiwanger and Krizan 1999]. A great number of studies focuses instead on the role of technological adoption. Another listed factor is dispersion in prices of equipment [Koeniger and Leonardi 2007]. Finally, many studies explain these differentials by imperfect labor market mechanisms and different government policies. In Polish context, here can be mentioned collective bargaining in case of mining industry or EU subsidies in agriculture.

Summing up, standard microeconomic theory underlines a clear relationship between wages growth and productivity, with wages adjusting to changes in productivity, whereas in the long run the elasticity of substitution between capital and labor is relevant. More sophisticated theories, like efficiency wage theory allow for the possibility that, even in the short-run, increase of wages may cause higher productivity and it may be efficient for entrepreneurs to set wages at levels different from that implied by the simple microeconomic theory. In any case, it is assumed that favorable situation for the economy, is when increase of wages does not cause increase of unit cost of production, as it hinders competitiveness [Adamczyk 2007, Rembisz 2016]. Therefore, the rise in labour productivity ought to be at the higher rate as the rise in wages.

## WAGES AND LABOUR PRODUCTIVITY IN POLAND

This section discusses the dynamic of wages and labour productivity in manufacture and agriculture sector in Poland in the years 1991–2016. Figure 1 presents the labour productivity in both sectors, while the Figure 2 the average real wages.

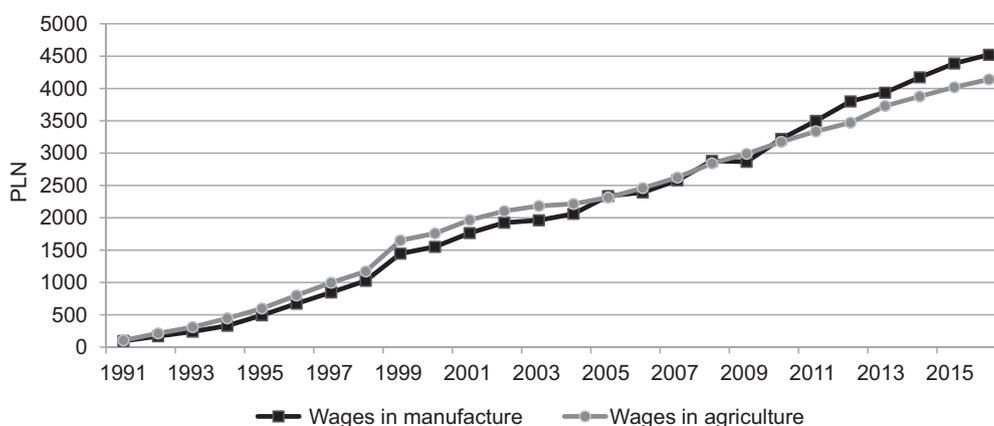
Due to transition of the economic system from centrally planned to market economy in 1989 and related to this change economic shocks, the values of the wages and labour productivity at the beginning of the research period were very low. At that time many enterprises faced a problem of overstaffing. During the next years, because of implemented structural changes and market oriented policies, the systematic increase of labour productivity and wages was observed. Among all sectors, manufacture demonstrated the highest growth of productivity.



The sudden growth in agriculture labour productivity in 2004 was substantially related to the change in GUS methodology of measuring working persons in agriculture.

**Fig. 1.** Labour productivity in manufacture and agriculture sector in the period 1991–2016

Source: Own elaboration based on GUS data.



**Fig. 2.** Average real wages in manufacturing and agricultural sector in the period 1991–2016

Source: Own elaboration based on GUS data.

The sizable increase of manufacturing production in those years was possible mainly as the result of the use of unutilised capacity in those enterprises, which were restructured in the years 1990–1991 as the response to the demand shocks [Zienkowski 2000]. High growth of productivity in manufacture was also the result of changes in the general economic environment, privatization and new management approach of entrepreneurs.

Comparing labour productivity in manufacture and agriculture it can be noticed that the latter has much lower values. While productivity in manufacture continuously and distinctly increases since 1991, the agricultural productivity is characterized by steady but very low growth. Thus, the disparity between labour productivity in these two sectors becomes bigger. It has been already stated that in EU countries labor productivity is higher in nonagriculture than in agriculture sector, but empirical studies show that this applies much more to less developed countries like Poland [Cai and Pandey 2015]. Moreover, labour productivity in the Polish agriculture is many times lower than in the remaining sectors of the economy [Jarka 2016]. This results mainly from high level of labour resources in agricultural enterprises, still a considerable share of small, not effective farms as well as from exogenous factors like market condition resulting from restrictions on exports.

Agriculture is a highly labour-intensive activity but some people working in this sector have non-farm occupation at the same time. Moreover, as self-employment is often in agriculture, underreporting of some income tends to bias downward true value of production. Since accession to the European Union in 2004, Poland closed 27% of the productivity gap<sup>4</sup> with the EU-15. Despite the progress, Poland's comparative labor productivity remains low in few key sectors, including agriculture and manufacturing. In these sectors the productivity gap is 56 and 54%, respectively [Bogdan et al. 2015].

Analyzing the level of wages in both sectors, no big differences can be noticed. Moreover, the empirical evidences indicate that, opposite to other sectors of economy, in agriculture the wage rate exceeds the level of productivity<sup>5</sup> [Rembisz 2016]. This argument implies that, firstly, regarding allocation of resources, agriculture is on the privileged position and takes advantage of intersectoral allocation [Rembisz 2016]. Secondly, there are other, than labour productivity, sources of pays. These are mainly EU direct payments to farmers and transfers of values from other sectors. As an example, in 2004 EU direct payments constituted on average of 13.5% of farm income, while already in 2010 this share exceeded 60% [Kruszewski and Sielska 2012]. This results in low competitiveness of this sector and dependence on subsidies.

<sup>4</sup> Ratio between the productivity of Poland and EU-15. Productivity is measured as value added per employee.

<sup>5</sup> Measured as value added per employee.

## DATA ESTIMATION AND METHOD

### Data

I use annual data for the period 1991–2016. All data are collected from the Central Statistical Office of Poland. Table 1 presents the list of variable names applied in this research and their definitions. In the analysis I use log form of variables to deal with heteroscedasticity, and also because of more convenient interpretation.

**Table 1.** The list of the variables

Time-series variable	Definition
agri_wages	real average monthly wage in agriculture sector
manu_wages	real average monthly wage in manufacturing sector
agri_lab_productivity	agricultural labor productivity
manu_lab_productivity	manufacturing labor productivity

Source: Own elaboration.

Wages are expressed by average monthly real wages<sup>6</sup> in Poland in manufacturing and in agricultural sector. Real wages are obtained by using the Consumer Price Index (CPI). Labour productivity is calculated as the ratio between output and input use. The output can be measured either by global production or gross value added. Taking into account data availability for the years 1990–2016 and the fact, that there is usually a strong correlation between these two measures, I calculate labour productivity in agriculture as the global production produced by working person<sup>7</sup>. In case of manufacturing sector I take into account marketed production<sup>8</sup> obtained from each employee.

### Method

In order to determine relationships among time series variables regarding wage and labour productivity, for agriculture and manufacturing sectors separately, I adopt the autoregressive distributed lag (ARDL) framework, popularized by Pesaran and Shin [1995]. The ARDL model is a dynamic model in which the effect of a regressor  $x$  on  $y$  occurs over time rather than all at once and that provides results both for the long-run and short-run relationship. The model can be formulated as follows:

$$\Delta y = \beta_0 + \sum_{i=0}^n \beta_1 \Delta y_{t-1} + \sum_{i=0}^n \beta_2 \Delta x_{t-1} + \sum_{i=0}^n \lambda_1 y_{t-1} + \sum_{i=0}^n \lambda_2 \Delta x_{t-1} + \varepsilon \quad (1)$$

where:  $y$  – depended variable;

$x$  – regressor.

The first part of the equation with the  $\beta$  terms represents the short-run dynamics, whereas the second part with the  $\lambda$  terms represents the long-run relationship.  $\Delta$  is the operator of the first difference.

<sup>6</sup> Calculated by GUS methodology and include average monthly wages of employed persons.

<sup>7</sup> Includes working persons in the farms of natural persons, farms of legal persons and entities without legal personality (for methodology see GUS).

<sup>8</sup> Global production in section A and marketed production in industry calculated by GUS.

ARDL approach is appropriate for not large samples and applicable irrespective of whether the regressors are purely integrated of order zero:  $I(0)$ , or of order one:  $I(1)$ , or a mixture of both. However, there is still a requirement that none of the explanatory variables is of  $I(2)$  or higher. Therefore, as a first step, I test for the stationarity status of all variables to determine their order of integration. I apply Dickey–Fuller Test with GLS Detrending (DF-GLS) on each of the concerned variables. The presence of unit root indicates that it is a non-stationary process. Further, if the unit root can be removed after a time-series variable is first-differenced, then it can be confirmed that the time-series variable is an  $I(1)$  variable [Hamilton 1994]. By applying unit root test it is necessary to determine the length of the lagged  $\Delta y_{t-i}$  term. I specify the lag length by employing the Schwarz Information Criterion (SIC) automatic selection method with a maximum lag length of 2. The results of the unit root tests are reported in Table 2.

**Table 2.** Results of unit root test (ADF-GLS test)

Time series variables (in natural logarithms)	Levels (with intercept)	1st differences	Order of integration
Agricultural wage	1.58	-4.24***	$I(1)$
Manufacturing wages	1.68	-3.96***	$I(1)$
Agricultural labor productivity	-1.47	-2.38**	$I(1)$
Manufacturing labor productivity	1.70	-2.12**	$I(1)$

$H_0$ : has unit root (non-stationary).

\*\*, \*\*\* – indicate rejection of unit root at the 5 and 1% level of significance, respectively.

Source: Own elaboration.

The results indicate that all the time-series variables are not stationary at levels but their first differences are stationary at 1 or 5% level of statistical significance, meaning that they have the same integration order  $I(1)$ <sup>9</sup>.

Having established that none of the variables is  $I(2)$ , ARDL model is performed to examine the possible presence of cointegration among the variables, and to estimate the long-run coefficients, if such cointegration does, indeed, exist. First, I conduct bounds test for the null hypothesis of no cointegration. If the calculated  $F$ -statistic exceeds critical value, the null hypothesis can be rejected. If cointegration is confirmed, then the next step is to estimate the long-run coefficients by the ARDL approach. Then I perform residual diagnostics including autocorrelation, normality and heteroskedasticity tests.

## RESULTS

The estimates of ARDL bounds tests are summarized in Table 3. The first model includes the examination of possible cointegration between considered agricultural variables, while the second model between manufacturing variables. In order to select the optimal lag length for each variable in both models, I use Schwartz Bayesian Criterion (SBC) with the maximum lag length of 3 in both models as I deal with annual data and not large sample.

<sup>9</sup> For the confirmatory purpose two other unit root test are conducted: ADF (augmented Dickey–Fuller) and PP (Phillips–Perron). The results are consistent with the findings under the DF-GLS unit root test.

**Table 3.** ARDL bounds tests estimates

Time series variables	F-statistics
Model I: ln(agri_wages), ln(agri_lab_productivity)	34.39 ***
Model II: ln(manu_wages), ln(manu_lab_productivity)	93.74***

$H_0$ : no long run relationships exists; \*\*\* – rejection of  $H_0$  at the 1% level of significance.

Source: Own elaboration.

In both models the null hypothesis of no cointegration is rejected at 1% of statistical significance. This indicate the long-run relationship between real wage level and labour productivity in agriculture as well as in manufacturing sector. Next, I estimate the ARDL models. The outcomes of model I referring to agricultural sector are listed in Table 4.

**Table 4.** Estimates of ARDL(1,3) model I

Depended variable	ECM term	Short run coefficients			Long run coefficients	
		$\Delta(\text{agri\_wages})$ (-1)	$\Delta(\text{agri\_lab\_productivity})$	C	agri_lab_productivity	C
			-0.03			
agri_wages	-0.24***	0.75***	(i = 1) 0.09 (i = 2) -0.08 (i = 3) 0.13**	0.96***	0.40***	4.00***

\*\*\* – 1% level of significance. Optimal lag length (1,3) selected by SBC; i – lag’s number; ECM – error correction parameter; adj.  $R^2 = 0.99$ .

Source: Own elaboration.

Firstly it is necessary to look at the error correction term, that refers to the last-period deviation from a long-run equilibrium and influence short-run dynamics. Thus, it shows the speed with which model returns to equilibrium following an exogenous shock (in this case change in labour productivity). The negative and significant value of this term indicates long run causality running from independent to depended variable. The results reveal that there is a long run causality running form labour productivity to the wages in agriculture. The system corrects its previous period disequilibrium at a speed of 24% of disequilibrium correction yearly. In short-run the agricultural labour productivity variable with lag 3 is highly significant and affects wages (coefficient 0.13).

Further, the results indicate, that the long run relationship between wages and labour productivity in agriculture sector is given as follows:

$$\ln(\text{agri\_wages}) = 0.40 \ln(\text{agri\_lab\_productivity}) + 4.00 \quad (2)$$

This means that the long run elasticity of agriculture wages is 0.40. In equilibrium a 1% increase in the agriculture labour productivity increases wages by about 0.4%.

The estimates of the second model that includes manufacturing variables are reported in Table 4.

**Table 4.** Estimates of ARDL(1,0) model II

Depended variable	ECM term	Short run coefficients			Long run coefficients	
		manu_wages(-1)	manu_lab_productivity	C	manu_lab_productivity	C
manu_wages	-0.37***	0.62**	0.24***	0.99	0.64***	-0.003

\*\*\* – 1% level of significance. Optimal lag length (1,0) selected by SBC; ECM – error correction parameter; adj.  $R^2 = 0.99$ .

Source: Own elaboration.

Error correction term is negative and significant indicating long run causality running from labour productivity to the wages in manufacturing sector. The speed of adjustment is 37% of disequilibrium correction yearly. The short-run results in model II reveal that labour productivity significantly influence manufacturing wages in  $t$ -period (coefficient 0.24).

The long run relationship between wages and labour productivity in manufacture sector can be formulated as follows:

$$\ln(\text{manu\_wages}) = 0.64 \ln(\text{manu\_lab\_productivity}) \quad (3)$$

From the equation it can be concluded that, in the equilibrium real manufacturing wages increase by 0.64% if labour productivity in manufacture increases by 1%.

Finally, the residual diagnostics on ARDL model I and II is applied. I perform diagnostics including Ljung-Box Multiplier (LM) autocorrelation test, normality test, and heteroskedasticity test. The results of both models show that there is no evidence of non-normal distribution, autocorrelation or heteroskedasticity effect in the residuals.

## CONCLUSIONS

The relationship between labour productivity and real wages is well-documented in the theoretical literature. The main purpose of this study is to contribute to the existing empirical evidences by investigating the cointegration between real wages and labour productivity in two different sectors, agricultural and manufacturing, in Poland after introducing the free market economy.

Labour productivity in manufacturing is much higher than in agricultural sector. While the former demonstrates continuous and distinct growth since 1991, the latter is steadily characterized by very low values. However, with regard to the level of wages there are no essential disparities between these two sectors. Agriculture is on the privileged position and takes advantage of intersectoral allocation of resources.

The results of ARDL models reveal that the dynamic interactions among wages and productivity in Poland are consistent with the theoretical expectations. There is a long run causality running from labour productivity to wages in both sectors. The results do not confirm the opposite causality (i.e. from wages to labour productivity). This relation, however, differs depending on the economic sector. The yearly speed of adjustment following change in labour productivity is smaller in agricultural than in manufacturing sector and amounts 24 and 37% of disequilibrium respectively. Furthermore, the labour productivity affects real wages to a lesser degree in agriculture than in manufacture. Increase of 1% in labour productivity leads to 0.40% higher wages in agricultural, and

to 0.64% higher wages in manufacturing sector. The short-run analysis for both sectors is quite different as well, with the results that labour productivity positively affects wages in period  $t-3$  in agricultural (coefficient 0.13) and in  $t$ -period in case of manufacturing (coefficient 0.24) sector.

The results emerge that in both sectors labour productivity rises at higher rate than real wages what is advantageous for the economy. This is in line with existing evidences [Jarka 2016, Rembisz 2016]. But in case of agricultural sector, labour productivity affects wages slower and to a lesser extent than in manufacture. Very low agricultural labour productivity in Poland in comparison to other EU countries may suggest low rationality of management in agriculture taking into account producer's equilibrium, what results in low competitiveness of this sector and dependence on EU direct payments to farmers.

Relation between wages and productivity is likely to be affected by other factors as well, such as changes in technology, composition of the workforce, cost of capital or wage bargaining. Given the specificity of the aim of my research, and data availability these factors are not considered in this research. Nevertheless, in future this study can be further extended by including other relevant variables.

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## **DŁUGOOKRESOWA ZALEŻNOŚĆ MIĘDZY POZIOMEM WYNAGRODZEŃ A WYDAJNOŚCIĄ PRACY W SEKTORACH ROLNYM I PRZEMYSŁOWYM W POLSCE**

### **STRESZCZENIE**

Celem artykułu jest zbadanie długookresowej zależności między poziomem realnych wynagrodzeń a wydajnością pracy w sektorach rolnym oraz przemysłowym w Polsce w latach 1991–2016. W celu określenia długookresowej dynamiki zastosowano model autoregresyjny z rozkładem opóźnień (ARDL). Potwierdzono wpływ wydajności pracy na poziom wynagrodzeń w obu sektorach. Wzrost wydajności na poziomie 1% powoduje zwiększenie się realnego wynagrodzenia o 0,40% w rolnictwie i o 0,64% w przemyśle. W następstwie wzrostu wydajności pracy roczna prędkość osiągnięcia stanu równowagi przez wynagrodzenia wynosi 24% w rolnictwie i 37% w przemyśle.

**Słowa kluczowe:** wynagrodzenia, wydajność pracy, model autoregresyjny z rozkładem opóźnień