

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Statistics



Bachelor Thesis

Statistical analysis of sales of a selected company

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

Zsolt Szabo

Economics and Management

Thesis title

Statistical analysis of sales of a selected company

Objectives of thesis

The main goal of the thesis is to assess the sales of a selected agricultural company. The sub-goal is to identify important factors influencing the agricultural machinery sales.

Methodology

This thesis seeks to analyse the company data with statistical methods, using the program SAS Studio. These methods incorporate descriptive and inferential statistics, including setting up hypotheses and using time series analysis on a given period.

The proposed extent of the thesis

30 – 40 pages

Keywords

Statistics, agriculture, John Deere, SAS studio, statistical analysis.

Recommended information sources

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Declaration

I declare that I have worked on my bachelor thesis titled "**Statistical analysis of sales of a selected company**" by myself, and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on the 15.03.2023

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Statistical analysis of sales of a selected company

Abstract

The bachelor thesis seeks to analyse the sales conducted by Agroservis s.r.o. The company mentioned is the importer of John Deere machines into the Slovak Republic.

First part is the theoretical in which already existing researches are collected about the topic, which is agriculture industry and its presence in Slovakia, John Deere and its competitors and what the influencing factors are for the John Deere machine sales.

The practical part is about analysing the sales of John Deere tractors, harvesters and the most-popular models, which later are compared to their closest competitors on the Slovak market. Other factors were also tested against the sales to see if there is any influence on the John Deere sales. The objective is to assess the sales, find correlation of the sale trends.

The results showcase what are the affecting factors of John Deere tractor and harvester sales in Slovakia.

Keywords: John Deere, Sales, Slovakia, Time Series, New Holland, Claas, Tractor, Statistics, Harvester

Statistická analýza prodeje vybrané společnosti

Abstrakt

Bakalářská práce si klade za cíl analyzovat prodej realizovaný společností Agroservis s.r.o. Uvedená společnost je dovozcem strojů John Deere do Slovenské republiky.

První část je teoretická, ve které jsou shromážděny již existující výzkumy k tématu, kterým je zemědělský průmysl a jeho zastoupení na Slovensku, firma John Deere a její konkurenti a jaké jsou faktory ovlivňující prodej strojů John Deere.

Praktická část se zabývá analýzou prodeje traktorů, sklízecích mlátiček a nejoblíbenějších modelů John Deere, které jsou později porovnány s jejich nejbližšími konkurenty na slovenském trhu. V porovnání s prodejem byly testovány i další faktory, aby se zjistilo, zda mají na prodej strojů John Deere nějaký vliv. Cílem je vyhodnotit prodeje, najít korelaci trendů prodeje.

Výsledky ukazují, jaké jsou faktory ovlivňující prodej traktorů a kombajnů John Deere na Slovensku.

Klíčová slova: John Deere, prodej, Slovensko, časová řada, New Holland, Claas, traktor, statistika, kombajn.

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1 Introduction

Most of the Central-European countries are highly dependent on agriculture. Traditional and also modern farming can be found. These countries mainly produce several crops. These crops can be divided into cereals, oil crops, and other crops. Cereals include Wheat, Barley. Oil crops: Sunflower Seed, Rapeseed. Root crops: potatoes, sugar beet. Others: Maize.

Slovakia is no different; the land sown in 2020 is 1 348 000 ha, which is relatively small compared to the country's size (*Plant Production*, 2020). Agricultural machinery is essential for efficiently cultivating these local crops to meet the constantly growing demand. Thanks to modern, sophisticated machines and techniques. The output of crops per area can be maximised.

Since we live in a competitive world with countless brands in each sector, it is no surprise that there are many leading brands and manufacturers in agriculture, each focusing on similar or different machinery.

This thesis seeks to analyse a company that sells these machines and equipment in Slovakia. The company is called Agroservis s.r.o., which was established in 1993. It gradually but steadily grew to become one of the largest agricultural firms in the Slovak Republic, selling world-renowned brands like John Deere, Kuhn, Dieci, and Bednar and also providing agricultural services.

Like any other company, the Theory of Firm also applies to Agroservis.

"The firm's objective is to maximise profit" (Spulber, 2009). Although many factors influence a company's profit and maximisation, statistical data analytics is important. Annansingh and Sesay (2022) state data is everywhere. It is considered the new oil and is fundamental to business decisions. "The ability to gather the correct data, analyse, interpret, and act accordingly is crucial for the company's success" (Annansingh & Sesay, 2022).

In the real world, data analytics gives us insights and tracks and estimates the sales of certain goods and services. With trends, we can see anomalies and patterns and act in time to further increase the firm's profit. Although having usable data is important, it not necessarily means the company can utilise it to its benefit and improve.

2 Objectives and Methodology

2.1 Objectives

The main objective of the thesis is to assess the sales conducted by Agroservis s.r.o. The data used for this thesis is obtained from internal and external sources, which means from annual reports of the company database.

The practical part consists of more parts. Firstly, descriptive statistics were applied to sale numbers obtained from the John Deere database and analyse the sales. Then assumptions were set up and checked whether there were significant correlations.

2.2 Methodology

2.2.1 Descriptive statistics

Descriptive statistics is a statistical technique used to summarize the data and describe the general characteristics of a sample or population by summarizing their values. It provides a basic understanding of the sample, such as its mean, median, standard deviation, range (minimum and maximum), and number of observations. Descriptive statistics are not predictive and do not tell us anything about what will happen in the future with a particular sample.

2.2.2 Inferential statistics

Inferential statistics is a branch of statistics that deals with the use and interpretation of inferences. The term "inferential" means to infer or draw conclusions from data.

Inferential statistics help understand the relationships between variables by using statistical techniques such as correlation, regression analysis, and hypothesis testing. It also provides guidance on interpreting results obtained in other research areas, such as experimental design, sampling error, confounding factors, and model assumptions.

2.2.3 Time series analysis

The statistical technique of time series analysis is used to study the changes in a variable over time. It allows you to see how one variable varies with respect to another, in our case, the time series variable. The first variable is the dependent variable, and the second is the independent or explanatory variable. The values of these variables can be plotted on a graph and then compared over time. This comparison can be made using a line or an area chart, depending on each situation's representation.

Trend functions were used in the thesis.

“In the regression analysis section, the estimated regression equation describing a straight-line relationship between an independent variable x and a dependent variable y is written as:

$$y' = a + b x$$

Where y' is the estimated or predicted value of y . To emphasize the fact that in forecasting the independent variables is time, we will replace x with t and y' with T_t to emphasize that we are estimating the trend for a time series. Thus, for estimating the linear trend in a time series we will use the following estimated regression equation (Hlavsa & Pacáková, 2020)”.
Linear trend equation:

$$T_t = a + bt$$

where:

T_t = linear trend forecast in period t

a = intercept

b = the slope of the linear trend line

t = time period

Quadratic trend function: $y = a + bt + ct^2$ can be applied if it fits the data better.

The time series was done using SAS Studio, as well as the correlation of the residuals, which was used throughout the thesis. Pearson's coefficient of correlation was used.

These coefficients can indicate a weak, medium, or strong correlation.

When this coefficient is between 0 and 0.35 it is considered weak; when it is between 0.36 and 0.67 it is considered medium correlation; when it is between 0.67 and 1, it is a strong correlation (Taylor, 1990). Note that this value only ranges from -1 to 1. There are positive and negative linear correlations as indicated by the numbers mentioned before. The positive correlation means that when the variable on the x-axis increase, the variable on the y-axis increase too. The opposite is true for the negative, x-axis variable increases, the y-axis variable decreases (*Types of Correlation, n.d.*).

3 Literature Review

3.1 Agriculture industry

Agriculture is a major industry; it is the branch of science that deals with cultivating and breeding plants, animals, and microorganisms. The primary objective of agriculture is to increase food production and be sufficient to feed the growing population. Agriculture also includes animal husbandry, fisheries, hunting, and forestry.

Europe itself has 20 million people working directly in the agriculture sector. Thanks to the climate, the quality of soil, and technology, the EU is one of the leading producers and exporters.

Central-European countries are highly dependent on farming. Mostly crop production is present in this area, but animal husbandry is significant as well. Although Slovakia's GDP is made up of services, 2.8% of it is from Agriculture, which is more precisely 2180 million euros. This can be divided into two main sectors: crop output, which is 62.9% of the agriculture output, and 37.1%, which is animal husbandry. The Crop production sector can be further divided into sub-categories. The most produced crops are cereals with 30%, of which wheat and spelt are 15%, Grain maize at 10%, and rye and meslin at 4%. The next sub-category is industrial crops, which comprise 15.4% of the total crop production, of which 13% are oil seeds and oleaginous fruits and 2% are sugar beet.

The Animal sector (37.1%) can be divided into animals and animal products. The live animals are 18.4% of this sector, of which pigs are 7.6%, Cattle 5.2%, Poultry 4.7%, and sheep and goats are 0.6%. Animal products are divided into two main parts, milk (14.3%) and egg (3.7%) production (*Agriculture and rural*, 2021).

3.1.1 Agriculture and other industries

Agriculture is an essential industry; it is one of the pillars of other industries, as it provides all the necessary raw materials for them while the said industry processes the raw materials into finished products. One could not grow and progress without the other; they depend on each other. This means there is an interdependence between agriculture and industry.

A large percentage of the population is engaged in farming, as mentioned in *Interdependence of Agriculture*, n.d. People's fundamental and most basic need is food. Once this is met, they also need other products manufactured by other industries, such as clothing, shoes, entertainment devices, cars, tractors, and farming machinery.

As the industrial sector produces quality equipment, seeds, fertilisers, and irrigation devices as well, the efficiency of crop production can be highly increased. This means the production per hectare is more.

The industrial sector provides better quality seeds, which are the starting point of farming. These seeds are made to be more resistant to the elements, have a higher yield, and be more compatible with the local soil. To do this, research centres are needed with laboratories. These are all provided by the industrial sector.

Manure used to be the main fertiliser, and it is still used today. It comes from the farming sector itself, meaning there is no need for other industries. On the other hand, the need for an alternative was necessary. The alternative is chemical fertilisers, which are produced by the chemical industry. Thanks to the fertilisers, the yield has increased significantly.

All this mentioned before would not be effective if there is no proper irrigation, which is essential for crop production. The main source of water is rainfall, but irrigation is needed due to rising temperatures and decreased precipitation. The technological sector provides adequate machinery and infrastructure for irrigation; if there were no industry, there would be no other solution for it.

The technological sector is also the provider of modern farming machinery and equipment. These innovations, like tractors, harvesters, and seeding machines, further increase the efficiency of crop production. The need for less manpower makes it more cost-effective for farmers.

Otherwise, it would not be possible to grow enough crops to feed the entire population (*Interdependence of Agriculture*, n.d.)

3.1.2 Challenges in the farming industry

Like most industries, the farming sector faces some challenges as well. It is inevitable to make some changes in how we manage the production of agricultural goods.

Modern agriculture is a complex, unpredictable business, and farmers must be aware of the problems that they are facing or will be facing in the near and distant future.

The changing climate is one of them, to which agriculture is vulnerable. Changes in the average temperature and precipitation highly affect productivity and yield, which have many consequences. Farmers must adapt and act accordingly to climate change. Many regions in Central Europe are drying out and need irrigation devices to grow crops. These devices are very expensive investments, which many small or moderate-sized farms can't afford.

Barriers to entry is a term used in a business that refers to the ability of a company to enter a certain industry. The barrier is high in agriculture as a new entrant must have the appropriate skillset, experience, fields, and machines to do a business, with no guarantee of profit. Bigger farms usually make it hard to enter, and they try to buy out smaller farms.

Barrier to exit is the opposite of entry; it means how hard it is to leave the industry.

Farms have high fixed costs and need employees with specialised skills, which means it is hard to exit once you are in the business. (*Barriers*, n.d.)

Regulations are also playing a part when it comes to challenges in modern-day agriculture. Green deal will be one that will try to make agriculture carbon neutral by 2050. Another interesting one is that the EU regulates how much livestock manure can be used; the maximum allowed amount shall not exceed 170 kg/ha/year. (Oenema, 2004)

3.2 Brief history

Agriculture has been present in central Europe for thousands of years. The earliest form was hunting and gathering, which evolved into animal husbandry and later crop production. People used primitive tools, animal power, and manpower to work in the fields. They spent most of their time planning and working in the fields to put food on the table; it was the largest employment source in central Europe.

Due to the landscape of Slovakia, animal husbandry was practiced in the mountain regions, mostly sheep and cows. Shepherds took care of the sheep. They used them for cheese products and their wool to make products like coats from them. In the lower regions, crops were produced for bread.

The industrial revolution hit Europe as well, and it brought new processes in manufacturing and mechanisation in farming. This led to increased food production. Many inventions, such as tractors, harvesters, seed drills, and triangular ploughs, took place during this time. These inventions include not only machines but techniques like crop rotation and selective breeding of animals. Crop rotation was invented long before and used for thousands of years, but it was made widespread during the 18th century. During the 1950s, it was believed that crop rotation was not needed anymore due to synthetic fertilisers, but that has been proven wrong over time and is still used today. (Bullock, 1992).

During the Soviet Union, agriculture was not really improving or being innovative. Although they used machines, it was nowhere near as sophisticated as western machinery. It changed after the fall of the Soviet regime in 1991.

3.2.1 History of John Deere

John Deere, the founder of Deere & Company, was a blacksmith who developed the first commercial self-scouring steel plough in 1837. As the cast iron ploughs used back then didn't perform well in the hard soil and needed to be cleaned often during operation, his new innovative design quickly became favoured by many farmers. Ten years after the invention, he was making 1000 ploughs a year, which were known for their high quality and reliability. In 1868 the business was incorporated under the Deere & Company name, which is known today.

In 1918, John Deere entered the tractor business with a tractor called Waterloo Boy, it was their first iteration of a tractor that was gasoline or kerosene powered, and it changed American farming. In 1916, more than a hundred small companies made tractors, but only two survived till the 1930s, one of which was John Deere. This proves how good their products are. In 1935, the first tractor was built for industrial use, the Model "DI" (*Running*, n.d.).

In the 50s, John Deere was a big, established company with a good dealer network across the states. "Deere manufactured a long line of farm equipment in addition to eight models of their venerable two-cylinder tractors. The company had dealers in every state in the Union and, north of the border, in every province of the Federation. At those dealerships, farmers could buy a wide range of equipment for tillage (ploughs, cultivators, disk harrows, disk tillers), for planting (corn, vegetables, potatoes, grain, fertiliser), for haying (mowers, rakes, wagons, balers) and for harvesting (combines; windrows; threshers; corn pickers, shellers, and snappers; harvesters for cotton, potatoes, and beets) and even grain dyers (Dietz, 2011)."

The major innovations started in the 60s-70s as the company was stable and could fund research and development. "In the 1960s and 1970s, Deere & Company was among the healthiest of all the large corporations in North America. (Dietz, 2011)."

John Deere had two-cylinder tractors until 1959. In 1960 they introduced the 4M six-cylinder engines in the Model 8010. Farmers could work more efficiently in the fields by allowing them to tow bigger equipment by making tractors with more cylinder options with bigger displacements. The 8010 was able to pull eight ploughs at seven miles per hour (Ganzel, 2006). This meant John Deere was getting ahead of its competitors it had. "By 1964, John Deere was the number one producer of farm and light industrial equipment in the U.S. with 34 per cent of the total market share (Ganzel, 2006)".

In the 60s, Deere & Company not only focused on tractors and machines for agriculture but also wanted to enter the lawnmower market, as it was huge in the US. They introduced the John Deere 60 lawn tractor in 1966. Putting the "tractors" on suburban lawns all over the US really brought the brand into the mainstream. As was a great success, and John

Deere rapidly got popular. This popularity further grew with the introduction of a line of snowmobiles in 1971, which they produced until 1982. They sold their snowmobile business to a competitor, Polaris (*What is the history*, n.d.).

In the 1970s, they introduced the II. Gen of their tractors, in 1972, they debuted something they never did before. Instead of sitting on top of the tractor, Gen IIs had an enclosed cockpit called "Sound Guard." This meant it had a cabin with sound deadening, just like the modern ones, and a roll bar in case of a rollover which can happen in hilly terrain. The biggest of these cabin-equipped tractors was the John Deere 4630 row crop tractor, with 150hp.

In the 1980s, John Deere focused on fuel efficiency, which was not an objective before. The embargos and farm crises were due to crop overproduction and low exports. Despite the crisis, John Deere was able to develop new machines.

The big American fields needed a beast that could pull more ploughs than before so they released the biggest tractor to date, the V8-powered Model 8850 with 370hp and four-wheel drive.

In the 90s, they tried to enter a new market again, but this time not with a tractor. The new vehicle was all about utility. It was introduced in 1992, the Gator TH, for all sorts of work in mind. The Gator had six wheels, of which four were driven. Later they also made a four-wheeled version as well with 4WD. This was not only important for farmers and workers who used these small four-wheeled vehicles, but they were incredibly fun, so they inspired a new type of motorsport where they used these to race. Later brands like Polaris and Yamaha started to produce higher-powered versions that weren't meant for work.

They also released a new line of tractors in 1994, the 8000 series. Another game changer for the farming industry. Engineers drastically improved the turning radius of the new tractor, which would help the farmers to get their tractors to the fields more easily and make tighter turns on the fields.

In August 2001, John Deere launched 24 new tractors at a dealer meeting in Albuquerque, New Mexico. A few inventions in the new 8000 and 9000 series tractors, like Independent

Link Suspension and ActiveSeat, made them more comfortable to ride in, meaning the long hours spent at the fields were more enjoyable.

Since 2000 they have made many significant innovations, such as the StarFire GPS which was co-developed with Nasa (What, 2018). It is a fully automated guidance system for Farming Machinery. It has features like AutoTrac. "AutoTrac Turn Automation gives you a complete solution for accurate and repeatable end-of-pass turns throughout the entire field. It automatically completes accurate turns and carries out end-of-pass functions at appropriate times during the turn. This reduces strain on the operator and reduces input costs" (*AutoTrac*, n.d.)."

Benefits of the autonomous tractors are: "Typically, when a tractor crisscrosses a field, the rows overlap by about 10 per cent, Pickett explains. This means a significant portion of the field receives double the necessary seed, fertiliser, and pesticide, and the job takes longer than necessary. Eliminating overlap also reduces fuel costs, wear and tear on the machinery, and tractor-operator time, since an operator is required to monitor operating conditions and avoid collisions. And higher accuracy also means more reliable yield maps. (*How Nasa*, 2018)".

The StarFire system was one of the first products made for precision agriculture.

John Deere will focus on fully autonomous tractors and precision agriculture in the present and in the future. He will also try to offer zero-emissions electric and hybrid-electric solutions by 2026.

3.2.2 History of John Deere and Agroservis in Slovakia

After the fall of the communist regime, western brands started to enter the eastern European market. John Deere wasn't an exception. The company Agroservis was established in 1993 with the aim of selling John Deere machines. In 1991 eleven different agricultural firms imported John Deere machines. Agroservis quickly become known as an importer of high-quality and reliable equipment. The interest gradually grew in these new machines, so it was needed to solve service and a reliable supply of spare parts. This led to the start of building a sales and service network across the country.

Although high-quality John Deere machines are selling successfully, good and reliable service is needed to keep the machines running when there is a highly demanding season. Agroservis solved this by focusing on service and spare parts. This also became a selling point of this brand. Farmers can rely on John Deere and Agroservis.

The success of the western John Deere inspired the management to increase their offerings further, so they signed a contract in 1997 with a French manufacturer of agricultural technologies called Kuhn. Later more brands were offered in the portfolio, such as Austrian Brantner, which produces tractor-trailers and semi-trailers, and French company Perard which makes manure spreaders and transfer trucks. Irtec makes irrigation devices. Bednar is also offered; it is a Czech company specialising in soil processing machines and mulchers. In 2016 Dieci telescopic handlers were added to the portfolio. (*O nas*, n.d.)

3.2.3 History of competitor brands in Slovakia

Like Agroservis, most of the firms that imported the machines from competitor brands were established after the fall of the Soviet Union.

Agrall s.r.o. The importer of Claas and Väderstad machines has been in the market for 30 years. Claas Harvesters are the biggest competition for John Deere harvester sales.

Fendt, another tractor manufacturer competitor for John Deere, was also imported into the Slovak market in 1993 by a company called Hriadel spol. s.r.o. They also offer service and after-sales support with parts for Fendt machines. Another brand on their portfolio is Horsch, a German brand of agricultural tools such as ploughs and seed spreaders.

Agritec, the importer of New Holland and Case machines, also started in 1993; a Czech company, Agrotec, operated in the Slovak Republic. In 2000 they separated from the parent company and began to operate alone as the only distributor.

The firms and brands mentioned above are the main competitors for John Deere and Agroservis in the Slovak market and internationally. Although John Deere offers the best after-sales services, such as repair, part availability, and warranty, there is significant competition on the market.

3.3 Types of farming machinery

There are various types of agricultural machines and equipment, each with its own purpose, though there are some that are multi-purpose. These machines and equipment will be categorised.

3.3.1 Tractors

Tractors are the most versatile machines in modern farming. They are made to have high torque at low-speed applications. Tractors are used to help farmers harvest crops, clear land, and transport goods. Tractors have been around for over 100 years and have evolved into more sophisticated machines that can do many more tasks than they could in the past. Farmers can attach several specialised pieces of equipment to them to do the needed tasks. Over time, tractor technology has improved a lot, and now they are used for other things such as road building and construction work.

Tractors are mostly used in crop production. These are called row crop tractors. They can be attached with ploughs for tillage, cultivators, seed spreaders, fertiliser sprayers, and balers. Green feed harvesters can be attached so farmers can cut their grasslands and process the hay for their animals. Some tractors also accept front attachments, such as hydraulic front-end loaders; these can be used to move manure to the trucks, stack bales, and move palettes. On smaller farms, this can replace telescopic handlers. Snowploughs can be used for the winter months to clear the roads.

There are multiple types of tractors, and each is specialised for an application. The two main types are wheeled and continuous-tracked tractors. The most widespread is the first type mentioned, which is the wheeled tractor with usually rear-wheel-drive systems.

Although the John Deere 9R series are equipped with four-wheel-drive, they are wheeled. Tracked tractors have become more popular lately because of the better traction and more evenly distributed force on the fields, reducing soil damage. John Deere 9RT and 9RX series are tracked tractors, the latter one with four independent tracks replacing the wheels.

3.3.2 Harvesters

Harvesting has always been a very important job that requires manpower and time. It has been evolving ever since it was "invented." People used hand tools and hands to harvest each year until modern harvesters were invented and utilised.

Hiram Moore built and patented the first combine harvester in 1834 in the United States (*Brief*, n.d.). "Moore's machine, which was drawn by mules or horses, could reap, thresh, and winnow grains. In 1839, a harvester pulled by 20 horses harvested more than 20ha in a single day (*Brief*, n.d.)". The combined harvesters used nowadays do the same tasks but more precisely and effectively. This means cutting the crops (reap), separating the grain part from the straw and husks (thresh), and separating the grains from the chaff (winnows). Therefore, it is called a "combined" harvester because it combines these three processes. Multiple types of harvesters exist, each for a certain type of crop and uses.

The most common type is the self-propelled crop harvester, used for grain crops. These are the most efficient for big-scale crop production and can be used for barley, corn, flax, oats, rapeseed, rice, rye, sorghum, soybeans, sunflowers, and wheat (*Types*, 2022).

Some plants and vegetables require a special proprietary harvester; these include sugar cane and cotton.

3.3.3 Tillage equipment

In 1837, field preparation would forever change thanks to John Deere's self-scouring plough (*Tillage*, n.d.). Since then, they have been innovating with other brands and making more effective tractor-towed versions.

Tillage is a very important part of crop production. It prepares the soil for the seed, encouraging better root growth and integrating fertilisers into the soil.

There are multiple types of tillage equipment for each season and type of soil.

Disk cultivators, Field Cultivators and Mulch Finishers, Rippers, Vertical Tillage.

3.3.4 Balers

Baler or hay press was invented in the 1800s, just like most of the agricultural equipment of which we use the modern version nowadays. The first hay presses were stationary and

built into barns. Later, portable balers were invented. In the 1900s, self-tie balers came to life, similar to what we use today.

Balers are important machines that cut straws of grains into bales for later use. Hay bales are made from cut and dried grass, and it is for feeding ruminant livestock during the winter months.

There are two main types of balers; they produce either round or squared bales.

The round bales are denser and much more weather/moisture resistant so they can be stored outside. The smaller square bales are better for farms with fewer animals to feed and can be more easily moved and stored inside the barn.

3.3.5 Sprayers

Modern farming wouldn't be the same without sprayers and their substances; they are an important tool for making crop production more efficient and higher yields. Sprayers are tools for applying herbicides, pesticides, and fertilisers on crops.

Sprayers can be self-propelled or tractor-mounted/towed. The self-propelled ones are the pinnacle of modern sprayer technology, and they can recognise and target weeds using computer vision and machine learning. This technology makes significant savings in herbicide use.

3.4 Factors affecting the sales of John Deere

3.4.1 Participants of the market: competitors

With any market and industry, there are competitors which prevent the monopoly of a company. This induces accelerated research and innovation. Competition is fundamental for a healthy market. Although the Slovak market is close to an oligopoly as few companies fulfil the needs of the market and making others hard to enter. Friedman (1984) states that the actions of any one firm have quite noticeable consequences for each of the other firms; the products are perfect substitutes, and the industry is producing homogeneous goods.

Several brands in the Slovak market compete with John Deere and can probably influence the sales of Agroservis s.r.o. The actions of any one firm, however, have quite noticeable consequences for each of the other firms.

The most significant companies we can mention are Claas, Zetor, Case, and New Holland. Claas is a competitor to John Deere in the Slovak market, mostly when it comes to Combine Harvesters. They also sell tractors, but the other brands mentioned are more significant. New Holland, Case, and Zetor compete with John Deere when it comes to sales of tractors, and all three are equally significant. Some less significant brands are Valtra, Kubota, Massey Ferguson, Deutz, and Fendt.

3.4.2 External factors

One of the biggest factors in Slovakia when deciding to get a new farming machine or not is the subsidies from European Union. The buyers usually wait until a subsidy is available and get the machine that it was given for. This can influence which year which machine sells better. Subsidies play a great role when buying new machines globally (Balasubramanian, 2020).

The income of farms is mostly dependent on the yield of crops, which is further influenced by the weather of the certain year. The current price of goods on the market. If the farm is making a profit due to good yields and market price, it can consider buying new machinery for further improvement.

World events like the Covid-19 pandemic and the war in Ukraine increased grain prices, making people consider getting new machines. Due to the chip shortage and supply chain problems, the machines' prices increased significantly compared to previous years.

3.4.3 Characteristics of machines

The characteristics itself of the machine greatly influence the decision of the potential buyer. According to Balasubramanian (2020), one of the most important factors is the price of the machine itself. Farmers have more spending power to upgrade an aging fleet after drought in the US and China, and disruptions from Russia's war in Ukraine pushed up crop

prices. That's allowing Deere to increase prices for its tractors and other agriculture equipment by 11% next year stated by Deaux & Attwood (2022). The prices in 2022 recorded a high when compared to the last ten years (*Global, 2023*). On the graph below on the X-axis we can see the value in USD and on the Y-axis the years.

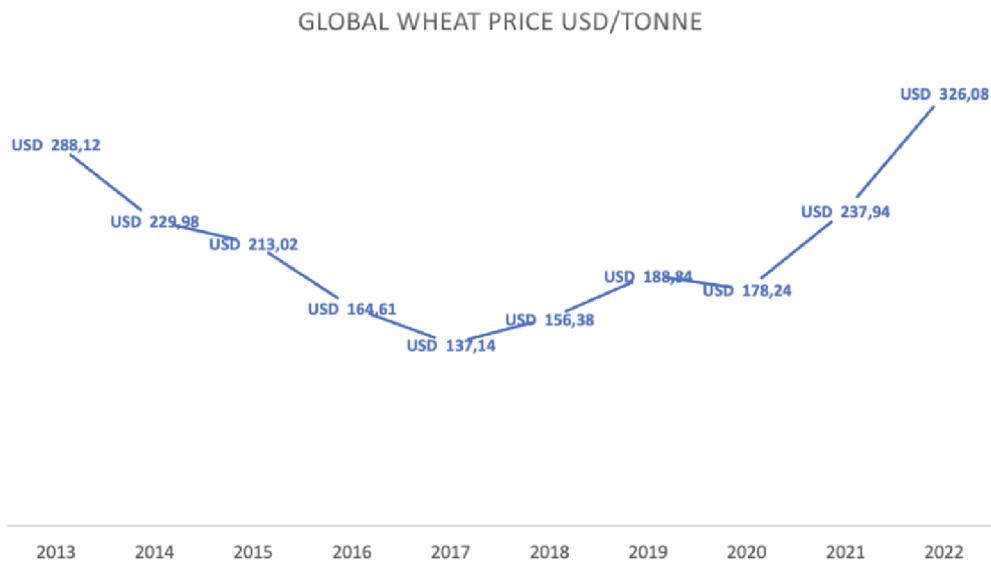


Figure 1 Global wheat prices 2013-2022 (*Global, 2023*)

4 Practical Part

4.1.1 Analysis of tractor sales of leading brands in Slovakia

Several brands have a significant part of the market share in the Slovak market. These include John Deere, Case, New Holland, Zetor, and Claas. The constructed table showcases the sales of these brands in the last ten years.

Year	Brand				
	John Deere	New Holland	Case	Class	Zetor
2013	206	90	83	47	73
2014	106	71	86	48	93
2015	202	111	81	27	113
2016	143	99	108	37	112
2017	98	72	71	52	127
2018	178	135	75	51	168
2019	196	74	85	32	206
2020	136	96	59	39	167
2021	128	94	66	32	121
2022	150	96	75	22	177

Table 1 Tractor sales of major brands (self-constructed table)

The overall average of tractor sales is 100.28. Some players, more precisely John Deere and Zetor, sold above average. The mean of John Deere sales is 154,3, and the mean of Zetor sales is 135.7. Other manufacturers sold under the average. New Holland with 93.8, Case with 78.9, and Claas with 38,7.

As the products are perfect substitutes for each other, the customer may decide to go with another brand, decreasing the sales and market share of John Deere. The market has a limited number of customers, as these goods are very specific, and the barrier to entry when it comes to farming is high.

4.2 Analysis of sales of John Deere in Slovakia

Current John Deere tractors and machines are differentiated by numbering and letters. The premium row crop tractors are differentiated like this: 7R 350. The first number indicates the series/size of the tractor, the R indicates that it is a premium line machine, and the last three digits indicate the tractor's horsepower. This way, it is easy to determine the size and power of the machine. The mid-spec tractors are the M-series. 8R, 7R, 6R, and 6M series exist in the current line-up, each with several horsepower ratings and specifications.

The 4WD tractors are the 9R series. 3 versions exist, the 9R, 9RT and 9RX, also with the horsepower after the series number. 9R is the wheeled version, 9RT is a single-tracked version, and 9RX is the highest-end one with four independent tracks.

Harvesters are differentiated in a similar fashion. There are three series: S, X, and T. These are different in the use case, as each type is more intended for a specific task. The S and X-series are commonly used for high-moisture corn, tough-threshing small grains. The X is the bigger machine, capable of harvesting more bushels. The T-series is for wheat, canola, and barley. It is one of the most popular ones in Europe, the T660 and the T670.

On the Slovak market, the leading tractor series is the 6 series row crop tractors, which are the most suitable for the farm sizes here. These mid-sized tractors offer a wide range of HP and specifications. The average sale QTY for the last 5-year period is 78 pieces. The second most popular series is the 8 series, which fulfil the needs of bigger farms. These high-end tractors are more powerful and can tow any attachments that are needed for the task. The mean of the sales is lower, with 30. Other models can be found but in much lower numbers.

4.2.1 John Deere 6 series and 8 series tractor sales

The most popular tractor models on the Slovak market by John Deere are the 6 and 8-series tractors and the T and S-series harvesters. The graphs below represent the sales of these machines in the last five years. On the X-axis the sales are presented in pieces and on the Y-axis the years.

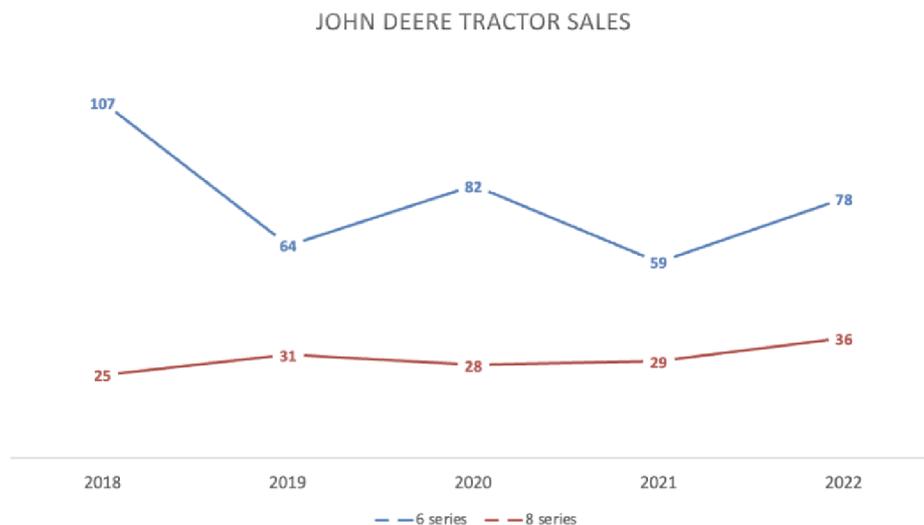


Figure 2 John Deere 6 and 8 series tractor sales (self-constructed graph)

The 6 series are the smaller utility tractors with less power output, mainly used for row crop production and work around the farms. Farmers can attach balers, sprayers and other accessories, depending on the more specific model, as more variants exist. The horsepower ranges from 70hp to 250hp, meaning it has a wide variety of use cases.

The mean of 6 series sales is 78, and the other observed values seem to vary.

First-year resulted in 107 sales and dropped to 64 in the next year. This is a -40.19% change compared to 2018. In 2020 the sales increased to 82, which is a 28.13% improvement, although the Covid-19 pandemic hit the world. The year 2021 was worse than the previous year, with sales of 59, an all-time low in the five-year period. This could have been caused by the effects of the pandemic. The following year, 2022, although there were some difficulties in the world, it has been a better year, with sales of 78 and an improvement of 32.20%. The introduction of the new 6R models could be the reason for this change. The time series analysis was done using a linear trend model, and the trend of the function is $y' = 96.9 - 6.3t$. The -6.3 is the slope of the

function, which tells us the sales are decreasing over time. The goodness of fit denoted R^2 is how well the data fit the model, in this case, 0.3585, meaning the model covers 36% of the data.

The 8 series is the bigger, more powerful model, with power ranging from 230hp to 410hp. These models are more expensive compared to the 6 series, resulting in fewer sales. The other reason can be the farm sizes in Slovakia are smaller, so many farms choose a smaller tractor that is more suitable for their needs.

The mean of the 8 series sales is 29.8, which is another value that the other values tend to vary. The graph showcases some slightly increasing trends. This can be proved by the time series trend. The trend function is $y' = 23.8 + 2t$. The 2 indicates the slope has an increasing tendency, meaning the sales are improving. The R^2 is 0.5988 meaning the model explains 60% of the data.

4.2.2 John Deere T series and S series harvester sales

The John Deere has two harvester models available on the Slovak market, the smaller and more popular T series and the bigger, more expensive S series. The sales of the T660 and T670 are significantly bigger, as these are the most suitable for the farm sizes in Slovakia, and these are made for our crops. The S series also can be found here, but in very small numbers; only the biggest farms can afford and utilise them effectively. The graph on the X-axis shows the sales in pieces and on the Y-axis the years.

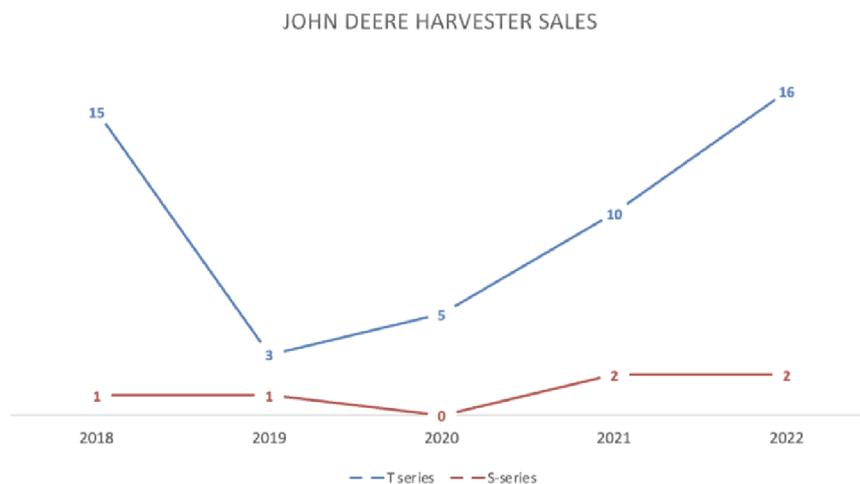


Figure 3 John Deere T and S series harvester sales (self-constructed graph)

As seen on the graph, the sales of the T series harvesters decreased by a significant margin in 2019 and seemed to recover slowly. The U shape of the graph indicates that a quadratic regression would be better suited. After applying the polynomial regression, one can conclude that it was right, as the I^2 indicates that the model fits 86% of the data. The trend function is $y'=26.6-15.814t+2.786t^2$, meaning the sales should increase over time.

The S-series harvesters are not selling as well as the T-series. A linear regression model has been made. The trend function for the times series is $y'=0.3+0.3t$, meaning there is a positive trend. The R^2 value is 0.3189, explaining 32% of the model.

4.2.3 John Deere 6 series vs New Holland 6T series

The John Deere 6 series and the New Holland 6T series are the closest competitors on the Slovak market when it comes to mid-sized row crop tractors. John Deere 6 series offer a wider range of tractors with horsepower ranging from 70hp to 250hp. New Holland 6T power is usually slightly lower; the power range is between 96hp and 175hp. Although the 6 series by John Deere sells significantly better, my interest is in whether the competition affects the sales in any way. The best way to test whether there is a relation is by using linear trend analysis. On the graph down below, the X-axis represents the sales in pieces and the Y-axis the years.

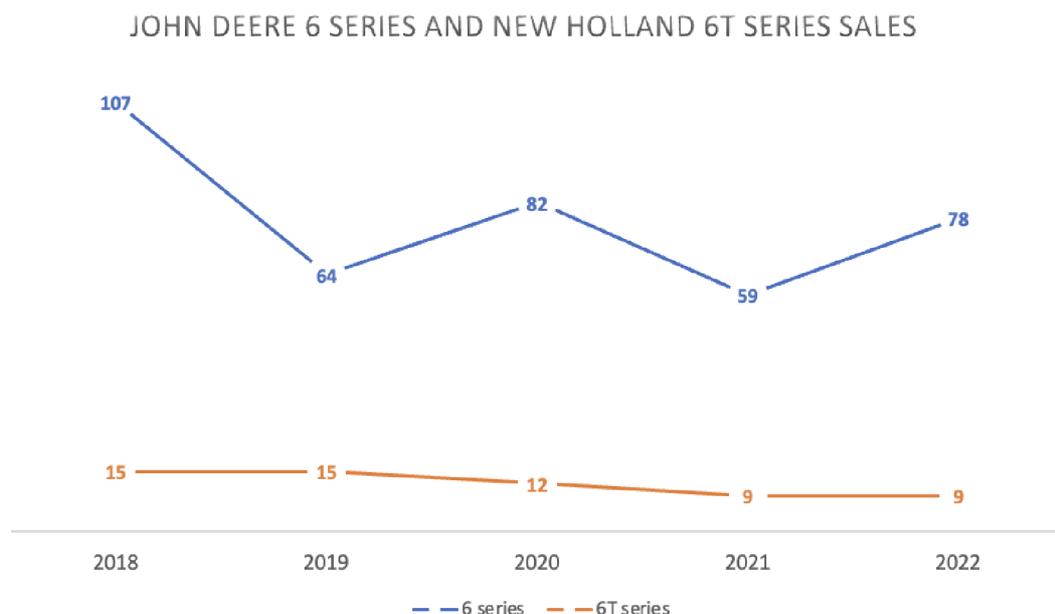


Figure 4 John Deere 6 series and New Holland 6T series sales (self-constructed)

The graph above explains the sales of John Deere mid-sized 6 series tractor sales and the competitor 6T series tractor sales. It clearly shows that both brand sales are slowly decreasing over the years.

While John Deere sales are significantly more, a decreasing linear trend can be found. The biggest drop was from 2018 to 2019, with a decrease of -40.19%. The reason is that in 2018 there was no subsidy tender for tractors. The change from 2019 to 2020 changed positively, with an increase in sales of 28.13%. The reason again is the subsidies, as there were written for tractors in 2019. Although there were in 2020 too, the sales decreased in 2021, which can be affected by the increasing prices due to Covid-19 and the micro-chip shortage. In 2022 the sales rose again. The time series for the 6 series is $y' = 96.9 - 6.3t$, which indicates that there is a declining trend. The R^2 is 0.2807, meaning the model explains 28% of the data.

New Holland 6T series sales clearly have a decreasing trend. Although, the same subsidies apply to these machines as well. The time series is $y' = 17.40 - 1.8t$. The trend has a negative slope to it, meaning the sales are decreasing. The goodness of fit value, R^2 is 0.90, which indicates a good fit. The model explains 90% of the data.

When correlating the residuals of the time series, there is a low degree of correlation, with the Pearson's coefficient being -0.1884, indicating a negative linear correlation.

Pearson Correlation Coefficients, N = 5	
	JD 6 r_
NH 6T r_ NH 6T r_	-0.18840

Table 2 Correlation of residuals for John Deere 6 series and New Holland 6T series sales (self-constructed)

4.2.4 John Deere 8 series vs New Holland 8T series

The John Deere 8 series and the New Holland 8T series are the flagships of these brands when it comes to 2WD row crop tractors. They are the biggest, most powerful tractors these brands can offer. John Deere offers a bigger 9R series, but it is 4WD. The same goes with New Holland, their 9T series is the only series that offers more performance than the 8T, but again they are 4WD. Due to the size of Slovak farms, the 9R and 9T series are very rare, and only a few farms can afford and utilise such machines. Hence the 8 and 8T are the most popular large-sized tractors on the Slovak market. On the following graph, the X-axis is the sales in pieces and on the Y-axis the years.

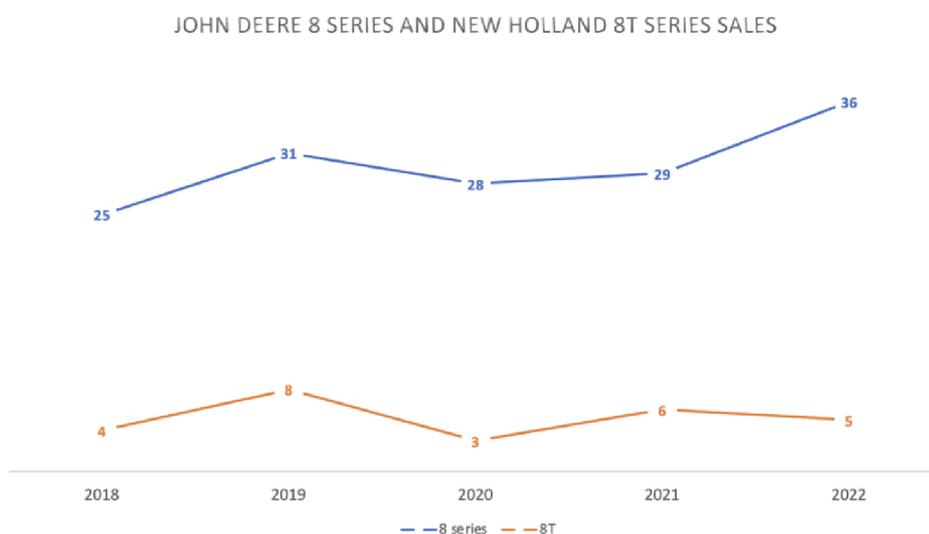


Figure 5 John Deere 8 series and New Holland 8T series sales (self-constructed)

As seen on the graph above, the John Deere 8 series tractors seem to have a slowly increasing trend. The sales increased from 25 to 31 with an increase of 25% in the first two observed years. In 2020 the sales dropped and were followed in 2021, with the sales being 28 and 29. The year 2022 brought an increase in sales with 36 machines, with a chain index of 24,14%. The time series for John Deere 8 series tractors is $y' = 23.8 + 2.0t$. This confirms the increasing trend of sales. The R^2 value is 0.5988, meaning the model explains 60% of the data, indicating a good fit.

New Holland sales seem to be stagnating; by looking at the graph, there might be a negative trend. Later to be confirmed by the B coefficient of the time series. The time series is $y' = 5.2 - 2.6645E-16$. This indicates a negative trend but the number is so small it

can be considered zero. The R^2 is surprisingly 0, meaning the model does not explain the data, and the best fit is a horizontal line.

When checking the correlation of the residuals, there is a moderate correlation between John Deere 8 series sales and New Holland 8T series sales with a coefficient of 0.5624.

Pearson Correlation Coefficients, N = 5	
	JD8 r_
NH 8T r_ NH 8T r_	0.56237

Table 3 Correlation of residuals for John Deere 8 series and New Holland 8T series sales (self-constructed)

4.2.5 John Deere harvester vs Claas harvester sales

When it comes to harvesters in Slovakia, John Deere and Claas are the best-selling. These two brands are the closest competitors. It is clear that Claas was leading the sales, but it seems to be changing. On the graph, the X-axis is the sales and the Y-axis shows the years.

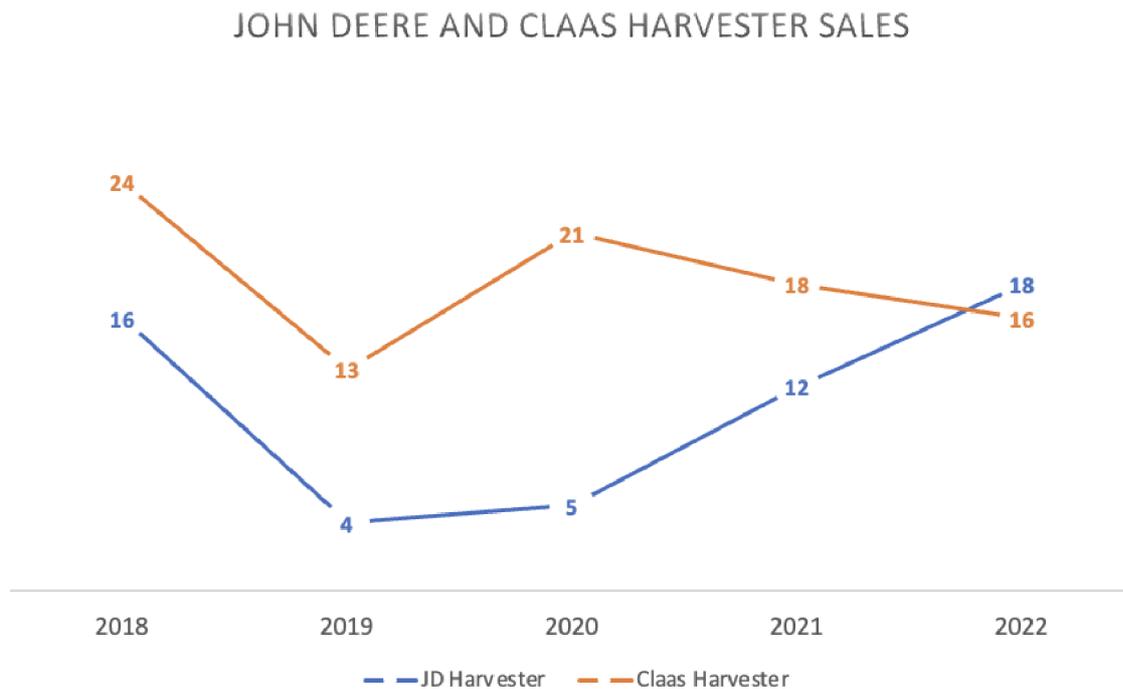


Figure 6 John Deere and Claas harvester sales (self-constructed)

John Deere sales seem to have had a big drop in sales from 2018 to 2019, with only four sales in 2019. This is a -75% decrease, which is quite significant. From 2019, the sales seem to recover and have a positive trend. In 2022 the sales surpassed those of the competitor. The time series for John Deere is $y' = 6.714 + 5.117t + 0.8367t^2$. This indicates a positive trend, meaning the sales are increasing. The I^2 is 0.8775, meaning the model explains 88% of the data.

Claas sales also dived in 2019, from 24 to 13, but not as much as John Deere sales, with a decrease of -45.83%. The next year it started to improve again, with a second fall in sales from 2020. The overall graph seems to have a negative trend. The time series is $y' = 21.70 - 1,10t$. The time series equation confirms the negative trend, meaning the sales are decreasing. The R^2 is only 0.1653, meaning the model only covers 17% of the data, resulting in a poor fit.

The correlation analysis of the time series residuals revealed a strong positive correlation between the John Deere harvester and Claas Harvester sales, with a coefficient of 0.7423.

Pearson Correlation Coefficients, N = 5	
	JDH r_
Claas H r_ Claas H r_	0.74233

Table 4 Correlation of residuals for John Deere Harvesters and Claas harvester sales (self-constructed)

4.2.6 John Deere prices and sales

John Deere sales are increasing, although prices are rising too. This suggests that price affects the sales of tractors. The following analysis will check whether there is a significant relationship between the price changes and sales during the last 5-year period. On the X-axis the price is showed in euros and on the Y-axis the years.

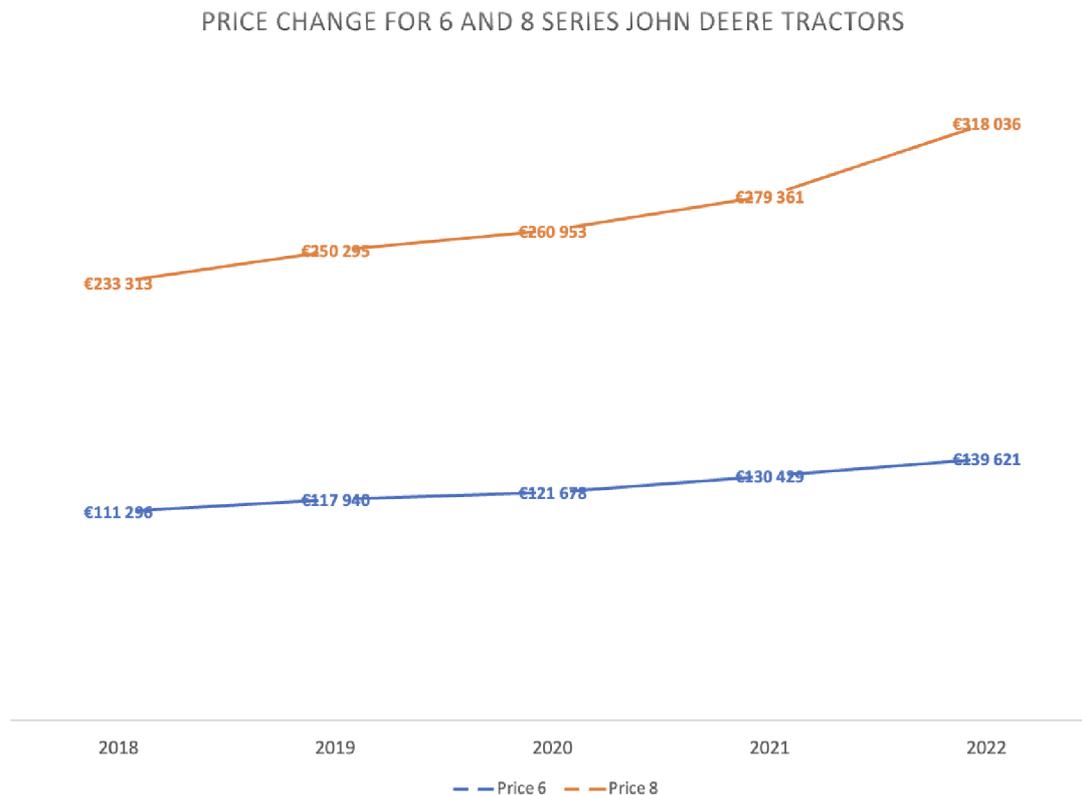


Figure 7 Price change for 6 and 8 series John Deere tractors (self-constructed)

The prices have significantly increased during the years, especially the price of 8 series tractors. The price increase is 25.45% for the 6 series from the year 2018 to 2022 and 36.31% for the 8 series. The reason is the supply chain problems and semi-conductor shortage, which is used for microchip production, and high crop prices due to the war in Ukraine.

The time series for the price of 6 series is $y' = 103451 + 6913.9t$. This clearly indicates the increase, as the trend has a positive slope.

The R^2 value is 0.9782, which is nearly a perfect fit, as the model covers 98% of the data.

As previously calculated, the time series for John Deere 6 series sales is $y' = 96.9 - 6.3t$, with a negative trend.

The correlation analysis of residuals shows a weak correlation between the John Deere 6 series tractor sales and its price with a coefficient of 0.1965.

Pearson Correlation Coefficients, N = 5	
	JD 6 r_
Price JD 6 r_ Price JD 6 r_	0.19647

Table 5 Correlation of residuals for John Deere 6 series sales and price (self-constructed)

John Deere 8 series tractor prices increased more significantly than the 6 series, which could be because of more micro-chips used, halting the production. The time series for the said tractors is $y' = 23.8 + 2.0t$. The positive slope indicates a rising trend. The prices have also steadily risen since 2018, with the time series being $y' = 208838 + 19851t$. After checking the correlation analysis of residuals, there is a strong positive correlation with a coefficient of 0.747.

Pearson Correlation Coefficients, N = 5	
	JD8 r_
Price JD8 r_ Price JD8 r_	0.74687

Table 6 Correlation of residuals for John Deere 8 series sales and price (self-constructed)

4.2.7 John Deere tractor sales and global wheat prices

One of the determinants for the farmer's profit is the grain price they can sell for, meaning with good prices on the global market, the farmers can make higher profits, even if the yield is not so great in the given year. When the profits are high, farms can consider buying new machines which can further increase their efficiency, leading to even more profits. As mentioned by Deaux & Attwood (2022), John Deere aims for higher profit as well because their customers have more spending power due to increased grain prices.

The following analysis will check whether there is a correlation between John Deere tractor sales and global wheat prices, as wheat is the most planted crop in Slovakia, with 15% of total crop output (*Agriculture and rural*, 2021). On the X-axis we can see the sales in pieces and the price of wheat in USD, the Y-axis shows the years from 2013 to 2022.

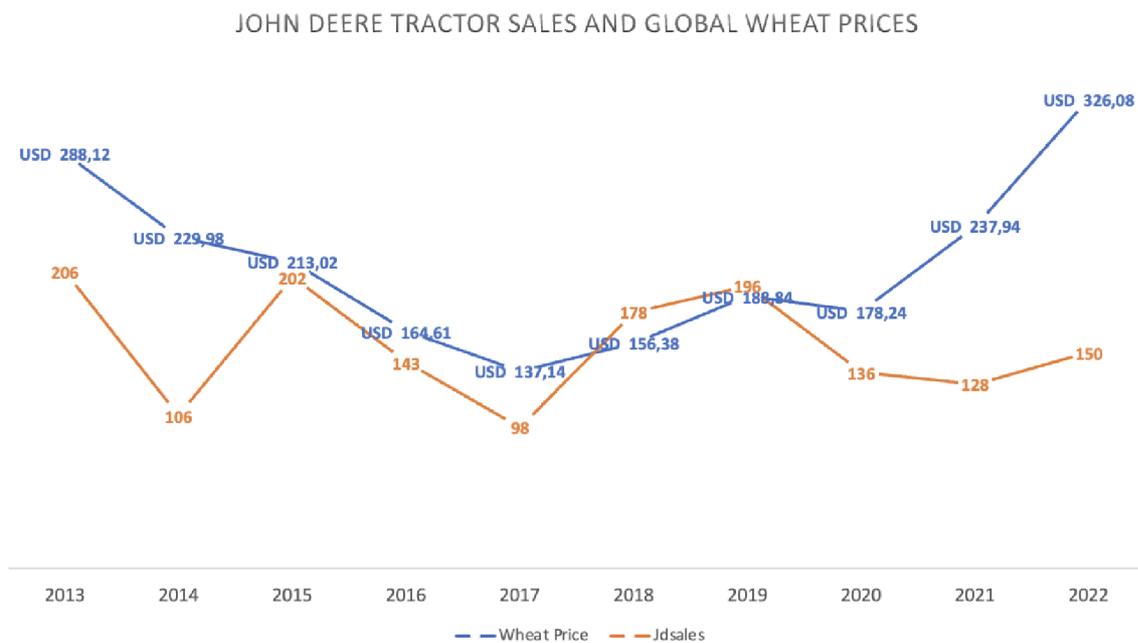


Figure 8 John Deere tractor sales and global wheat prices 2013-2022 (self-constructed)

John Deere tractor sales have a trend function of $y' = 169.00 - 2.673t$, meaning there is a decreasing trend. Some anomalies can be found, increases, which are caused by subsidies by European Union. R^2 value is low, with only 0.042. The model explains 4% of the data.

The time series trend function for global wheat prices is $y' = 367.801 - 81.223t + 7.558t^2$. The goodness of fit is I^2 with a value of 0.94, meaning the mode covers 94% of the data.

The residuals' correlation reveals a moderate correlation between John Deere tractor sales and global wheat prices. The correlation coefficient is 0.637.

Pearson Correlation Coefficients, N = 10	
	Jdsales r_
Wheat price r_	0.63673
Wheat price r_	

Table 7 Correlation coefficient for John Deere tractor sales and global wheat prices per tonne (self-constructed)

5 Results and Discussion

The findings are that although the mid-sized John Deere 6 series tractors are the most popular on the Slovak market, with a mean of 78 pieces for the last five years, the time series have a negative trend, meaning the sales are slowly decreasing. It was compared to the closest competitor, the New Holland 6T series, which is similar in size and uses applications and HP. The results show that the tractor sales of these brands are declining but do not affect each other; only a weak correlation was found when comparing the residuals of the time series. The John Deere 6 series also correlated to its price trend, as there was a significant increase in its price. The correlation of the residuals of the time series shows that there is only a weak correlation.

When it comes to the bigger, more premium machines, a positive trend was found for John Deere 8 series tractors, meaning the sales are slowly increasing. The average sales for the five years are 30. The 8 series was compared to the closest competitor, which is the New Holland 8T series. The trend for the 8T is negative, revealing the sales are declining. The John Deere 8 series time series trend and the price of the John Deere 8 series were also analysed, resulting in a strong correlation.

Unlike tractors, the biggest rival when it comes to harvesters is Claas. John Deere and Claas harvester sales were analysed using time series with the correlation of residuals. However, John Deere sales plummeted in 2019, with sales only of 4 pieces. After the big fall, sales steadily rose, surpassing Claas sales in the last year. The residuals' correlation revealed a strong positive correlation between John Deere and Claas harvester sales.

The overall John Deere tractor sales have slightly declined for the last ten years but seem to recover for the last years, as grain prices are high. The global wheat prices were correlated with the tractor sales, and a strong correlation was found using the correlation of residuals of the time series.

6 Conclusion

Although Slovak agriculture output is just a smaller part of Slovakia's GDP, its importance is significant, especially in the southern region. There are many agricultural machine vendors on the Slovak market, which sell regardless of how the others perform. The market can be identified as an oligopoly, as a few suppliers dominate it.

This thesis aimed to assess the sales of one of the leading brands found in the Slovak market, John Deere, of which the sales were analysed using statistical methods, mostly time series correlations, trying to determine what influences the sales.

The sales of the mid-sized 6 series tractors and the competitor New Holland 6T series are decreasing. The two brand sales do not affect each other, meaning even the closest competitor's sales are not influential. The price of the John Deere 6 series has been increasing for the past years and was correlated with the sales, but the results were similar when compared with the competitor; the price has a weak correlation with the sales. This indicates that the 6 series is an established product that is selling well regardless of external influence.

The bigger and more powerful 8 series is different, as it is more expensive, and the price increase has been significantly bigger than the 6 series. There is a strong correlation between the sales and the price of the machine. Also, it was correlated with the New Holland 8T series, and it was found that there is a strong correlation too. The sales of these two machines tend to move in a similar fashion.

When it comes to harvesters, the most expensive machines sold by John Deere in big numbers, the competitor is Claas. Claas was leading the market by sales for the last five years, and only in 2022 was John Deere able to take over. The correlation between John Deere and Claas harvester sales is strong.

It was also examined if there is a correlation between global grain prices and sales of John Deere tractors, as the war in Ukraine increased the prices of grains by a big margin. The grain that the analysis was conducted with is wheat, as it is the main product of Slovakia of

crops. The test was done for the last ten years as there was sufficient data to conduct such a test. The correlation revealed a strong correlation between wheat prices and tractor sales.

Although John Deere is not leading in every segment, their tractors are selling significantly better than the competitors, and the harvester sales seem to improve. This study showcased that the sales of these machines are hard to influence and will sell no matter the influencing factor; some factors can still affect the sales.

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