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AGE AND WEAR OF SELECTED MEANS OF PRODUCTION IN FARMS

Summary

The paper aims at determining the relationship between age and degree of wear of selected technical fixed assets in farms. The correlation and regression analyses were performed for age as an independent variable and physical wear and functional wear as dependent variables. The research comprised 90 farms in southern Poland and focused mainly on farm buildings and mechanical equipment used in the farms. The results indicate, inter alia, an average or strong correlation between age and physical wear and a significantly weaker correlation between age and functional wear.
***Key words**: physical wear, functional wear, age, mechanical equipment, buildings*

WIEK A ZUŻYCIE WYBRANYCH TECHNICZNYCH ŚRODKÓW PRODUKCJI W GOSPODARSTWACH ROLNYCH

Streszczenie

Celem pracy jest określenie zależności pomiędzy wiekiem a poziomem zużycia wybranych technicznych środków trwałych w gospodarstwach rolnych. Dokonano analizy korelacji oraz regresji dla wieku jako zmiennej niezależnej oraz zużycia fizycznego oraz funkcjonalnego jako zmiennych zależnych. Badania przeprowadzono w 90 gospodarstwach rolniczych Polski południowej. Zakresem badań objęto najczęściej występujące w gospodarstwach obiekty budowlane oraz sprzęt mechaniczny. Stwierdzono m. in. w przypadku większości obiektów budowlanych i wszystkich obiektów mechanicznych przeciętny lub silny związek korelacyjny pomiędzy wiekiem a zużyciem fizycznym oraz znacznie mniejsze zależności korelacyjne pomiędzy wiekiem a zużyciem funkcjonalnym.
***Słowa kluczowe:** zużycie fizyczne, zużycie funkcjonalne, wiek, obiekty mechaniczne, obiekty budowlane*

1. Introduction

In the context of structural changes and implementation of new technologies in agricultural production there is a natural need to assess the technical means of production. The literature of the subject matter presents very little information on technical condition and modernity of both, the buildings and tractors and machines used in farms. During their service life, equipment and buildings lose their utility value as a result of the wear process. The issue of wear and technical condition is very important, particularly in relation to machines and equipment used very intensively in relatively short periods of agrotechnical works [11]. The term physical wear means permanent, undesirable physical and chemical changes occurring during the service life, as a result of which the period of ability to perform utility functions by a facility becomes gradually exhausted. These processes result in changes of material properties or shape, mostly related to the existence of friction, pressure and chemical reactions inside the material and between the material and the environment [8, 10]. The degree of technical wear of fixed assets depends on age, durability of used materials, quality of workmanship, method of operation and operating conditions, design defects, maintenance, etc. Such wear is most often determined in percent [7, 9].

The term functional (moral) wear refers to permanent, undesirable changes of functional properties of facilities in relation to current standards resulting from technical and technological advancement [2]. In other words, functional wear is a loss of value of a facility caused by its reduced ability to satisfy specific needs of the user, as a result of e.g. technical and technological advancement. Due to significantly extended service life of agricultural equipment in Poland and long service life of farm buildings, the issues of physical and functional wear and its rate become particularly important.

2. Purpose and scope

The presented results are a fragment of a wider research on the degree of wear of technical means of production in agriculture. The purpose of the paper is to determine the relationship between age and degree of wear of selected technical fixed assets in farms. The correlation and regression analyses were performed for age as an independent variable and physical wear and functional wear as dependent variables. The research was conducted in 90 farms in southern Poland. The scope included most frequent farm buildings: cowsheds, garages, fruit and vegetable storehouses, greenhouses and barns. In case of mechanical equipment the scope included tractors, ploughs, tractor-mounted sprayers, trailers, manure spreaders, mowers and delivery vehicles.

3. Research methodology

The research was based on guided interview at farms in Krakow and Nowy Sącz counties. The technical conditions of buildings and mechanical equipment were evaluated using the methods presented in the literature [1, 4, 5, 6, 12].

Individual elements of facilities were evaluated. Weights were determined for individual elements according to the share of element replacement costs in the total costs of a facility.

The technical condition of each element was graded on a 0-3 scale, where

- 0 – element in need of an overhaul (or replacement),
- 1 – medium condition,
- 2 – good condition,
- 3 – very good condition.

Such technical description of a facility was then used to calculate its physical wear according to the formula:

$$S_{fz} = [1 - \sum_{i=1}^{n} (\frac{o_i}{p_i} \cdot w_i)] \cdot 100\% \quad (1)$$

where:

S_{fz} – physical wear, %,
n – number of evaluated elements of the building,
i – *i*th element of the building,
o_i – score on technical condition of the *i*th element of the building (o_i = from 0 to 3),
p_i – maximum score (p = 3),
w_i – weight of the *i*th element of the building (from 0 to 1; sum of weights= 1).

The degree of functional wear was determined according to the methodology presented i.a. in Professional Standards of Real Estate Appraisers [9], taking into account the proportions of changes of technical parameters of the evaluated facility and the benchmark – a state-of-the-art facility. The evaluation was made in terms of modernity, functionality, reliability, energy demand, safety, environmental impact. These factors were used to calculate the so-called weighted average degree of wear according to formula 2. The weights were assigned on a discretionary basis – on a case-by-case basis for individual categories of facilities.

$$S_{fn} = [1 - \sum_{j=1}^{m} (\frac{o_j}{p_j} \cdot w_j)] \cdot 100\%, \quad (2)$$

where:

S_{fn} – functional wear, %,
m – number of evaluation parameters/criteria,
j – *j*th evaluation parameter/criterion,
o_j – score of the *j*th parameter (o_j = from 0 to 3),
p_j – maximum score of the *j*th parameter,
w_j – weights of the *j*th parameter (from 0 to 1; sum of weights = 1).

The correlation and regression analysis was performed on the Statistica software. The independent variables included age (x_i) of farm buildings and age (r_i) of mechanical equipment, and the dependent variables were physical wear (y_{if}) and functional wear of (y_{im}) of farm buildings and physical wear (z_{if}) and functional wear (z_{im}) of mechanical equipment. The regression equations were formulated when the correlation coefficient was equal to or greater than 0.4.

4. Results

The research was conducted in areas dominated by horticulture. Thirty farms included in the research dealt mostly in growing of vegetables, 30 – in growing of fruit, and the next 30 had diversified production. The average farm area in the "vegetable group" was 7,21 ha, among the fruit farms – 6.72 ha, and among the diversified farms – 6.63 ha. Livestock was raised at commercial scale mainly in diversified farms, and the average livestock count was 9.83 LSU per farm. The farms included in the research generally had small greenhouses used to grow seedlings and storehouses for fruit and vegetables. The latter used to be other farm buildings in the past (cowsheds, piggeries, etc.) which became unused due to the change of the farm production profile and were subsequently converted to storage facilities. Table 1 presents general information on farm buildings included in the research. The most numerous were garages (79) and barns (72), and the least numerous were storehouses (29). The average age ranged from 16 years (storehouses) to 37 years (barns). In case of all farm buildings, except storehouses, the physical wear exceeds the functional wear.

Table 2 presents general information on mechanical equipment included in the research, among which the most numerous were tractors (126), and the least numerous were manure spreaders (32). The average age was ranged 12 years in case of sprayers to 21 in case of manure spreaders. All mechanical equipment had significantly higher physical wear than functional wear.

The analysis of data presented in Table 3 shows a significant relationship between age and degree of wear as indicated by the correlation coefficient in the 0.27–0.81 range. Greenhouses are the fastest wearing buildings, the reason being the microclimate inside, particularly high humidity which promotes corrosion of steel structural parts, heating and lighting systems, etc. In addition, glass or (less frequently) plastic walls and roofs of a greenhouse have relatively low durability. The low cowshed wear rate (k_i = 0.27) results mostly from the character of use. The cowsheds in the farms included in the research were mostly built many years ago, and now due to prevailing horticultural profile are filled with livestock only partially or are used as storage facilities, hence the wear process is slower. The analysis of data presented in Table 3 shows that age has much lower impact on the functional wear rate (in comparison to physical wear), as indicated by the correlation coefficient (k_j). The functionality loss rate is higher in facilities generally affected by fast technical and scientific advancement, in terms of both the design and equipment. Such facilities include greenhouses (k_j = 0.52) and fruit and vegetables storehouses (k_j = 0.42). The greenhouses are ageing mainly as a result of newer solutions in microclimate control, such as irrigation and fertigation systems, shading, heating, ventilation, CO_2 enrichment. On one hand, the innovations reduce production costs and on the other hand they increase the yield.

Table 1. Number, age and wear of selected farm buildings
Tab. 1. Liczba, wiek oraz zużycie wybranych obiektów budowlanych

Building type	Number (pcs)	Age (years)				Wear (%)	
		Mean	Minimum	Maximum		Physical	Functional
Cowsheds	31	**29**	2	49		43	18
Barns	72	**37**	7	59		49	12
Greenhouses	34	**19**	5	35		35	33
Garages	79	**21**	1	36		32	14
Storehouses	30	**16**	3	40		28	29

Source: own work / Źródło: opracowanie własne

Table 2. Number, age and wear of mechanical equipment
Tab. 2. Liczba, wiek oraz zużycie obiektów mechanicznych

Equipment type	Number (pcs)	Age (years)			Wear (%)	
		Mean	Minimum	Maximum	Physical	Functional
Agricultural tractors	126	19	2	42	39	28
Ploughs	82	20	1	46	42	26
Sprayers	83	12	1	27	27	15
Trailers	69	20	5	38	44	24
Manure spreaders	32	21	4	30	50	32
Mowers	37	16	3	27	31	22
Delivery vehicles	52	13	3	26	32	18

Source: own work / Źródło: opracowanie własne

Table 3. Relationship between age and wear for selected farm buildings
Tab. 3. Zależność pomiędzy wiekiem a zużyciem wybranych obiektów budowlanych

Building type	Physical wear		Functional wear	
	Correlation coefficient (k_i)	Regression equation	Correlation coefficient (k_j)	Regression equation
Cowsheds	0.27	-	0.27	-
Barns	0.41	$y_{2f} = 0.5618x_2 + 33.6$	0.30	-
Greenhouses	0.81	$y_{3f} = 1.3066x_3 + 6.7$	0.52	$y_{3m} = 0.3287x_3 + 7.4$
Garages	0.57	$y_{4f} = 0.8975x_4 + 8.2$	0.23	-
Storehouses	0.59	$y_{5f} = 0.6907x_5 + 12.9$	0.42	$y_{5m} = 0.3691x_5 + 8.3$

Source: own work / Źródło: opracowanie własne

Table 4. Relationship between age and wear for selected mechanical equipment
Tab. 4. Zależność pomiędzy wiekiem a zużyciem wybranych obiektów mechanicznych

Equipment type	Physical wear		Functional wear	
	Correlation coefficient (k_i)	Regression equation	Correlation coefficient (k_j)	Regression equation
Agricultural tractors	0.49	$z_{1f} = 1.1297r_1 + 13.4$	0.43	$z_{1m} = 0.6078r_1 + 14.4$
Ploughs	0.42	$z_{2f} = 1.0375\ r_2 + 19.2$	0.16	-
Sprayers	0.66	$z_{3f} = 1.2883\ r_3 + 6.9$	0.46	$z_{3m} = 0.8155r_3 + 5.1$
Trailers	0.45	$z_{4f} = 0.9543\ r_4 + 25.4$	0.31	-
Manure spreaders	0.61	$z_{5f} = 1.3315\ r_5 + 24.2$	0.21	-
Mowers	0.56	$z_{6f} = 1.4923\ r_6 + 7.9$	0.39	-
Delivery vehicles	0.57	$z_{7f} = 1.8864\ r_7 + 6.0$	0.59	$z_{7m} = 1.0962r_7 + 4.1$

Source: own work / Źródło: opracowanie własne

In case of storehouses, the new developments in storage technology mostly concern the microclimate control in chambers which results in reduced storage losses and in better quality of fruit and vegetables stored even for a long time. Unfortunately, the majority of greenhouses and storehouses included in this research are obsolete.

The values of correlation coefficient between age and degree of wear of mechanical equipment presented in Table 4 clearly prove that there is a relationship. The machines with the fastest wear rate are sprayers and manure spreaders for which the correlation coefficient (k_i) is 0.66 and 0.61, respectively. The low durability of sprayers is mainly a result of structural materials used: plastics for tanks and nozzles, and rubber for hoses. Both plastics and rubbers have a much faster natural ageing rate and are more susceptible to mechanical damage than for instance metals. The physical wear of manure spreaders is also affected by their operation conditions, i.e. the materials that are in contact with during work. Due to nitrogen content, the manure is highly corrosive to steel parts. In addition, the manure spreaders are often used also as means of transport which significantly extends their time of operation during a year. The correlation between age and degree of functional wear clearly proves that the highest wear rate affects the most complex and technically advanced equipment. In case of equipment included in the research, this category includes delivery vehicles ($k_j = 0.59$). sprayers ($k_j = 0.46$) and tractors ($k_j = 0.43$). Moreover, in case of sprayers the obligatory certification requirements are not without significance either as they contribute to implementation of more advanced and environmentally friendly solutions.

5. Conclusions

The findings of the research indicate that:

1. In case of farm buildings (except cowsheds), the relationship between age and degree of physical wear was medium, strong or very strong, as proven by the correlation coefficient k_i in the 0.41-0.81 range.
2. The highest correlation between age and physical wear of farm buildings ($k_i = 0.81$), was recorded for greenhouses which mainly stems from low durability of structural materials, operating conditions, and high intensity of use. The lowest correlation between age and physical wear of cowsheds may be a result of low intensity of use, that is low filling with livestock, particularly in farms focusing on growing fruit or vegetables.
3. Among the farm buildings, the average correlation between age and functional wear was noted only in storehouses ($k_j = 0.42$) and greenhouses ($k_j = 0.52$). These are the facilities with generally the fastest technological advancement in terms of structure and equipment.
4. For all mechanical equipment the correlation between age and physical wear was average or strong, as indicated by the correlation coefficient k_i in the 0.42 – 0.66 range.

5. The highest correlation between age and physical wear of sprayers (k_i = 0.66) and manure spreaders (k_i = 0,61) can be explained by a relatively low durability of structural materials of sprayers, and operating conditions and intensive use of manure spreaders which are also used as means of transport.
6. The average correlation between age and functional wear of mechanical equipment was found only in case of delivery vehicles (k_j = 0.59), tractors (k_j = 0.43) and sprayers (k_j = 0.46). Vehicles and tractors are technical means with the highest complexity of design and operation and generally they belong to the area where the technical advancements occur very fast. As far as the sprayers are concerned, the cause of this relationship is also technical advancement and in addition the changing legal regulations concerning their operation.

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