

DETERMINANTS OF AGRICULTURAL TRACTOR SELECTION – ASSESSMENT FROM THE PERSPECTIVE OF A SUPPLIER OF VEHICLES AND MEANS OF TRANSPORT USED IN AGRICULTURE

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Abstract:

The subject of the research described in the presented study are the determinants of the selection of agricultural tractors. The research was conducted from the perspective of suppliers of vehicles and means of transport used in agriculture. Its fundamental aim was an attempt to answer the question concerning factors that are crucial from the buyer's perspective and determine their decision to choose a specific tractor. Achieving the main goal required identifying and defining factors conditioning the decision-making process (the multi-criteria model), which was validated later in the study (the assessment of the significance of requirements). Such an approach enabled conclusions and recommendations regarding the method and direction of improvement in the range of offered tractors and related logistic customer service processes. The main burden of the study fell on desk research analysis including the overview of available literature and documentation sources as well as an expert debate (the method of competent judges). In order to transfer the issue to the level of the agricultural machinery sector – through an interview among a deliberately selected group of suppliers of vehicles and means of transport used in agriculture (including New Holland, Claas, Fendt, John Deer, Kubota, Deutz Fahr, Case IH, Massey Ferguson, Zetor, Farmtrac Tractors Europe) – the importance of determinants was clarified (the hierarchy of importance).

Keywords:

determinants of the choice of agricultural tractors, agricultural vehicles and means of transport.

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1. A word of introduction

The starting point of the presented study are the authors' experiences, which well illustrates the possibility of adapting the results obtained in interdisciplinary research to the needs of newly identified problems defined in management practice. Nowadays, whenever it is assumed that production will be adjusted to the dynamically changing customer requirements (responsive manufacturing), it should be ensured that in each case a product tailored to the customer's needs is created [1]. Therefore, apart from personalization of the final product [2], the issue of agile reorganization of production [3] depending on changes in the economic situation on the market is also important. Meeting the challenges related to low-emission production constitutes an important point on the development map of modern enterprises [4]. It is the responsibility of the latter to take appropriate actions aimed at increasing the efficiency of creating new products and managing their circulation [5]. Increasing environmental pressure [6] combined with shrinking natural resources will force the closing of the raw material cycle and the re-use of resources previously treated

as waste [7]. As a serious challenge, it requires a number of adjustments in the production area. This raises crucial technological issues for enterprises, as the circular economy will require new materials and new methods of product design (eco-design) and types of sales. Therefore, global manufacturers, wanting to maintain their market position, constantly modify their methods of operation to achieve previously assumed results and ensure final success. The situation is similar on the Polish market of the agricultural machinery sector, where sales processes are subject to the pressure of changes in the environment. Market changes resulting from new trends [8], distribution channels, customer expectations, technological changes and methods of communication [9] become visible.

Therefore, the development of sales requires knowledge of the factors determining the choice of a specific product [11–13]. It also demands adaptation to the specificity of a given sector. The research referred to in this paper was conducted with the agricultural machinery sector in mind. It was carried out from the perspective of suppliers of vehicles and means of transport used in agriculture. Its aim was to attempt an answer to the question of the factors that are crucial from the buyer's point of view and determine their decision to choose a specific agricultural tractor. At the theoretical level, the method of reconstruction and interpretation of the literature on the issues of logistic customer service was applied (the determinants of supplier selection, supplier qualification, the criteria for locating supplies), while at the design level, a research procedure was initiated based on a creative discussion conducted among deliberately selected field experts (competent judges). At the practical level, it was necessary to develop a list of factors determining the choice of an agricultural tractor and verify their significance in business practice – the assessment of selected determinants from the perspective of suppliers of vehicles and means of transport used in agriculture. Companies related to brands such as: New Holland, Claas, Fendt, John Deer, Kubota, Deutz Fahr, Case IH, Massey Ferguson, Zetor, Farmtrac Tractors Europe were invited to participate.

2. Agricultural tractors – market characteristics

Agricultural tractors (Figure 1) are vehicles whose primary task is to cooperate with agricultural tools and machines [18–19]. According to road traffic law, an agricultural tractor is a motor vehicle [20] designed to be used together with equipment for agricultural, forestry [14–15] or horticultural jobs [16]. Such a tractor can also be adapted to pull trailers and for earthworks [20]. A tractor connected in this way with a tool, machine or trailer constitutes a machine unit or a transport unit [17]. It should be added here that in order to improve and increase the efficiency of work performed using tractor units, it is necessary to obtain information about the forces at work between the tractor and the tools attached to it. A lot of researchers have dealt with this issue [25–27].

Additionally, an agricultural tractor can transmit useful energy through the towing attachment or through the power take-off shaft (PTO), as well as through the external hydraulics unit. The basic components of an agricultural tractor include the drive transmission mechanisms, the running gear, the braking mechanism, the hydraulic lift, external hydraulics, the pneumatic system, electrical devices and the cabin. The running gear is most often wheeled with drive on one or both axles [21]. The hydraulic lift is important and used to connect machines to the tractor by means of attachment devices – a swing hitch, a transport hitch or a drawbar. The hydraulic lift is also called the three-point hitch as it is the most important element of

the Three-Point Suspension System. The three-point hitch allows lifting tools to the transport position and setting them to the working position. Connecting the implements to the tractor at three points using ball joints allows their

multi-directional movement. Tractor manufacturers are implementing electronic linkage control more and more frequently. The most universal solution is the three-point hitch located at the front of the agricultural tractor [22–24].

Fig. 1. John Deere agricultural tractor model 6140M



Source: <https://www.deere.pl> (view date 04/01/2024).

Choosing the right brand of an agricultural tractor is one of the most important decisions for every user (farmer). This choice not only determines the comfort and efficiency of work in the field, but also the durability of the machine and the costs of its operation. An agricultural tractor can be a universal or specialized machine, and the choice will depend on the application. In the course of the selection, one must first consider the annual use of the tractor. In each case, the type of the tractor must also be adapted to the specificity of the farm, including the type of cultivated soil. The size of the fields is also important – farms with relatively small fields should be equipped with tractors with a fairly high level of maneuverability. It is assumed that on multi-purpose farms and those focused on animal production, a larger number of tractors of different power levels are used, while on farms focusing mainly on cereal cultivation, there are fewer tractors, but they are of much higher power. The power of the agricultural tractor should also be adapted to the needs of the farm and the type of soil.

The most noticeable trend in the designs of modern agricultural tractors is the increasing share of electronic devices and systems replacing traditional levers activating the functions of working units. The common rail system in the engine or hydraulic lift control using the EHR system are standard equipment in many tractors (including lower power ones). PowerShift gearboxes, in which some gears (the so-called half-gears) can be changed under load, are becoming an increasingly universal standard. In more advanced tractor designs, gear changing is performed by means of a joystick with a multi-function lever. In such designs, gears can also be changed automatically based on a programmed sequence. Many modern tractors, instead of dual-clutch PowerShift gearboxes, use CVT (Continuously Variable Transmission) gearboxes with an infinite number of gear ratios, engaged without disconnecting the drive. Such gears are

controlled by electronic systems enabling programming of the driving speed of the unit.

The electronics also allow the driver to control the valves of the external hydraulic system. In this case, hydraulic valves are actuated by fingertip buttons or joysticks (crossgate levers) with programmable buttons. A characteristic feature of modern agricultural tractors are thus armrests. The joystick integrated with the armrest allows the driver to adjust the speed (without the need to press the gas pedal) and the direction of travel. The multifunctional lever also offers cruise control and speed memory functions. In addition, the joystick has buttons for activating the lift, PTO, automatic driving and sequence of actions.

The ISOBUS data transfer bus is standard in modern tractors. This solution offers a lot of possibilities in terms of tractor and machine control, all through just one terminal. Other advantages of ISOBUS include the ability to collect data from sensors of various types placed on the tractor and machines useful in managing the machinery and the entire farm. Terminals operating within the ISOBUS standard that tractors are equipped with are highly developed devices offering tablet capabilities, including browsing websites, receiving e-mails and access to farm production management software.

According to market research, the most frequently chosen tractor brands in Poland include: New Holland, John Deere, Kubota, Deutz-Fahr, Case IH, Massey Ferguson, Valtra, Farmtrac Tractors Europe, Claas, Solis and Fendt. These are both global technological leaders as well as brands with an established position in Poland. Their popularity is based on solid construction, modern solutions, a wide range of models and a well-developed service network. The identifying features of selected brands of agricultural tractors are shown in Table 1.

Table 1. Key values of selected tractors – TOP 12 most popular brands in January – November 2023.

No.	Brand	Country of origin	Key characteristics	Number of registrations	Photo
1.	New Holland	USA Italy	Distinguished by its designer appearance and numerous accessories	1517 pcs.	
2.	John Deere	USA	Modernity and precision of workmanship	1473 pcs.	
3.	Kubota	Japan	Quality and comfort of work, modern design. Attention to workmanship, modern technologies	1074 pcs.	
4.	Deutz-Fahr	Italy	Reliability and price	796 pcs.	
5.	Case IH	USA	High efficiency and performance	556 pcs.	
6.	Massey Ferguson	USA	Comfort and economy	460 pcs.	
7.	Valtra	USA	Reliability, versatility, durability	426 pcs.	

No.	Brand	Country of origin	Key characteristics	Number of registrations	Photo
8.	Farmtrac Tractors Europe	Poland	Simple and reliable design – without excessive amounts of electronics	367 pcs.	
9.	Claas	Germany	Precision appreciated by demanding users	348 pcs.	
10.	Solis	India	High quality products. Value and economy	308 pcs.	
11.	Fendt	Germany	A renowned German manufacturer with its timeless style, a quality leader	281 pcs.	
12.	Zetor	Czech Republic	Ease of use and reliability	274 pcs.	

Source: own study based on data from the Central Register of Vehicles and Drivers and the Polish Chamber of Commerce for Agricultural Machines and Facilities

Two brands alternate at the top of the list of the most frequently chosen tractors: John Deere and New Holland. The number of registrations of vehicles in January-November 2023 period was: New Holland – 1,517 pcs. John Deere – 1,473 pcs. In 2022, a total of 1,849 New Holland vehicles were registered and 1,617 of John Deere ones.

Therefore, the question arises: what factors influence such a high level of registrations (read: purchases) of these vehicles, and therefore what criteria do users (buyers) follow when choosing an agricultural tractor from the said manufacturers? In the context of the above, attention was paid to selected values that define the indicated brands. The test results are presented in Table 2.

Table 2. New Holland and John Deere tractors' key characteristics – evaluation in the context of the criterion

Brand	Key characteristics	Value manifestation
New Holland	Power and efficiency	<ul style="list-style-type: none"> - Technologically advanced engines. - The vehicles meet the requirements of the Stage V exhaust emission standard. - Fuel saving. - High efficiency and performance.
	Parts and service	<ul style="list-style-type: none"> - New Holland has developed a range of original spare parts. - They were manufactured while maintaining the same quality standards as components installed in brand new tractors.
	Sustainable development	<ul style="list-style-type: none"> - Promoting the life cycle of circular products. - Regeneration of components in accordance with an approach based on circular economy.
	Simple operation	<ul style="list-style-type: none"> - Extended service intervals of up to 600 hours. - All daily maintenance checks can be performed quickly and easily.
	A pleasure to drive	<ul style="list-style-type: none"> - VisionView™ deluxe cab, specially designed to maximize comfort at work.
	Dealer network	<ul style="list-style-type: none"> - Sales and servicing are carried out by the Authorized Dealers' Network throughout Poland. - 14 dealers, 45 sales centres and an additional 4 sub-dealer centres.
	Additional warranty	<ul style="list-style-type: none"> - The customer can extend the warranty up to 5 years for an additional fee.
	Model range	<ul style="list-style-type: none"> - The range of tractor models has been developed following intensive consultation with New Holland customers, including contractors and general agricultural and arable farmers.
	Financial services	<ul style="list-style-type: none"> - In 2014, the Polish branch of CNH Industrial Capital Europe SAS was established. The company provides financial services to customers of authorized dealers of New Holland agricultural machinery. - Flexible financial solutions tailored to individual needs of New Holland customers.
	Elegant line. Attractive design	<ul style="list-style-type: none"> - The design is distinguished by headlights, side air intakes and a roof with a downward-folding profile equipped with up to 16 LED cabin lamps, including marker lights in a classic car style.
	Versatility	<ul style="list-style-type: none"> - The tractor is perfect for agricultural work, but it also works well with PTO-driven equipment and – as a result of its maneuverability – with a front loader. Additionally, the machine can be successfully used in transportation. New Holland is also an excellent solution for municipal services in cities and communes.
John Deere	Innovation	<ul style="list-style-type: none"> - G5 or G5 Plus display (offers additional features such as AutoTrac, section control and variable rate, increasing operator comfort). - JDLink (a telematics system that enables the visualization and comparison of data from the entire fleet of John Deere machines. It provides access to real-time information, such as fuel consumption and engine load, which facilitates effective tractor management). - Starfire receiver (geolocation accuracy between passes. These receivers track 4 satellite constellations, which guarantees signal stability and full accuracy in a short time). - John Deere Operations Center. Free online platform or mobile application enabling comprehensive farm management. It enables the digital management of data from every area of agricultural activity.
	Sustainable development	<ul style="list-style-type: none"> - Commitment to the development of agriculture, improving its efficiency and caring for the planet and machine operators.
	Sales and service network	<ul style="list-style-type: none"> - Providing after-sales service (the customer's distance from the nearest service point should not exceed an hour). - Each dealer runs the so-called harvest duty shifts. - Replacement vehicles. - Spare parts supplied within 24 hours.
	Corporate Social Responsibility (CSR)	<ul style="list-style-type: none"> - \$200 million to make a lasting, purposeful impact in the communities we serve and the families who live, work and learn with us (John Deere Foundation).
	Power, efficiency, ergonomics	<ul style="list-style-type: none"> - Comfort of operation in a modernized cabin. - Bright and reliable lighting due to lighting packages. - High performance as a result of powerful engines. - Exceptional performance and power resulting from a wide range of transmissions. - Comfort and stability provided by the frame and optional suspension systems

Source: own study based on John Deere's (www.deere.pl) and New Holland's (www.agriculture.newholland.com) promotional materials.

To sum up, it should be emphasized that by joining the threads related to Agriculture 4.0, John Deere and New Holland do not merely offer excellent efficiency and versatility of tractors, but extremely attractive benefits (values) reinforcing the trend of precision agriculture as well.

3. Material and method (evaluation catalogue)

In order to identify the criteria for selecting an agricultural tractor, the knowledge of nine experts (the creative discussion) directly related to production companies operating in the agricultural machinery sector was used. In the course of the selection process, the following were considered: primarily their professional experience (implementation, sales and marketing processes, management and logistic customer service). In each case, the participants were professionally active people, actively involved

in the management or sales and product processes of the enterprises they originated from or for which they worked. Additionally, the experts were selected on the basis of such features as competence (expressing the degree of qualification of the expert in the field and determined on the basis of the analysis of the expert's creative activity, the knowledge of the sector, understanding of the problems), creativity (the ability to solve creative tasks), the attitude to research and development work, conformism, constructive thinking or self-criticism. Detailed characteristics of the experts are presented in Table 3.

Table 3. Directory of domain experts

Acronym	Expert	Tasks / specialization	Number	Age	Seniority	Company size
B.P. I.K., P.N, G.W. T.P. B.W.	Business owners (agricultural machinery sector)	Organization and management: developing and implementing the company's strategic goals (including marketing, sales, implementation)	6	30–40 years old		Small company (up to 50 employees) 2 persons
J.K.	Product manager	Monitoring the market and competition. Defining the product vision. Developing the vision among stakeholders for the product. Prioritizing product features and capabilities.	1	41–50 years old	Up to 15 years 1 person	Medium-sized company (51–250 employees) 4 persons
W.B.	Chairman of the Board	Coordination of the Company's activities in all areas of its operations, including those related to the product	1	60 years and older	Over 15 years 9 people	Big company (over 250 employees) 3 persons
P.L.	Director of Product and Network Development	Co-creation and implementation of sales strategy. Identifying and needs. Introducing tools aimed at increasing sales shares	1			

Source: own work.

The total number of experts and the percentage composition of the group were related to the scope of the problem being solved, the reliability of the assessments and the expenditure on conducting the expertise. The size of the problem being solved determined the need to include only field specialists (agricultural tractors) in the expertise. This is related to the number of different aspects and factors that should be considered when solving the problem.

The brainstorming session led to establishing three key stages: (1) *Discussion of the work and formulation of the tasks to be solved during the session*. It was agreed that each expert had the right to comment

on the topic discussed. It was also noted that in addition to presenting one's own ideas, it was worth developing and combining ideas against findings of outstanding researchers (due to the desire to examine the most popular trends and standardize the approach when formulating evaluation criteria, the analysis of texts in Polish and English was performed), (2) *conducting a brainstorming session* (creating a list of choice determinants), (3) *clarification of the suggested criteria* (discussing the criteria in relation to the way they are interpreted, grouping similar criteria). Closing the session, the final assessment of the results was formulated. In this way, the final form of the assessment sheet was established (Table 4).

Table 4. Determinants of the choice of an agricultural tractor – results of the creative discussion

No.	Acronym	Criterion	Comments / Conclusions
1.	$P_{\text{ROD}^{\text{QUAL}}}$	Product quality (agricultural tractor)	Product durability and reliability. The tractor has the ability to perform its intended functions over the long foreseen period (over 5 years).
2.	$TE_{\text{CH}^{\text{EFFIC}}}$	Technological efficiency determines the profitability of production activities	The minimum efficiency of the tractor should be high enough to enable the completion of a certain amount of work before the deadline. It should therefore ensure timely performance of work in accordance with agrotechnical requirements, with a guarantee of the highest possible quality and low losses. One of the most important technical parameters of an agricultural tractor is its power ¹ , gearbox ² , fuel consumption or ease of use (ergonomics). Other important parameters are the tractor's own weight, length, width and wheel track. The basic equipment and amenities such as air conditioning, interior LED lights or reversing cameras were analysed.
3.	B_{RAND}	Brand	The tractor brand is a set of unique features and attributes used to identify it. According to market research, the most frequently chosen tractor brands in Poland include: Zetor, Ursus, John Deere, New Holland, Case IH, Massey Ferguson, Fendt and Deutz-Fahr. These are both global technology leaders as well as well-established brands. Their popularity is based on solid construction, modern solutions, a wide range of models and a well-developed service network.
4.	P_{RICE}	Price	The amount that the buyer spends in the exchange process; the cash that the buyer must sacrifice in exchange for the purchased values represented by the tractor.
5.	$\text{SPARE}_{\text{PARTS SERVICE AND SUPPLY}}$	Service; spare parts' supply	Assessment criteria: Reliable supply of spare parts, access to spare parts (own warehouse), quick response, cost analysis and effective repair, only original spare parts, a wide range of services, qualified staff and positive customer reviews.
6.	$\text{COSTS}_{\text{OF OPERATING}}$	Operating costs	The costs associated with operating the tractor are divided into maintenance costs (fixed costs), such as depreciation, insurance, and costs of its use (variable costs), such as repair costs, fuel and lubricant costs, maintenance costs, etc.
7.	$\text{ABOUT}_{\text{K.GW.}}$	Length of the warranty period, scope and possibility of extending the warranty	The law does not regulate the duration of the warranty, so it is up to the manufacturer. If the manufacturer does not specify the protection period, it is assumed to be 2 years from the moment the consumer receives the goods. Most agricultural tractor manufacturers give customers a lot of choice regarding the so-called options or additional warranty. The price in this respect varies greatly and depends on the customer's preferences in terms of the number of hours, period, model, or even the scope of the warranty. Extraordinary warranties are based on their uniqueness, and include, among others: a very long validity period, a wide scope of protection, offering the customer a particularly simple and convenient complaint procedure or the right to a refund without asking for reasons.
8.	PAY_{TERM}	Extended payment term	The seller offers the advantage of deferring payment in time. Sometimes the seller grants deferred payment, but requires payment of part of the obligation immediately.
9.	BART_{ER}	Possibility of settlement with used tractors	Purchase of a used tractor by the dealer, which is acquired as settlement in the sale of a new one. If there is a difference between the delivery value, the difference is compensated by the repayment on behalf of the buyer.
10.	$\text{OPER}_{\text{TRAIN.}}$	Operation training	Applies to safe use, maintenance, adjustments, assembly, transport, as well as all other information regarding the safe use of the tractor.
11.	$\text{GR}_{\text{SUR.}}$	Granting sureties	Strengthening the dealer's credibility through a guarantee provided by the manufacturer is one of the surest ways for the buyer to protect himself against risk.
12.	$L_{\text{OAN.ASS.}}$	Help in obtaining a loan	Consulting in the field of obtaining financial resources. The offer is tailored to the customer's needs and requirements. Cooperation with banks and lessors.
13.	$\text{SUBS}_{\text{ASS.}}$	Assistance in obtaining a subsidy	Professional assistance in obtaining funds for the purchase of a tractor. Specialist knowledge in the field of obtaining EU funds, subsidies, EU funding, management and settlement of EU projects.
14.	DEL_{TIME}	Delivery/processing time	The minimum delivery time allowed by the ordering party.
15.	$\text{MULT}_{\text{.FUNC.}} \text{MOD}_{\text{.LEV.}}$	Multifunctionality Modernity level	Tractors equipped with a number of technical solutions that enable an increase in the efficiency of agrotechnical operations and improve the comfort of the operator's work. In the most advanced designs, the operator is replaced by systems that activate functions controlling the tractor's assemblies in automatic mode. A high degree of meeting the requirements resulting from the needs, taking into account the latest achievements and experience in the processes of design, construction, production and operation. An increasing share of electronic devices and systems.
16.	$R_{\text{EF.}}$	References from other users	Confirmation of the manufacturer's brand received from existing users.

¹ Accurate planning of tractor power for a farm with a specific area of agricultural land and the direction and structure of production requires a detailed analysis of the production activities carried out on the farm.

² The number of gears directly affects the efficiency and economy of work.

No.	Acronym	Criterion	Comments / Conclusions
17.	E _{ERGO.}	Ergonomics	Designing all tractor operating systems in accordance with the recommendations of conceptual ergonomics. Safety and counteracting burdensome and unfavorable effects of workspace elements, thus ensuring optimal working conditions for the operator.
18.	M _{ANUF.}	Origin of the tractor manufacturer (country of production) implying production methods in accordance with the concept of a sustainable economy	The choices are determined by the specificity of the country, structure and dominant forms of distribution, as well as the degree of concentration of manufacturers. The company uses efficient and modern production technologies that are neutral (not harmful) to the environment. New methods of organizing production (aimed primarily at eliminating any losses resulting from production processes) significantly defining the agricultural tractor as a sustainable product. In the context of sustainability, attention is paid to the tractor's compliance with EU directives. The compliance with the regulations on technical conditions and tractor equipment (traffic on public roads) is key, as well as meeting environmental standards that are a prerequisite for sustainable production.
19.	EU _{FUNDS}	Possibility of financing from EU funds	The tractor is eligible for direct farming subsidies. This is confirmed by the assessment of the rationality of purchase and use made by comparing the potential use on the farm with the value of the indicator constituting the evaluation criterion – the basic or additional criterion – established for a given type of tractor.
20.	C _{OMP.}	Compatibility – matching the tractor to the existing machinery	Smooth and flexible configuration of machine and tractor operating parameters. Trouble-free operation of the tractor, which is possible as a result of matching it to the existing machinery. Such an approach allows the user to optimize cultivation technology, reduce costs, shorten process time and increase the quality of crops.
21.	D _{EALLOC.}	Attractive location	Natural factors, including: soil type – mainly due to its compactness affecting the resistance of tillage tools and the required pull class of tractors cooperating with these tools, as well as climatic conditions, especially the level and frequency of rainfall during periods of field work. Topographic factors: topographic relief, number of plots constituting the farm and their distance from the habitat (the layout), the condition of access roads, the size and shape of fields, terrain obstacles. Economic factors: the current state of farm equipment with the means of mechanization and the possibility of implementing machinery investments, the profitability of introducing technical progress depending, among others, on the ratio of the cost of mechanization to resources and labor costs, expected measurable and non-measurable effects of modernization.
22.	F _{LEX.}	Flexibility; possibility of configuration according to one's needs and preferences	The customer is involved in the creation of the values of which they themselves are the recipients; the customer's actions consist in the broadly understood individualization of the value composition, i.e. taking actions aimed at obtaining values tailored to their needs and expectations (customization).
23.	RES.TO.BAD _{SERV.}	Resistance to bad service	The machine is resistant to human errors, which reduces unplanned downtime and extends the time of failure-free operation. The increase in safety also results from the use of increasingly better technologies and security systems.
24.	RES.TO. _{WORK.COND.}	Resistance to changing working conditions	Operation of the machine in conditions resulting from disturbances violating its normal operating conditions.
25.	T _{EST.}	Testing opportunities	Allowing the user to "own" the machine for a day. During this period, the agricultural manufacturer can test the tractor free of charge.

Source: own work.

The model of determinants of the choice of an agricultural tractor presented in this study was developed in such a way that the individual criteria are correlated, intertwined and complementary. The defined determinants are not permanent categories: the model was constructed in such a way that it can be modified and supplemented according to one's needs. The authors are aware that creating lists is very difficult, as individual experts develop a wide spectrum of criteria, without ranking them, naming and interpreting them differently. Moreover, the choice of criteria is always a subjective matter and depends on the needs of their authors or the institution for which they were developed. Therefore, the authors point out that the identification of choice determinants is not a one-time act, but should be a periodically repeated process aimed at updating, correcting and adapting to the constantly changing environmental conditions in which manufacturers operate.

3. Survey results (hierarchization)

Due to the difficulties in reaching a large group of enterprises that could constitute a representative research sample, the study was conducted on a purposively selected sample. Forty-one (41) professional managers were invited to participate in the research whose insight is based on reliable

knowledge, professional skills, rational methods, efficient and effective methods and strategies of sales management. In order to obtain the fastest possible answers, surveys were carried out among respondents associated with (through cooperation): (1) Spare Parts and Agricultural Machinery Production Plant "Fortschritt", (2) Poznań University of Life Sciences, (3) Polish Chamber of Commerce for Agricultural Machines and Facilities.

The vast majority of the survey was completed by people holding top management positions in the company. Most often, they were owners and co-owners (53.49%) or members of the company's management board (32.56%). The percentage of respondents from senior or middle management of the company (6.98%) and those holding lower positions in the company (2.33%) was much smaller. The majority (51.22%) of the respondents representing enterprises completing the survey questionnaire had master's degrees. It should be stressed that a separate (and relatively numerous) category included people who not only possessed higher education, but had also completed postgraduate studies (7.32%). There was a visible share of people with higher education – bachelor's or engineer's degrees (12.20%). Still, only 29.27% of respondents had less than higher education (having graduated from vocational and secondary schools, with people with secondary education dominating in this group).

The majority of the respondents completing the survey questionnaire were people aged 45–54 (43.90%). There was also a significant share of people aged 36–44 (21.95%) and 55–65 (14.63%). Younger people, i.e. under 35 years of age, constituted only 4.88% of all respondents, and those aged 65+ – as much as 14.63%. Those surveyed had very extensive experience in working in the sector, as 78.05% would boast over 15 years of work experience in the industry. There was also a large share of people (19.51% in total) whose work experience in the sector of technical means of agricultural transport was within the range of 6–15 years. Respondents with little experience (fewer than 5 years) constituted only 2.44% of all the participants.

In this part of the study, an attempt was made to verify the theoretical assumptions – resulting from expert research – concerning the type of specific determinants significantly influencing the decision to choose an agricultural tractor. The verification was preceded by an analysis of the literature and indications of the so-called competent judges (experts), whose suggestions and recommendations were used to construct the research tool. First, basic descriptive statistics were determined for all analyzed factors. The respondents assessed the determinants on a five-point Likert scale, where the value of 1 meant very low importance and 5 meant very high importance). Table 5 shows the order of the analysed factors according to their arithmetic mean value.

Table 5. Determinants of the choice of agricultural tractor – significance assessment

No.	Abbreviation	Min.	Max.	Mean	1	2	3	4	5
					% of indications / number of indications				
1.	Technological efficiency determines the profitability of production activities	4	5	4.90	-	-	-	9.8 (4)	90.2 (37)
2.	Agricultural tractor quality	4	5	4.88	-	-	-	12.2 (5)	87.8 (36)
3.	Brand	3	5	4.66	-	-	7.3 (3)	19.5 (8)	73.2 (30)
4.	Compatibility – matching the tractor to the existing machinery	3	5	4.59	-	-	9.8 (4)	22.0 (9)	68.3 (28)
5.	Operating costs	3	5	4.51	-	-	12.2 (5)	24.4 (10)	63.4 (26)
6.	Delivery/processing time	2	5	4.44	-	4.9 (2)	9.8 (4)	22.0 (9)	63.4 (26)
7.	Possibility of financing from EU funds	3	5	4.40	-	-	12.2 (5)	34.1 (14)	53.7 (22)
8.	Multifunctionality Modernity level	3	5	4.39	-	-	12.2 (5)	36.6 (15)	51.2 (21)
9.	Service; spare parts supply	1	5	4.27	2.4 (1)	2.4 (1)	12.2 (5)	31.7 (13)	51.2 (21)
10.	Resistance to changing working conditions	3	5	4.27	-	-	17.1 (7)	39.0 (16)	43.9 (18)
11.	Price	1	5	4.24	-	2.4 (1)	14.6 (6)	39.0 (16)	43.9 (18)
12.	Positive reviews from other users	2	5	4.24	-	2.4 (1)	12.2 (5)	43.9 (18)	41.5 (17)
13.	Ergonomics	3	5	4.22	-	-	14.6 (6)	48.8 (20)	36.6 (15)
14.	Flexibility; possibility of configuration according to one's needs and preferences	3	5	4.17	-	-	24.4 (10)	34.1 (14)	41.5 (17)
15.	Resistance to bad service	1	5	4.02	2.4 (1)	2.4 (1)	17.1 (7)	46.3 (19)	31.7 (13)
16.	Possibility of testing	1	5	3.85	4.9 (2)	7.3 (3)	19.5 (8)	34.1 (14)	34.1 (14)
17.	Assistance in obtaining a subsidy	2	5	3.76	-	9.8 (4)	31.7 (13)	31.7 (13)	26.8 (11)
18.	Length of the warranty period, scope and possibility of extending the warranty	1	5	3.66	4.9 (2)	7.3 (3)	29.3 (12)	34.1 (14)	24.4 (10)
19.	Assistance in obtaining a loan	1	5	3.63	2.4 (1)	9.8 (4)	34.1 (14)	29.3 (12)	24.4 (10)
20.	Origin of the tractor manufacturer (country of production) implying production methods in accordance with the concept of sustainable economy	1	5	3.63	2.4 (1)	14.6 (6)	24.4 (10)	34.1 (14)	24.4 (10)
21.	Attractive location	1	5	3.63	2.4 (1)	12.2 (5)	29.3 (12)	31.7 (13)	24.4 (10)
22.	Extended payment date	1	5	3.51	7.3 (3)	7.3 (3)	31.7 (13)	34.1 (14)	19.5 (8)
23.	Possibility of settlement with used tractors	1	5	3.46	4.9 (2)	9.8 (4)	36.6 (15)	31.7 (13)	17.1 (7)
24.	Operation training	1	5	3.44	4.9 (2)	9.8 (4)	41.5 (17)	24.4 (10)	19.5 (8)
25.	Granting sureties	1	5	2.78	12.2 (5)	29.3 (12)	34.1 (14)	17.1 (7)	7.3 (3)

Source: own work.

Most of the articulated determinants (defined in the expert discussion) are crucial. The average indication ranges between 2.78 (in the case of one factor) and 4.90, considering the characteristics that define them. It can

be noted that in the case of fifteen factors, the average rating of the respondents regarding their level of importance is above 4.00. The remaining nine postulates were rated by the respondents as having a value close

to 4.00 (the average ranged from 3.44 to 3.85). Therefore, the analysis of the distribution of means led to the observation that the determinants, from the perspective of how they are perceived, are little differentiated in terms of the assessment of their significance. Similar analysis regarding the degree of significance of the determinants was carried out considering the characteristics of the respondents. When analyzing the determined averages, it is evident that the respondents' age or length of service in the industry do not significantly influence the assessment. In fact, for most of the factors analyzed, the differences between the means did not occur or were relatively low.

Therefore, the analysis of the factor evaluation (from the point of view of comparing the average value) did not lead to valid conclusions regarding the direction of their significance. The vast majority of postulates in this approach were more or less important.

4. Discussion and conclusions

The quality of crops depends on high-quality agrotechnical procedures (i.e. optimally performed work). In the context of the above, the choice of an agricultural tractor is significantly determined by its technological efficiency (average rating 4.90; 90.2% of indications for a rating of 5 points) and the resulting product reliability (average rating 4.88; 87.8% of indications for a rating of 5 points). Therefore, with the latest achievements and experience in the processes of design, construction, production and operation in mind, tractor manufacturers focus on meeting the requirements resulting from the current needs of users to a large extent. Among the determinants of choosing an agricultural tractor, the leading one is the brand, which occupies a relatively high position in the criteria ranking (average rating 4.66; 73.2% of responses for a rating of 5 points). Over the last few years, there has been a significant shift in emphasis in the methods and subjects of brand management among agricultural tractor manufacturers. Activities in this area have evolved from those aimed solely at promoting the product brand to promoting the company's operating philosophy, which constitutes the basis of the corporate brand. The core of this philosophy is the assumption that the organization itself is a carrier of specific value for the customer. In practical terms, applying this philosophy means increasing the emphasis on creating corporate brands, while reducing the importance of product brands. In a situation where the product ranges of many companies become similar to each other, it is more and more difficult to earn market recognition based solely on product characteristics. In this situation, a lot of manufacturers distinguish themselves on the basis of their identity. As a result, brand promises become company promises.

When choosing a tractor, the integration of the entire machinery park is important. Tractors with parameters adapted to existing machines (e.g. tractor-trailer, tractor-sprayer) are desirable. Compatibility is therefore an important criterion when choosing a specific agricultural tractor (average rating 4.59; 68.3% of responses for a rating of 5 points). A tractor with high power is desirable. There are many applications of this type of device. It allows its user to perform a lot of field and transport works, both during cultivation and care, as well as during the subsequent harvesting. Due to its high engine power, it is able to pull not only the weight of the attached machine, but oftentimes a huge load as well. It should be mentioned that some tractors may be equipped with loaders. The tractor then takes over the functions of an excavator or a loading device.

When choosing a tractor, the cost criterion is considered, which involves the necessary expenses related to the maintenance, use, decommissioning and storage of the tractor constituting the subject of the contract (average rating 4.51; 63.4% of responses for a rating of 5 points). The use of the operating cost criterion favors manufacturers of tractors that are more expensive to purchase but cheaper to maintain. In the case of an agricultural tractor, the calculation of operating costs – especially those regarding the level of power consumption – should take into account the manufacturer's declaration. However, the parameters provided by manufacturers are usually declarative in nature. According to the authors, however, they are sufficient for the purpose of comparing offers submitted by the suppliers.

The manufacturer should pay attention to the set of benefits (values) that it can provide to the user. These benefits include specific functions and features of the product, but also delivery time (average rating 4.44;

63.2% of responses for a rating of 5 points), the possibility of financing the purchase of the tractor from EU funds (average rating 4.40; 53.7% of responses for a rating of 5 points), multifunctionality and modernity level (average rating 4.39; 51.2% of responses for a rating of 5 points) or the supply of parts interchangeable (average rating 4.27; 51.2% of responses for a rating of 5 points).

The respondents considered the ability to operate the tractor in difficult conditions (average score 4.27; 43.9% of responses for a score of 5 points). Therefore, a thorough design process leading to the safe and efficient operation of the tractor is indispensable. Therefore, it is an extremely detailed and complicated practice carried out among tractor manufacturers operating in the sector.

For several years now Poland has seen an increase in the share of high-performance tractors in the domestic supply structure. Users are interested in a modern and safe high power tractor. This determines the price at which agricultural manufacturers are willing to purchase a tractor. Therefore, the price remains a moderate selection criterion (average rating 4.24; 43.9% of responses for a rating of 5 points), as are the references of other users (average rating 4.24; 41.5% of responses for a rating of 5 points). Accordingly, users may in particular demand that tractor suppliers have a sufficient level of experience demonstrated by appropriate references to previous deliveries. In order to maintain a high standard of agricultural production, tractor operators must feel comfortable in the workplace. The ergonomic design of the cabin and the ease of movement in the human-machine system are key factors influencing the ease of operation and thus determining the choice of a tractor from a specific manufacturer (average rating 4.22; 36.6% of responses for a rating of 5 points). Among the sources of competitive advantage, the marketing concept of competition applies, which assumes not only passive adaptation to market needs, but, where possible, an active impact on the customer. In the context of the above, the possibility of configuring the tractor according to one's own needs and preferences was stressed (average rating 4.17; 41.5% of responses for a rating of 5 points).

The determinants of choosing an agricultural tractor, although slightly less important, yet still important, especially from the manufacturer's point of view, include: resistance to poor service, the possibility of testing the tractor, assistance in obtaining subsidies, the scope and possibility of extending the warranty, as well as assistance in granting a loan.

The issue of warranty is typically addressed by regulations containing certain general provisions regarding the procedure to be followed in the event of discovering tractor defects. The parties to the contract may also agree on the duration of the contract as well as the detailed manner in which the buyer will pursue their rights and proceed in the event of reporting a defect. And because it is a tool that ensures that the quality of the tractor is maintained for a certain period of time after the transaction is concluded, it is also eagerly used by agricultural manufacturers. The desire for the completed object of the order to maintain its functionality for as long as possible means that the possibility of extending the warranty period is an important criterion for choosing a tractor.

The way production and consumption are organised [28] contributes to global warming, pollution, use of raw materials and depletion of natural resources [29]. The challenge faced by the modern manufacturer is therefore to create a positive trend, such as: (1) improving the overall environmental performance of products at every stage of their life cycle, (2) promoting and stimulating the demand for better products and production technologies, (3) helping consumers make better choices by adapting products and business models to contemporary conditions [30]. The authors' observations indicate that a certain group of manufacturers still think in a linear way, wanting to transform a given "input" into a product, without considering the reprocessing of by-products. This leads to wasting energy and resources [31]. With reference to the ongoing flagship initiative on resource efficiency, calling for setting medium and long-term goals for resource efficiency and how to achieve them, the production of tractors in accordance with the principles of sustainable development was stressed. Users become increasingly more aware of the interconnections between the economic sphere of the manufacturer's activity (activities aimed at meeting its needs), limited environmental resources constituting the natural restraint on the ability to meet the needs, and the ethical imperative of ensuring social cohesion on the local and global scale (meeting the needs of all people).

The decision-making process of purchasing agricultural tractors is a complex issue, both in organizational and economic terms and as such has been the subject of research by many authors [32–37]. The result of this paper is models supporting users' decisions regarding the selection of agricultural tractors. Regardless of the available studies, in the course of numerous meetings and conversations with representatives of economic practitioners, the authors are asked questions about the determinants of choosing an agricultural tractor manufactured in accordance with the concept of sustainable manufacturing, especially with the consideration of the values defining the user's perspective. In view of the above, the authors decided to conduct a series of studies aimed at answering the question about the factors that are crucial from the buyer's perspective and determine their decision to choose an agricultural tractor. The authors' belief that there exists economic demand for results of an applied nature served as key inspiration for undertaking the research. Especially that cognitive processes create, evaluate and use knowledge to solve specific problems and are the basic resource for solving all problems of acting individuals and teams of people. They constitute the basis and key resource for solving management problems in enterprises. In the context of the above, eliminating this knowledge gap was considered desirable and justified.

Summary

The key to success is product development, which takes place within the reactive model – first, the needs and requirements of the environment are identified, and then a product is developed that takes those into account. The product should be a derivative of potential values (the greater the value of the product for the customer, the greater the chances for sustainable development, but full customer orientation does not require offering products as such but a specific value for a market segment). Depending on the circumstances, all of these dimensions may determine the choice of a particular supplier and constitute criteria for selecting tractors.

The expert interviews and surveys indicate that an agricultural tractor can be characterised by:

- diversity, which makes it available in many configurations (a wide range of models);
- customer orientation requires offering not only products but a specific value for a market segment;
- calculation of field work costs based on actual labor intensity standards, technologies used and the resulting efficiency;
- specific expectations regarding functional features (a proper response to these expectations encourages most customers to make purchases);
- striving for the highest quality by using available solutions and resources (the relationship between the level of quality and price as well as possible services provided with the product are one of the main factors determining development);
- maximizing product properties ensuring uninterrupted ability to work for the longest possible period of time;
- a bundle of interrelated physical features, utilities and benefits.

Taking the above as an interpretation, this study assumes that the criteria for selecting a tractor include physical features and elements determining the strength of perception of the product by potential buyers, as well as by competitors and suppliers, i.e. in the case of an agricultural tractor, these are durability, reliability, quality, aesthetics, price and technical solutions. It is assumed that these elements are not fixed categories. Changes or modifications to the components of this level depend primarily on technological progress, evolution of consumption patterns and socio-environmental standards. This means that the elements of a product should constitute a variable combination adapted to the needs, preferences and requirements of the market, at the same time making it possible to distinguish a given tractor from other competitive offers.

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