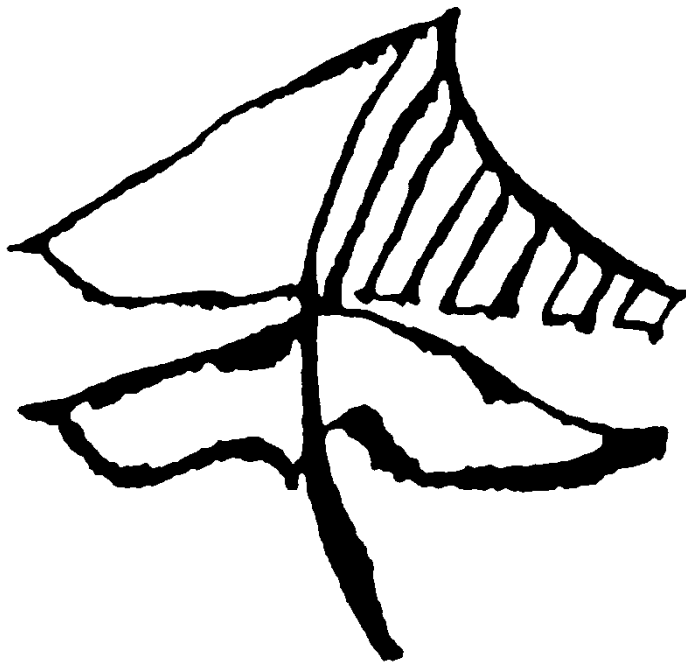


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CONTENTS

Elżbieta Badach, Monika Ziolo.....	7
THE IMPACT OF ROAD INFRASTRUCTURE ON SAFETY OF ROAD USERS IN THE ASPECT OF MULTIVARIATE STATISTICAL ANALYSIS.....	7
Zbigniew Gołaś	15
CHANGES IN THE FINANCIAL STRUCTURE AND LIQUIDITY OF FURNITURE MANUFACTURING ENTERPRISES IN POLAND BETWEEN 2005 AND 2014	15
Elżbieta Goryńska-Goldmann, Michał Gazdecki, Anna Wielicka-Regulska.....	23
QUALITY OF LIFE VS CONSUMERS' BEHAVIOURS AND FOOD HABITS.....	23
Tomasz Grzegorzczuk, Robert Głowiński.....	30
PATENTS AS FIRM'S INNOVATIVENESS INDICATOR: ADVANTAGES AND DISADVANTAGES	30
Emilia Grzegorzewska	35
DIVERSITY OF THE LEVEL OF INVESTMENT OUTLAYS ON FIXED ASSETS IN WOOD SECTOR IN POLAND.....	35
Marzena Karpińska	41
EXPERIMENTAL ECONOMICS AND MANAGEMENT SCIENCE	41
Karol Krajewski, Milena Lipińska, Małgorzata Wrzosek, Beata Bilka, Danuta Kołożyn-Krajewska	47
FOOD WASTE – FOUR DIMENSIONS OF SECURITY: ECONOMIC, SOCIAL, ENERGY AND ENVIRONMENTAL.....	47
Katarzyna Ostasiewicz, Józef Ledzianowski.....	54
INEQUALITY AVERSION AND USING FOREST AS A COMMON POOL RESOURCE.....	54
Wojciech Lis, Marek Wieruszewski, Zbigniew Malinowski	64
THE INFLUENCE OF OAK WOOD DIMENSIONS ON ITS VALUE AT SUBMISSION SALES.....	64
Katarzyna Mydlarz.....	73
ENVIRONMENTAL ASPECTS AND THEIR SIGNIFICANCE FOR BUSINESSES IN THE LUMBER INDUSTRY	73
Joanna Staniszevska	78
CHANGES IN THE STRUCTURE OF FRUIT PRODUCTION AND CONSUMPTION AFTER POLAND'S ACCESSION TO THE EUROPEAN UNION.....	78



Michał Sznajder, Joanna Staniszevska	86
ANGUS DEATON – THE NOBEL PRIZE LAUREATE IN ECONOMIC SCIENCES IN 2015	86
Piotr Rybacki, Andrzej Osuch, Czesław Rzeźnik, Robert Szulc, Katarzyna Szwedziak	92
ASSESSMENT OF PRACTICAL USEFULNESS OF EQUIPMENT IN MODERN AGRICULTURAL TRACTORS	92
Marek Tabert	102
PRODUCTION ORGANISATION SYSTEMS IN FURNITURE INDUSTRY ENTERPRISES	102
Marek Wieruszewski, Zbigniew Malinowski, Włodzimierz Popyk	112
VARIABLE ROOF TRUSS PRODUCTION EFFICIENCY	112



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Wojciech Lis



Elżbieta Badach, Monika Zioto¹

THE IMPACT OF ROAD INFRASTRUCTURE ON SAFETY OF ROAD USERS IN THE ASPECT OF MULTIVARIATE STATISTICAL ANALYSIS

Abstract: This article attempts to assess the diversity of road infrastructure in Poland by regions. The article takes into account the length of roads, expenditure on public roads, the volume of passenger and freight transport, and traffic congestion in individual provinces. The data obtained were compared with information on road safety including the number of accidents and people injured on the roads. Conducted multivariate statistical analysis of road infrastructure diversity indicates that the Silesian, Mazovian and Lesser Poland Voivodeships have the most developed road infrastructure in Poland, while it is the least developed in the West Pomeranian, Warmian-Masurian, Lublin and Podlaskie Voivodeships. Moreover, a very strong relationship was also observed between the development of road infrastructure and the number of injuries and deaths in individual provinces. The analysis of the structure of accidents shows that it is necessary to invest in highways and motorways in the eastern provinces where the number of deaths is the highest.

Key words: road infrastructure, road accidents, multivariate statistical analysis

INTRODUCTION

The needs of the human being have been evolving over centuries. It became increasingly important to overcome spatial, economic and social barriers. Many years of observations have shown that areas located near infrastructural systems with easy access are the fastest developing ones [Chudzik 1998]. The dynamic development of infrastructure is accompanied by a rapid development of the automotive industry. However, the development of road infrastructure and efforts to ensure safe riding conditions do not keep pace with increasing traffic congestion.

The aim of the paper is to present the variation of road infrastructure and to compare the activities undertaken to improve the quality of this infrastructure with the number of road accidents and traffic collisions and their effects by voivodeships.

Poland still lacks sufficiently developed road infrastructure, which often disqualifies Polish regions in the competition for location of large investments in this country, and more importantly affects safety of road users. That's why it is so important to develop and modernise road infrastructure.

Much is talked about a communication and transportation crisis, which is connected with congestion caused by accumulation of transportation and communicational needs, which are satisfied through movements of loads and people [Ciesielski 1992]. For that reason, investments in transportation should precede the development of other economic sectors so that the country's economic growth is not hindered [Ciesielski, Szudrowicz, 2001].

Importance of road infrastructure and economic effects of accidents

Road infrastructure plays an important role in supporting industry and trade, including international one. Infrastructure that is inadequate to the needs of users causes significant economic and social costs. In the case of road infrastructure, these are road accident victims - not only vehicle drivers and passengers, but also pedestrians, usually children and the elderly. The injuries of participants of road accidents entail huge losses and costs, which L. Brongel called the most expensive war of the modern world [Brongel 2007].

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Analysis of data from the European Transport Safety Council in 2013 shows that only Romania, Serbia and Latvia are ahead of Poland in Europe in terms of the number of road accident fatalities per 1 million inhabitants. Road accidents involve losses incurred by the whole Polish society. In 2013, road accidents cost Poland PLN 34.2 billion, whereas collisions - additional PLN 14.9 billion. The total cost was as much as PLN 49.1 billion. (fig. 1). According to analysts from the Road and Bridge Research Institute (RBRI), losses as a result of road accidents and collisions in 2013 accounted for almost 3 per cent of Poland's GDP, while the costs of such road incidents worldwide account for 1.5-2 per cent of GDP. Costs of hospital care for those injured in road accidents in 2013 were estimated by RBPI at almost PLN 343 million, while costs of maintenance of services taking intervention after accidents (the police, fire brigade or electricity emergency service) - at almost PLN 770 million.

Social Insurance Institute expenditures as a result of traffic accidents were little over PLN 3 billion. We should add to that losses incurred by employers, who lost their employees in road accidents. These losses were estimated by RBPI in 2013 at almost PLN 14.8 billion. It also estimated material damage as a result of road collisions and accidents, i.e. costs of damaged road infrastructure or cars in such incidents, at almost PLN 9.5 billion. Since the beginning of the decade, the number of accidents and fatalities in Poland has been on the decrease.

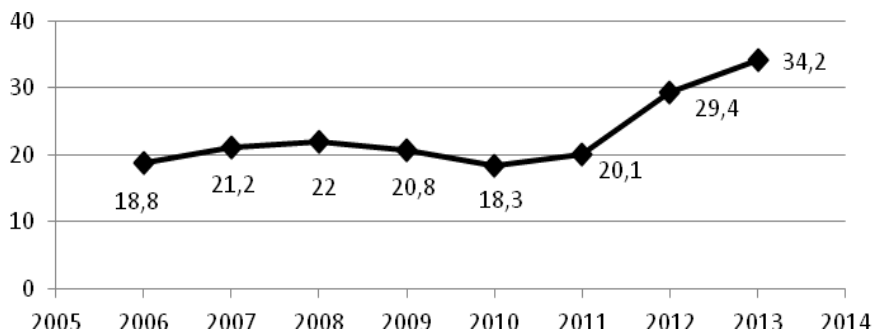


Figure 1. The costs of road accidents (in PLN billion) in years 2006-2013

Source: own study based on KRBRD

The main reasons for the low level of safety in road traffic on national roads include:

- road infrastructure not complying with safety standards, including small share of expressways and motorways, lack of equipment to protect pedestrians and cyclists.
- poor system for safety management in road traffic, including the lack or too lengthy introductory period for legal regulations concerning the structures and methods for managing this type of safety, poor communication with the society, lack of sufficient financial support for activities to increase safety in road traffic,
- weak safety culture, including dangerous behaviour of road users (speeding, driving without a seatbelt, drink or drug driving).

Although Poland is Europe's second, after Germany, market for road transportation, the biggest problem with the road infrastructure in Poland is the lack of a comprehensive system for motorway and expressway networks (as well as high-speed rail). Poor quality of roads, in turn:

- does not contribute to effective allocation of industry and services,
- limits the possibilities of flow of foreign investments,
- decreases mobility of labour force,
- significantly affects road safety,

- does not ensure appropriate quality of handling transport of persons and goods, and consequently decreases competitiveness of the Polish economy.

Bearing in mind the above-listed arguments, it is important to increase investments in express roads, especially that for many years Poland has suffered from underinvestment in road infrastructure and many countries are ahead of it in terms of the length of express roads. In 2012, over 10 thousand kilometres of motorways were recorded in: Spain (14 262 kilometres), Germany (12 845 kilometres), France (11 112 kilometres).

The situation has significantly improved over the last four years. The most dynamic growth in this type of network was recorded since 2010. In 2008, Poland had only 663 kilometres of motorways, while since June 2014 there has been an increase by 130%.

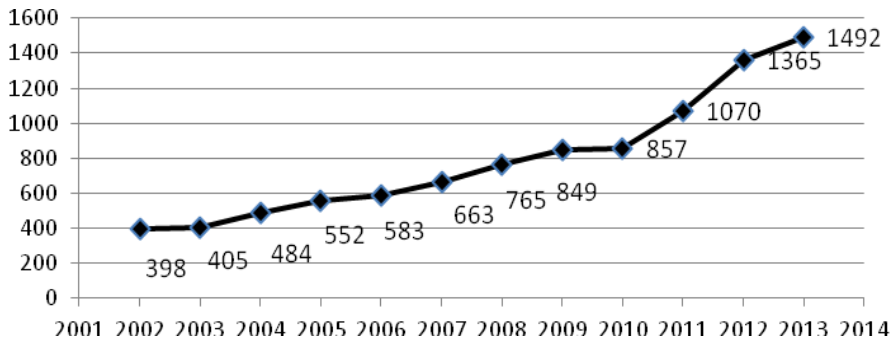


Figure 2. The length of the motorway network in Poland in the years 2002-2013 (km)

Source: own study based on GUS

A well-developed infrastructure leads to an increase in the quality of human capital. People living in small towns have easier access to education, entertainment, cultural events or health care [Calderon, Servén 2004].

Improvement of the state of infrastructure is characterised by economies of scale, allowing for increasing growth of total production [Aschauer, 1989]. This is due to the so-called external networking effects [Esfahani, Ramirez, 2003]. The denser the network of good roads, the bigger the group of potential suppliers and customers; the number of combinations of possible business contacts increases not only in a linear but exponential way.

STATE OF ROAD INFRASTRUCTURE IN POLAND

In terms of the dynamics of the development of a motorway network, Poland, with 134% increase in the number of kilometres of motorways between 2007 and 2012, occupies first place among European countries. Its network of express roads increased in this period by 230%.

Of importance for transport of persons and goods is road density. It varies significantly across the different voivodeships. The highest road network density in Poland is in Silesia (172.4 km) and in Lesser Poland (155.8 km), while the lowest one is in Warmian-Masurian Voivodeship (52.3 km), Lubusz (58.4 km) and West Pomeranian Voivodeships (59.2 km). Silesian Voivodeship has almost 3 times as many roads as Warmian-Masurian Voivodeship per 100 square kilometre. These disproportions result mainly from differences in population density in the different regions.

As a result, traffic congestion in Silesia is the highest countrywide - around two, three times as high as in Warmian-Masurian Voivodeship.

Table 1. Dynamics of increase in the number of kilometres of motorways in selected European countries in 2007-2012 in (%)

Country	Increase in motorway networks
Poland	134%
Hungary	61%
Spain	25%
Slovakia	15%
Czech Republic	12%
Germany	2%

Source: own study based on GUS, Road transport in Poland years 2010-2013

There is an urgent need to build motorway and express road networks and to improve the technical condition of the other roads, as traffic congestion on Polish roads is growing fast (Fig 3).

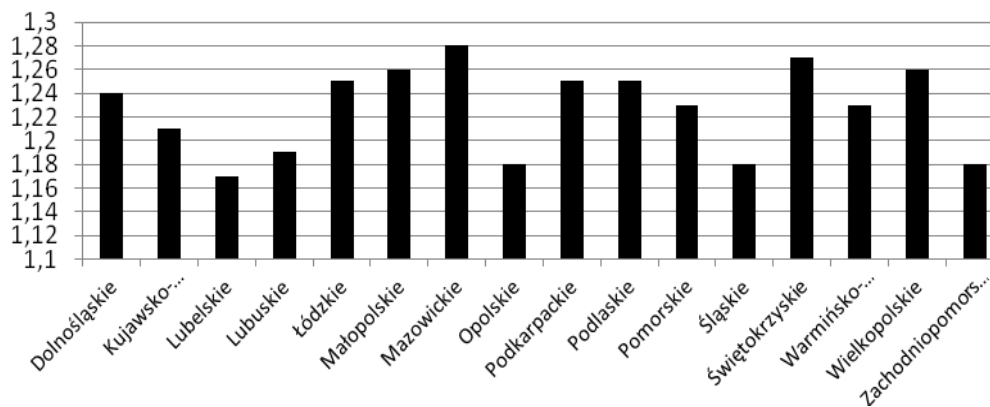


Figure 3. Changes in traffic in 2005-2010 in various Polish regions

Source: own study based on Transport of cargo and passengers in 2013, GUS

Between 2005 and 2010, traffic congestion on national roads grew by 23%. The least growth was recorded in Lublin Voivodeship (17%) and in West Pomeranian and in Silesia (by 18%). Silesia is a region where the average daily traffic on national roads is still the highest in the country and reaches 4899 vehicles per day. The biggest growth in traffic congestion was recorded in Mazovian Voivodeship (by 28 per cent).

The increase in traffic congestion in Poland is a result, on the one hand, of the growing number of cars and, on the other hand, increasing role of road transport of goods. Between 2003 and 2012, the number of cars in Poland increased by 66% [Kubik 2013]. In late 2012, there were 18.74 million passenger cars registered in Poland. In terms of the saturation of the automotive market, Poland's indicators are similar to those in the European Union. In December 2012, there were 486 cars per thousand inhabitants of Poland, while in the EU this figure was 484 on average [Transport..., 2013].

A point of significant concern, in terms of safety, may be the fact that the average age of cars driving on Polish roads has become significantly older. In 2003, 56% of cars were over 10 year old, whereas in 2012 the number of such cars increased to 80%.

MATERIAL AND METHOD

The basic aim of the paper is to present road infrastructure in Poland and to compare this information with data about road accidents to illustrate spatial variations in the phenomena examined. The evaluation of road infrastructure took into account the variables characterising the kinds and quality of roads in different voivodeships, the load on voivodeship road networks, changes in traffic congestion and average daily traffic of vehicles as well as transport of cargo and goods. All the variables describing road infrastructure were classified into a group of stimulants.

For verification of the relationship between variables, Pearson's linear correlation coefficient was used. Variables correlated at the level above 0.7 were excluded. Selection of variables also took into account the index of relative amplitude of fluctuations $A_f(x)$ to eliminate quasi permanent characteristics. The data was analysed by voivodeships in 2013. The analysis also took into account traffic increase index, which is examined every 5 years, therefore the analysis included data from 2011. The analysis indicated voivodeships where road infrastructure is most-developed and a group of voivodeships which require additional investment due to poor quality of roads leading to a large number of those killed and injured. The following variables were used in the analysis:

- x_1 - national roads per 100 square kilometres of the area;
- x_2 - voivodeship roads per 100 square kilometres of the area;
- x_3 - poviats roads per 100 square kilometres of the area;
- x_4 - gmina roads per 100 square kilometres of the area;
- x_5 - poviats roads per 100 square kilometres of the area;
- x_6 - motorways per 100 square kilometres of the area;
- x_7 - average daily traffic of vehicles;
- x_8 - traffic increase index for the period 2005-2010;
- x_9 - cargo to be transported in million t/km;
- x_{10} - transport of passengers in urban public transport per resident;
- x_{11} - expenditure on public roads in PLN thousand per one kilometre of road.

Table 2. Values of indicator describing the road infrastructure in 2013

Variables	Average	Minimum	Maximum	Coefficient of variation (%)
1	6.21	4.21	9.47	22.99
x_2	9.31	6.15	11.84	17.25
x_3	41.22	30.22	52.89	15.94
x_4	77.29	35.24	141.74	38.41
x_5	0.27	0.00	0.98	124.23
x_6	0.16	0.00	0.49	95.40
x_7	3416.69	189.00	5523.00	29.19
x_8	1.23	1.17	1.28	2.99
x_9	8388.31	4335.00	17809.00	53.66
x_{10}	78.17	25.34	209.54	62.88
x_{11}	100.35	33.42	233.22	67.63

Source: own calculation

In the examination of safety on roads, of the data describing the number of accidents, collisions, number of those killed and injured three variables were left after conducting a substantive and statistical analysis. All the variables were considered as destimulants.

x_1 - those killed per 100 thousand people;
 x_2 - those injured per 100 accidents;
 x_3 - number of road accidents per 10 thousand motor vehicles.

Analysis of varied variables required the use of a method that allows variables with different incomparable values to be compared. For that purpose, one of the methods of multivariate comparative analysis was used - zero unitarisation method, for which the standardisation formula for stimulants is as follows [Kukuła 2000]:

$$z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, \quad \text{when } X_j \in \{S\}, \quad (1)$$

For standardisation of destimulants, the following formula was used:

$$z_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, \quad \text{when } X_j \in \{D\}, \quad (2)$$

Table 3. Values of indicator describing the road accidents in 2013

Variables	Average	Minimum	Maximum	Standard deviation	Coefficient of variation (%)
1	9.09	5.8	11.6	1.75	19.25
x_2	122.80	115.5	136.4	5.26	4.28
x_3	13.91	8.2	22.0	3.77	56.92

Source: own calculation

Substitution of a set of characteristics describing a specific object with a synthetic variable (aggregate variable Q_i), which is the sum of all standardised characteristics, allows to describe the state of the phenomenon by means of one number.

This enables hierarchization of the set of analysed objects, creation of groups of similar objects, and thereby comparative studies in terms of the achieved level of development.

The evaluation of the variation of road infrastructure by means of multivariate statistical analysis shows that Silesian, Mazovian and Lesser Poland Voivodeships have the most-developed road infrastructure in Poland, while the least-developed infrastructure is in West Pomeranian, Warmian-Masurian, Lublin and Podlaskie Voivodeships. The network of national and voivodeship roads is the densest per 100 square kilometres in Silesian and Lower Silesian Voivodeships. The relatively biggest number of poviats roads is in Świętokrzyskie, Silesian and Łódź Voivodeships, whereas that of gmina roads - in Silesian and Lesser Poland Voivodeships. The shortest network of motorways runs through Warmian-Masurian, Podlaskie, Świętokrzyskie and Lublin voivodeships. Taking into account the average daily traffic of vehicles, roads are most intensively used in Lesser Poland (5523 vehicles/day), followed by Silesian Voivodeship (4899 vehicle/day), Mazovian and Łódź Voivodeships, where around 4000 vehicles drive per day. Expenditures on public roads varied significantly. The largest additional financing per kilometre of road was received by Lubusz and Subcarpathian Voivodeships - over 200 thousand, mainly for investment in express ways - followed by Silesian and Łódź Voivodeships (around 180 thousands). Lower Silesian and Kuyavian-Pomeranian Voivodeships received around 100 thousand per kilometre of road, while in the rest of voivodeships this amount was lower than 70 thousand.

Table 4. Rankings of voivodeships due to the diverse road infrastructure and road safety in 2013.

Item	Voivodeship	road infrastructure Q_i	Item	Voivodeship	road accidents Q_i
1	Silesian	8.35	1	Kuyavian-Pomeranian	2.52
2	Mazovian	6.16	2	Greater Poland	2.30
3	Lesser Poland	6.04	3	Silesian	2.14
4	Lower Silesian	5.58	4	Opole	2.06
5	Greater Poland	5.19	5	Subcarpathian	1.96
6	Łódź	5.07	6	Podlaskie	1.82
7	Świętokrzyskie	4.43	7	Lesser Poland	1.78
8	Kuyavian-Pomeranian	4.24	8	West Pomeranian	1.78
9	Pomeranian	3.98	9	Mazovian	1.71
10	Opole	3.60	10	Lublin	1.67
11	Lubusz	3.56	11	Lower Silesian	1.54
12	Subcarpathian	3.39	12	Pomeranian	1.35
13	West Pomeranian	2.33	13	Lubusz	1.24
14	Warmian-Masurian	2.19	14	Warmian-Masurian	1.13
15	Lublin	2.16	15	Świętokrzyskie	1.10
16	Podlaskie	2.11	16	Łódź	0.80

Source: own calculation

In the case of the ranking of road accidents, the higher the position, the smaller the number of injured on roads in a given voivodeship. Despite a very high traffic congestion in Silesian Voivodeship, it recorded the lowest number of fatalities (5.8), in contrast to Lublin Voivodeship, where 11.6 people died per 100 thousand people. The biggest number of fatalities was recorded in eastern voivodeships: Lublin, Podlaskie and Warmian-Masurian, which is related with the lack of express roads and motorways, and in Mazovian and Łódź Voivodeships, which have one of the largest transports of passengers and cargo.

The number of those injured per 100 accidents was the highest in Świętokrzyskie and Lower Silesian Voivodeships, where the highest indicator of traffic increase was observed between 2005 and 2010, 27% and 24 % respectively.

Moreover, a very strong negative relationship between the development of road infrastructure and the number of accidents in the different voivodeships was observed. Spearman correlation coefficient was -0.78, which indicates a strong dependence between the variables analysed.

CONCLUSION

The level of road infrastructure in Poland limits benefits that it could bring. For investments in infrastructure to be profitable, they should be made mainly in densely populated areas. Polish roads are among those most used for transport of goods across the European Union. Poland is in Top5 of countries with the largest tonnage of transported cargo. Highly intensive use of these roads results in their poor technical condition. 55% of national roads and only 29% of local government roads are in good condition.

Unfortunately, the safety level on Polish roads is significantly lower than the safety level in the other EU countries. The basic indices of traffic safety (death rate and concentration of fatalities) are in Poland several times higher than in Sweden, Holland or Great Britain. The road infrastructure, which is very neglected and in many cases does not meet safety standards, is changing very slowly. There are still too many old, low standard vehicles on Polish roads.

The multivariate statistical analysis of the variation of road infrastructure shows that Silesian, Mazovian and Lesser Poland Voivodeships have the best-developed road infrastructure in Poland, while the least-developed infrastructure is West Pomeranian, Warmian-Masurian, Lublin and Podlaskie Voivodeships.

Moreover, a very strong relationship was observed between the development of road infrastructure and the number of injured and fatalities in the different voivodeships. The analysis of the structure of accidents shows that it is necessary to invest in express roads and motorways in the eastern voivodeships, where the number of fatalities is the highest.

REFERENCES

1. Aschauer D. (1998), *Public Capital and Economic Growth: Issues of Quantity, Finance, and Efficiency*, The Jerome Levy Economics Institute, Working Paper No. 233.
2. Brongel L. (2007), *Złota godzina czas życia, czas śmierci* Krakowskie Wydawnictwo Medyczne, Kraków.
3. Calderon C.A., Servén L. (2004), *The effects of infrastructure development on growth and income distribution*, World Bank.
4. Chudzik B., Więckowicz Z. (1998), *Wyposażenie w infrastrukturę techniczną obszarów wiejskich makroregionu południowo zachodniego Polski V Konferencja naukowa: Infrastruktura techniczna wsi- ku integracji europejskiej*. S.C Drukpol, Kraków- Szczucin,
5. Ciesielski M., Długosz J., Gługiewicz Z., Wyszomirski O. (1992), *Gospodarowanie w transporcie miejskim*, AE, Poznań.
6. Ciesielski M., Szudrowicz A. (2001), *Ekonomika transportu*, AE Poznań
7. Esfahani H.S., Ramirez M.T. (2003), *Institutions, infrastructure, and economic growth*, *Journal of Development Economics*, vol. 70, issue 2.
8. *EU transport in figures statistical pocketbook 2013*.
9. Herrera S., Pang G. (2005), *Efficiency of Infrastructure: The Case of Container Ports*, World Bank, Policy Research Working Paper.
10. Kaliński J., *Autostrady na EURO 2012 (2013)*, „Kwartalnik Kolegium Ekonomiczno-Społecznego. Studia i Prace”, Oficyna Wydawnicza Szkoła Główna Handlowa w Warszawie.
11. Kubik A. *Polska dogoniła UE pod względem motoryzacji*, *Gazeta Wyborcza*, 27.08.2013.
12. Kukuła K. (2000), *Metoda unitaryzacji zerowanej*, PWN.
13. *Mały rocznik statystyczny Polski 2014*.
14. Rogacki H. (2007), *Geografia społeczno – gospodarcza Polski*. PWN S.A., Warszawa.
15. *Transport drogowy w Polsce w latach 2010 i 2011*.
16. Załoga E. (2007), *Ekonomiczne i społeczne wyzwania współczesnego transportu*. Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 454, Szczecin.

Zbigniew Golaś²

CHANGES IN THE FINANCIAL STRUCTURE AND LIQUIDITY OF FURNITURE MANUFACTURING ENTERPRISES IN POLAND BETWEEN 2005 AND 2014

Abstract: The main aim of the study was a multidimensional analysis of the financial structure and liquidity of furniture manufacturing sector in Poland according to the size of enterprises. The analysis was based on aggregated financial statements provided by enterprises between 2005 and 2014 and published by the European Central Bank in the database of the Bank for Accounts of Companies Harmonised (BACH). As the provided data shows, there were dynamic changes in the financial structure of furniture manufacturing sector in Poland. They caused an increase in financial liquidity and simultaneously, the risk of liquidity was considerably reduced. These changes took place in enterprises of all sizes, especially in large ones.

Key words: financial structure, financial liquidity, furniture industry, Poland

INTRODUCTION

The maintenance of financial liquidity is essential to the functioning and development of each enterprise because it guarantees fulfilment of current liabilities and contributes to creation of appropriate relations with creditors and capital providers. In consequence, this influences the possibilities to create additional market value.

Problems with financial liquidity are often caused by payment bottlenecks. They often occur during downturn periods and usually they affect small enterprises [Sierpińska & Wędzki 2001, Sielicka 2013], because small businesses usually have more difficult access to external financing. Apart from that, when they have poor financial results, usually they have no access to bank credits.

The aim of this study was to present the diversification and the trend of changes in the financial structure and liquidity of furniture industry in Poland according to the size of enterprises. The study was based on essential measures of the financial structure in furniture sector, indexes of static financial liquidity and indexes based on working capital.

MATERIAL AND METHODS

The assessment of the financial situation in furniture manufacturing sector in Poland was based on aggregated financial statements provided by enterprises between 2005 and 2014 and published by the European Central Bank in the database of the Bank for Accounts of Companies Harmonised (BACH) [Bank, 2016]. These statements enable multidimensional economic and financial analyses of different sectors of the economy in the EU member states according to NACE Rev. 2, i.e. the Statistical Classification of Economic Activities, which is applicable in the EU [NACE, 2016]. The BACH database includes aggregated accounting data of non-financial enterprises in 11 European countries (Austria, Belgium, the Czech Republic, France, Germany, Italy, the Netherlands, Poland, Portugal, Slovakia and Spain), which were harmonised according to European directives in order to make them as comparable as possible [The Bank, 2015].

The aforementioned sources of data were used to analyse and assess the essential determinants of the financial structure and liquidity of furniture manufacturing sector in Poland according to the size of enterprises. The methodology applied in the BACH database distinguishes classes of enterprise sizes only according to income rather than employment, income and balance sheet total, which is the classification model used in the EU [Commission, 2003]. The BACH database

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distinguishes the following three classes of enterprise sizes [Bank, 2016]: small enterprises (income < 10 million euros), medium enterprises (income 10-50 million euros) and large enterprises (income > 50 million euros).

The analysis of the financial structure and liquidity in furniture manufacturing sector in Poland was based on methodological tools of ratio analysis of financial statements [Gołębiowski et al., 2014; Gabrusewicz, 2014; Sierpińska & Jachna, 2004; Wędzki, 2006]. The BACH database was used to analyse changes in the assets and capital structure, indexes of static liquidity and indexes based on working capital [Bank, 2016].

RESULTS AND DISCUSSION

TRANSFORMATIONS IN THE FINANCIAL STRUCTURE OF FURNITURE MANUFACTURING ENTERPRISES

The starting point of the analysis was the financial structure of furniture manufacturing sector in Poland. It was based on essential relations between assets and capital, which provided information about the strategy of financing the activity and indirectly, about financial liquidity (Table 1). The first relation (total assets/equity) shows that during the period under investigation furniture manufacturing enterprises in Poland significantly and comparably reduced the scale of financing their assets with external capital in all enterprise size classes. Between 2005 and 2008 the capital leverage exceeded 220%, whereas at the end of the period under study it decreased to about 190%. In consequence of these changes the equity debt was noticeably reduced in all enterprise size classes from 122-131% to 82-93%.

As the data in Table 1 indicates, the financial structure of furniture manufacturing enterprises in Poland is increasingly determined by long-term capital. In all enterprise size classes the share of long-term capital in total assets increased. This means that enterprises increasingly use external sources of finance for investments. This tendency is particularly noticeable in the sector of large enterprises, where the share of long-term debt in assets increased at the fastest rate during the period under study, i.e. on average by 6.0% per year, whereas in small and medium enterprises the increase was slightly greater than 2%.

Table 1. Financial structure of enterprises in the Polish furniture industry in the years 2005-2014 according to the size of enterprises.

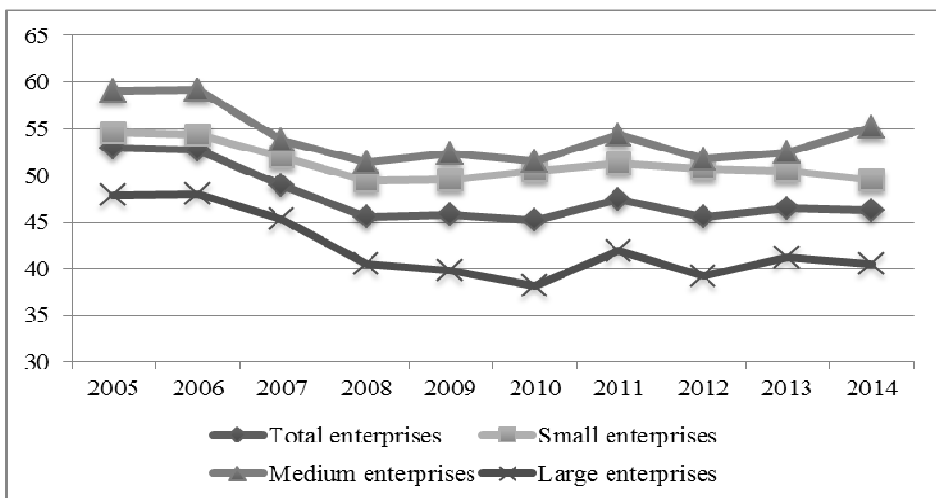
Size of enterprises	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Δ^1
Total assets/equity (%)											
Total	225,9	220,8	222,5	233,4	212,6	187,3	197,3	186,5	180,6	189,2	-2,0
Small	231,0	220,6	221,2	216,3	196,9	195,9	195,7	196,7	187,2	193,0	-2,0
Medium	222,0	223,5	221,6	219,8	202,3	195,2	197,9	185,0	182,8	181,8	-2,2
Large	225,5	219,3	223,5	251,0	229,3	178,5	197,8	182,8	176,5	191,7	-1,8
Total debt/equity (%)											
Total	125,9	120,8	122,5	133,4	112,6	87,3	97,3	86,5	80,6	89,2	-3,8
Small	131,0	120,6	121,2	116,3	96,9	95,9	95,7	96,7	87,2	93,0	-3,7
Medium	122,0	123,5	121,6	119,8	102,3	95,2	97,9	85,0	82,8	81,8	-4,3
Large	125,5	119,3	123,5	151,0	129,3	78,5	97,8	82,8	76,5	91,7	-3,4

Current assets/total assets (%)											
Total	52,9	52,7	49,0	45,5	45,8	45,2	47,4	45,5	46,5	46,3	-1,5
Small	54,6	54,4	52,0	49,4	49,6	50,5	51,3	50,7	50,5	49,6	-1,1
Medium	59,1	59,2	53,8	51,4	52,4	51,6	54,4	51,8	52,5	55,2	-0,7
Large	47,9	48,0	45,3	40,5	39,8	38,2	41,9	39,2	41,2	40,5	-1,9
Other financial assets and cash/total assets (%)											
Total	8,0	6,3	6,4	7,1	8,7	7,2	6,8	7,5	9,2	8,1	0,2
Small	8,0	8,2	9,1	10,	9,7	9,0	9,2	9,4	9,6	9,6	2,1
Medium	9,1	8,2	8,0	8,7	12,	10,1	8,5	9,8	10,9	10,7	1,8
Large	7,2	4,2	4,3	4,8	5,9	4,5	4,8	5,3	8,0	6,2	-1,7
Long-term liabilities/total assets (%)											
Total	10,8	14,	9,9	12,	15,	13,7	15,6	10,	12,0	17,2	5,3
Small	8,8	9,0	11,	12,	11,	10,4	10,5	9,9	9,6	10,9	2,4
Medium	7,6	8,8	13,	12,	12,	12,5	12,2	11,	10,3	9,2	2,2
Large	14,1	20,	7,5	12,	19,	16,1	19,9	10,	14,1	23,9	6,0
Current liabilities/total assets (%)											
Total	42,4	37,6	42,2	40,7	33,5	29,8	30,1	32,3	28,8	25,1	-5,7
Small	45,2	42,5	40,2	37,5	34,1	34,3	34,4	35,1	32,5	32,5	-3,6
Medium	44,3	43,5	38,1	37,8	34,2	33,3	34,4	31,7	31,7	32,8	-3,3
Large	39,4	31,6	45,2	43,7	32,8	25,2	25,8	31,2	25,5	18,2	-8,3

¹Δ – Average annual change in% (geometric mean)

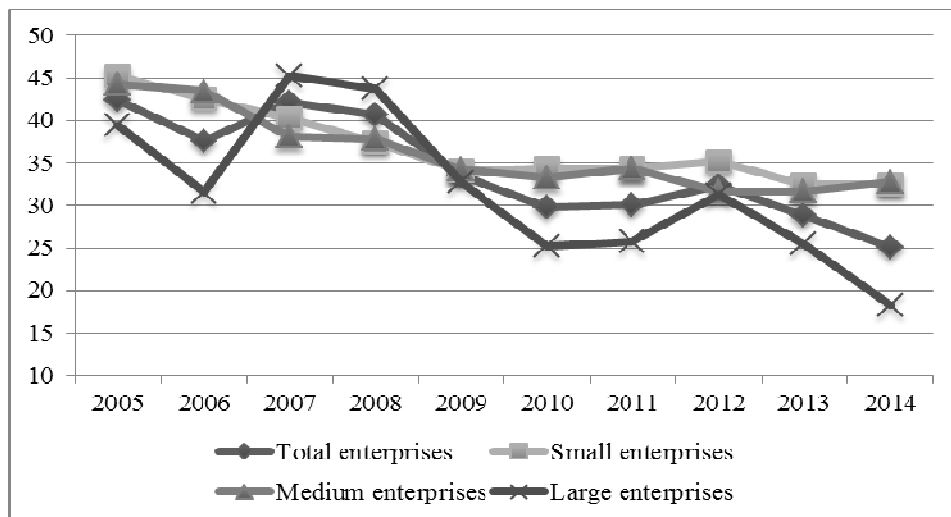
Source: own calculations based on Bank for the Accounts of Companies Harmonised [Bank, 2016].

Fig. 1. Changes in the share of current assets in total assets in companies of furniture industry in Poland in the years 2005-2014 according to the size of enterprises (%)



Source: own study based on the tab. 1

Fig. 2. Changes in the share of current liabilities in total assets in companies of furniture industry in Poland in the years 2005-2014 according to the size of enterprises (%)



Source: own study based on the tab. 1

The figures in Table 2 point to a favourable trend in structural changes, resulting in increased financial liquidity in furniture manufacturing enterprises. During the period under study the share of current liabilities decreased at a faster rate than the share of current assets in total assets.

Also in this case the greatest dynamics of changes could be observed in the sector of large enterprises, where the share of current assets in total assets decreased by 1.9% per year, on average, whereas the share of current liabilities decreased by as much as 8.3%. These changes were much less dynamic in the sectors of small and medium enterprises. Nevertheless, they also point to increased financial liquidity.

To sum up, the trend and dynamics of changes in the aforementioned indicators of the financial structure point to an increasingly conservative financing policy in the Polish furniture industry. Simultaneously, we can observe the growing importance of financial security of enterprises in this sector.

FINANCIAL LIQUIDITY OF FURNITURE MANUFACTURING ENTERPRISES

The conclusions drawn from the analysis of the financial structure of furniture manufacturing sector are largely confirmed by measures characterising its financial liquidity (Table 2). If we take the most common measures into consideration, i.e. current ratio and quick ratio, we can definitely say that they were high in all enterprise size classes during the whole period under investigation. They were within the normal range. Apart from that, the data in Table 2 show that there was a noticeable rising tendency of financial liquidity measured with these indicators. In the total furniture industry the current liquidity increased from 1.25 to 1.85, whereas quick liquidity increased from 0.82 to 1.26, i.e. by 48.0% and 53.7%, respectively. These changes were even more noticeable in large enterprises, where the liquidity measures changed by 82.8% (current liquidity) and by 97.4% (quick liquidity). In general, it means that the capacity to settle short-term liabilities improved significantly and simultaneously, the risk of financial liquidity was reduced.

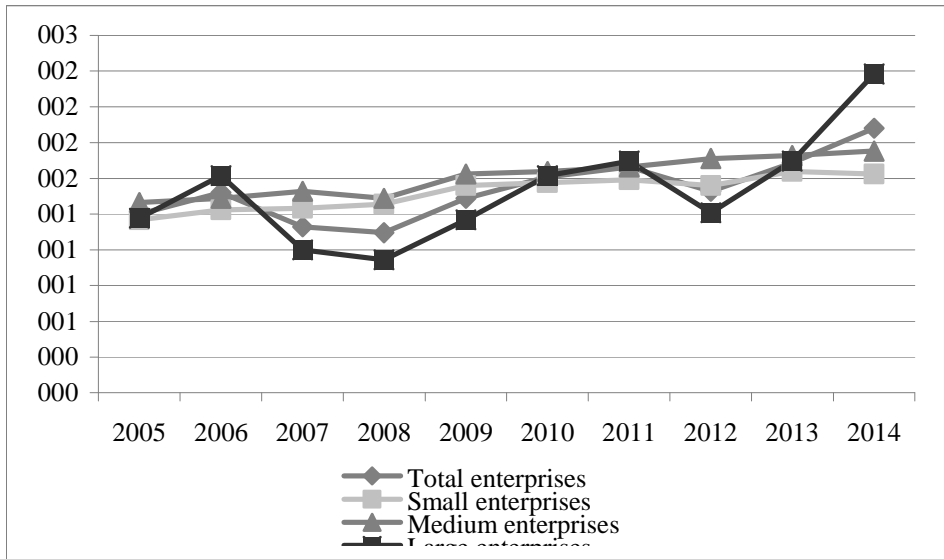
Table 2. Financial liquidity ratios of companies of furniture industry in Poland in the years 2005-2014 according to the size of enterprises

Size of enterprises	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Δ^2
Current ratio											
Total	1,25	1,40	1,16	1,12	1,36	1,51	1,58	1,41	1,61	1,85	4,4
Small	1,21	1,28	1,29	1,32	1,45	1,47	1,49	1,45	1,55	1,53	2,6
Medium	1,33	1,36	1,41	1,36	1,53	1,55	1,58	1,64	1,66	1,69	2,6
Large	1,22	1,52	1,00	0,93	1,21	1,52	1,62	1,26	1,62	2,23	7,0
Quick ratio											
Total	0,82	0,96	0,78	0,77	0,98	1,00	1,06	0,95	1,13	1,26	4,8
Small	0,80	0,84	0,83	0,86	0,97	0,94	0,97	0,93	1,03	1,01	2,6
Medium	0,92	0,92	0,95	0,95	1,11	1,10	1,10	1,14	1,21	1,17	2,8
Large	0,77	1,09	0,69	0,65	0,90	0,96	1,09	0,84	1,13	1,52	7,8
Inventory turnover											
Total	9,0	9,1	9,3	9,4	9,8	8,3	8,9	8,7	9,2	9,0	0,0
Small	9,3	9,2	9,1	8,7	8,5	7,8	8,1	8,2	8,7	9,2	-0,1
Medium	10,2	9,1	9,6	9,5	10,3	9,5	9,4	10,1	10,3	9,4	-0,9
Large	7,8	9,0	9,1	9,7	10,4	7,6	9,0	8,2	8,8	8,6	1,0
Receivables turnover											
Total	8,0	7,5	8,4	8,3	8,2	8,3	8,1	9,1	9,3	9,4	1,8
Small	8,6	8,5	9,8	9,3	8,9	8,0	7,9	8,6	8,7	9,1	0,7
Medium	8,2	7,7	9,4	8,5	9,6	8,8	8,1	9,7	9,3	9,2	1,3
Large	7,4	6,9	7,3	7,7	7,0	8,2	8,3	9,0	9,6	9,6	2,9
Turnover of trade payables											
Total	7,8	7,7	8,7	8,9	9,8	9,2	9,3	9,8	10,2	11,0	4,0
Small	6,7	7,3	7,9	8,0	8,5	8,0	7,9	8,1	9,0	9,9	4,5
Medium	7,5	6,8	8,7	8,9	10,1	8,9	8,7	9,2	9,4	9,5	2,6
Large	9,2	9,2	9,1	9,4	10,7	10,6	10,6	11,8	11,7	13,2	4,1
Cash conversion cycle (days)											
Total	39,5	41,6	41,1	41,6	44,6	48,4	46,5	44,4	43,1	46,6	1,9
Small	27,2	32,2	31,5	35,6	41,0	46,8	44,9	42,1	43,7	42,8	5,2
Medium	31,6	33,3	35,0	40,2	37,3	38,6	41,8	34,0	36,1	39,8	2,6
Large	55,9	54,2	50,1	45,8	52,8	58,2	50,4	54,3	48,1	52,8	-0,6
The cycle of the operating working capital (days)											
Total	82,6	84,6	78,4	75,5	74,6	82,2	79,1	75,7	72,1	70,8	-1,7
Small	76,5	76,5	69,8	71,6	75,8	81,7	79,8	76,5	73,2	68,6	-1,2
Medium	78,2	84,6	73,6	76,7	69,7	76,1	80,2	70,1	70,4	74,4	-0,6
Large	91,2	89,9	86,2	76,7	77,8	87,9	78,1	79,7	72,6	69,3	-3,0

¹ Δ – Average annual change in% (geometric mean)

Source: own calculations based on Bank for the Accounts of Companies Harmonised [Bank, 2016].

Fig. 3. Changes in the level of the current ratio in enterprises of furniture industry in Poland in the years 2005-2014 according to the size of enterprises



Source: own study based on the tab. 2

Another criterion of assessment of the financial liquidity of furniture enterprises was efficient management of working capital components. It was measured with the indicators of inventory turnover, receivables turnover and the turnover of payables to suppliers. The first indicator, i.e. inventory turnover, shows that in all enterprise size classes the efficiency of inventory management was comparable and stable over time. During the period under investigation the inventory turnover ratio ranged from 8 to 9. This means that the inventory cycle was about 40-45 days long. There was relatively more variation in the receivables turnover ratio, which changed favourably from the point of view of financial liquidity. In the total furniture sector it increased from 8.0 in 2005 to 9.4 in 2015. This means that the receivables cycle was reduced from 46 to 39 days. Changes in the receivables policy were particularly noticeable in the sector of large enterprises, where the receivables turnover ratio increased from 7.4 to 9.6 and the receivables cycle was reduced by 23%, i.e. from 49 to 38 days.

As far as the trade payables turnover (payables resulting from supplies and services) is concerned, furniture manufacturing enterprises in Poland decreasingly financed their activity by prolonging the time of payment to suppliers. As results from the analysis, the payables turnover ratio increased in all enterprise size classes. This means that payments for deliveries were made in a shorter time. In the total furniture industry the payables turnover ratio increased from 7.7-7.8 (2005-2006) to 10.2-11 (2013-2014). This means that the cycle of payments to supplier was reduced from about 47 days to about 35 days. These changes were mostly observed in the sectors of small and large enterprises. The trade payables turnover ratio increased from 6.7 in 2005 to 9.9 in 2014 in small enterprises, whereas in large enterprises it increased from 9.2 in 2005 to 13.2 in 2014. This means that the cycle of payment to suppliers was reduced from 54 days to 37 days in small enterprises and from 40 days to 28 days in large enterprises. However, it is necessary to stress the

fact that as far as financial liquidity is concerned, shorter trade payables cycles are not favourable because they reduce the time of having cash for other operational goals than payment of liabilities. However, on the other hand, excessive prolongation of payables cycles may lead to payment bottlenecks causing numerous liquidity problems to suppliers.

The working capital management policy affected by the inventory, receivables and trade payables turnover determines the length of the cash conversion cycle, which is one of the most objective measures of assessment of the financial liquidity of enterprises [Wędzki, 2003]. The data in Table 3 show that the time of recovering the funds invested in the activity of Polish furniture manufacturing enterprises was prolonged ($\Delta=1.9\%$), but in general, it was not too long. Changes in the cash conversion cycle point to a slight decrease in the working capital management efficiency. The main reasons of this tendency should be sought in reduced cycles of payables to suppliers. As far as financial liquidity is concerned, the most favourable situation was noted in the sector of medium enterprises, where the cash conversion cycle was also prolonged, but it was the shortest (31.6-39.8 days). On the other hand, the funds recovery cycle was significantly longer in the sector of large enterprises. Although the cash conversion cycle in these enterprises was relatively stable, but it was usually longer than 50 days.

The last measure of assessment of financial liquidity in furniture manufacturing sector was the operating working capital cycle. Its length provides information about financial security in the context of time for which this capital will suffice. In the total furniture industry and in individual enterprise size classes the length of this cycle decreased. Similarly to the cash conversion cycle, it points to a decrease in the working capital management efficiency. The scale of changes was small ($\Delta=1.7\%$), so during the whole period under study the working capital efficiency was relatively high in all enterprise size classes. The cycle was relatively strongly reduced only in the sector of large enterprises. On average the cycle was reduced by 3% per year and in 2014 (69 days) it was about 24% shorter than in 2005 (91 days). These results point to an increase in risk of liquidity but it is still relatively low. On average, the operating working capital secured more than two months' turnover in large enterprises.

SUMMARY

Between 2005 and 2014 there were significant changes in the financial structure of furniture manufacturing sector. The scale of financing the activity with short-term borrowed capital was reduced. These changes definitely point to an increase in financial security and they were proved with the measures of assessment of financial liquidity. During the period under analysis financial liquidity measured with the current and quick liquidity ratios increased in all enterprise size classes. At the end of the period under study it reached the level which indicated high coverage of current liabilities with current assets. As far as measures of liquidity based on working capital are concerned, there was a slight tendency to prolong the cash conversion cycle in consequence of reduction of times of payment to suppliers. As far as financial liquidity is concerned, shorter trade payables cycles are not favourable because they reduce the time of having cash for other operational goals than payment of liabilities. However, on the other hand, excessive prolongation of payables cycles may lead to payment bottlenecks causing numerous liquidity problems to suppliers. Nevertheless, changes in this area were not very dynamic and in general they do not undermine the good situation of furniture manufacturing enterprises in their capacity to settle short-term liabilities.

REFERENCES

1. Bank for Accounts of Companies Harmonised, www.bach.banque-france.fr, dostęp: 20.04.2016.
2. Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises, Official Journal of the European Union, L 124/36, 2003/361/EC,

- 20.5.2003, dostęp 20.04.2016, [http://eur-lex.europa.eu/legal-content/ EN/TXT/PDF/?uri=CELEX:32003H0361&from=EN](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003H0361&from=EN).
3. Gabrusewicz W. (2014). *Analiza finansowa przedsiębiorstwa. Teoria i zastosowanie*. PWE, Warszawa.
 4. Gołębiowski G., Grycuk A., Tłaczała A., Wiśniewski P. (2014). *Analiza finansowa przedsiębiorstwa*, Difin, Warszawa.
 5. NACE Rev. 2 - Statistical classification of economic activities in the European Community, Eurostat, Methodologies and working papers, <http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.pdf>, dostęp 20.04.2016.
 6. Sierpińska, M., Wędzki, D. (2001). *Zarządzanie płynnością finansową w przedsiębiorstwie*. Warszawa, PWN.
 7. Sierpińska M., Jachna T. (2004). *Ocena przedsiębiorstwa według standardów światowych*, PWN, Warszawa.
 8. Sielicka, B. (2010). Zatory płatnicze niszczą polskie firmy. <http://www.bankier.pl/wiadomosc/Zatory-pлатnicze-niszczą-polskie-firmy-2258842.html>. (dostęp 21.05.2016).
 9. The Bank for the Accounts of Companies Harmonized (BACH) database. (2015). *Statistics Paper Series*, September 2015, no 11, BACH Working Group, European Central Bank, www.ecb.europa.eu/pub/pdf/scpsps/ecbsp11.en.pdf, dostęp: 27.04.2016.
 10. Wędzki D. (2003). *Strategie płynności finansowej przedsiębiorstwa*. Oficyna Ekonomiczna, Kraków.
 11. Wędzki D. (2006). *Analiza wskaźnikowa sprawozdania finansowego*. Oficyna Ekonomiczna, Kraków.

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QUALITY OF LIFE VS CONSUMERS' BEHAVIOURS AND FOOD HABITS

Abstract. The aim of the study was to specify the elements describing consumers' behaviours and habits in terms of quality of life and to determine the relation between perceived quality of life and consumers' behaviours and habits as well as the interaction between them. It is possible to make a cause-and-effect model describing the influence of consumers' behaviours and habits on quality of life. The following behaviours should be taken into consideration when constructing the model of consumers' behaviours affecting quality of life: market behaviours, aspects of organising nutrition in the household, consumers' attitude to innovation, consumers' nutritional awareness, the system of values and lifestyle. The authors of the study proposed the quality of life index showing quality of life from the perspective of a household as a determinant of quality. The research concept will enable investigation of relations between behaviours associated with food consumption and quality of life.

Key words: quality of life, consumption, relation, behaviours, food habits, consumer.

INTRODUCTION

The contemporary world is characterised by rapid and far-flung changes in different areas of the life of society and in individuals' lives. Dynamic processes of progressing computerisation, globalisation of economy and culture, the development of young democracies with liberal and consumptive tendencies, extending life expectancy and growing women's occupational activity cause scientists, politicians and consumers to be interested in quality of life and its assessment [Brewer 2009, Campbell 2009, Kurek 2007, Lisiecka & Czyż-Gwiazda 2007, Mickel & Dallimore 2009]. These are examples of only a few factors affecting nutritional habits and food production, health, lifestyle and living standard, core values and their hierarchy, culture, consumer relations, interpersonal relations, mass culture and the sense of social and individual identity. These transformations became the basis of the research problem, which is the main motif of this publication.

Considerations on quality of life over a longer time horizon are a weighty economic and social problem. However, we can assume that improved quality of life in households will reduce expenses from the state budget on the health and social policy. The approach presented by the authors leads to the question what quality of life means to Polish consumers and how and to what extent nutritional behaviours and habits affect quality of life. The authors assume that if people always have access to necessary food in terms of quantity, health safety and acceptable prices that positively assess the quality of their lives⁴. Progressing economic growth allows for the improvement of the economic situation of an average Polish citizen sufficiently enough to make most of the society concentrate not only on the possibility to satisfy their nutritional needs but also on the appropriate quality of life, which is related to consumers' behaviours and habits both in terms of the market and consumption. In order to achieve this goal, it is necessary to conduct research to determine the current quality of life, assess how Polish consumers see quality of life and to determine how and to what extent consumers' behaviours and habits influence quality of life.

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⁴ According to the data found in „Diagnoza Społeczna 2015” resourcefulness of the Polish people facilitates systematic improvement of individual well-being (since 1992 a 3-fold decrease in poverty-stricken households can be observed). More than 80% of Polish people evaluate their lives positively [Czapiński 2015].

THE AIM AND METHODOLOGICAL REMARKS

The aim of this article is to specify the elements describing consumers' behaviours and habits in terms of quality of life and to determine the relation between perceived quality of life and consumers' behaviours and habits, including the interaction between them. For the purpose of the following research foreign and Polish secondary sources were used. Analytical, descriptive and deductive analyses were conducted. This article is a literature review describing results of empirical studies and chosen concepts from the field. It is also concerned with the food consumption behaviour and quality of life relationship model.

QUALITY OF LIFE – DEFINITION AND CONDITIONS

In economic sciences theoretical explanations of the issue of quality of life are provided by welfare economics. The branch has normative character and its aim is to evaluate the functioning of economy. Different researchers [eg. Czapinski & Panek 2013, Sampolska-Rzechuła 2013] very often pose questions about the efficiency of allocation of resources and the fair division of goods and services among different members of society. In everyday activity, both in business and in consumers' lives, it is important to search for solutions improving the conditions of life and increasing welfare.

Kurek [2007] thinks quality of life is the most important of known varieties of quality and it can be regarded as a factor stimulating the development of societies. Quality of life is often the primary aim of both practical, research activity, which is more and more often the subject of interest of sociological, psychological and philosophical sciences, and it is the primary aim of social policy and economic sciences. Considerations about the definition of quality of life stress the multitude of meanings and ranges of the concept. However, when we look at the theoretical background of the concept of quality of life, we can see that there are different approaches, depending which element is assumed as the basis of considerations, e.g. happiness, resources or needs [Kurek 2007].

Currently there are measures being taken to systematise knowledge about the quality of life and to form a definition of quality of life common to many field of study. This approach will enrich the quality of life analyses and help develop research instruments in the future [Sampolska-Rzechuła 2013].

Quality of life depends on human choices. High quality of life means being happy, joyful, satisfied with one's job and life and fulfilled. These elements are the most significant to an individual and one can authentically experience being a person and human.

The issue of quality of life is very significant and interesting because it translates into the quality of human being's life. One of indispensable elements related with the quality of an individual's life is at least the manner of shaping it, which is determined by human values and personal experience.

Thus, in considerations about quality of life it is necessary to pay attention to its conditions. Skrzypek [2007] points to the significance of objective conditions, which include economic conditions, health, education, leisure, social security, living conditions, natural environment, social environment and many more. On the other hand, subjective conditions are perceived by each person in a unique way, where life satisfaction as a whole is manifested in one's mental and emotional well-being, e.g. the categories of satisfaction, happiness or apprehensions. It is necessary to note the fact that the objective approach enables assessment of quality of life by means of quantitative and evaluative measures, whereas the subjective approach enables assessment by taking into account one's satisfaction with the degree of satisfying one's needs.

An overview of the literature shows that studies assessing quality of life in societies enabled the formation of economic and non-economic factors of assessment of the human living standard [Czapinski & Panek 2013]. These factors include: health, life safety, the state of the natural environment, inhabitants' living standard, the state of general transport and public city transport,

sports facilities, the possibilities of education, training and recreation, access to culture, commercial network, social assistance, labour market, insurances and retirement provisions, poverty, disability and other aspects of social exclusion.

Considerations about the assessment of quality of life strongly stress its dependence on the degree of satisfying human needs. The method of satisfying a particular need depends on a particular person's past, their experience, knowledge and cultural environment. Thus, the intensity of feeling and satisfying one's needs is different. In view of this fact, individual consumers' needs concerning the quality of their lives depend on factors such as, other people's life situation, tradition, environment or media. For example, when we look at demographic trends in Europe, we can observe an increase in the number of people aged 65 years or more. By 2025 more than 20% of Europeans will have been in this age group. In order to meet senior citizens' needs institutions offer a wide range of methods of education, organise special courses, activities and teaching aids especially for this age group. In broad perspective we can see that the main goal of such activities is the willingness to increase the number of active people, who are still learning, and to improve their well-being and quality of life⁵.

RELATION BETWEEN QUALITY OF LIFE AND BEHAVIOUR

The increasing concentration on quality of life proves that people are aware of the fact that it is necessary to abandon the lifestyle which prefers only material standards in life. In the information society it is important to consider the conditions of quality of life from different points of view. Consumers' behaviours are one of the aspects related with the analysis of quality of life. Consumers' behaviours are related with quality of life. A change in behaviours or the culture pattern may cause changes in the assessment and perception of quality of life. However, on the other hand, a change in the quality of life may entail cultural and social transformations [Kroenke et al. 2008, Lisiecka & Czyż-Gwiazda 2009].

People function in specific social structures which limit the freedom of action. The state is considered to be the basic structure. It is the task of state authorities to ensure good life to citizens. If the quality of human life depends on the guarantee of food safety, easy access to safe, healthy and good quality food, the state is obliged to guarantee this safety and high quality food. It is reflected by the assumptions and prognoses in the state's health policy. The aim of the health policy in Poland is to improve people's health and the resulting quality of life and to reduce inequalities in health. This aim can be achieved by the promotion of healthy lifestyle and creation of healthy environments for living, working and studying. Each individual should be aware of one's health and able to control and improve it. Eating habits are one of the factors enabling the promotion of quality of life.

When analysing quality of life it is necessary to consider its economic aspects. Quality of life is a primary aim in most contemporary concepts of socioeconomic development, which are closely related to the idea of sustainable development. The role of the determinants of social and economic development is very important. According to Kurek [2007], quality of life is considered to be the primary aim, which is pursued with due respect to the principles of sustainable development. Quality of life is interpreted as a better way of satisfying people's mental and physical needs by appropriate shaping of their attitude to the natural environment (e.g. the quality of air, water, food, etc.).

⁵ E.g. the project 'Evaluation toolkit on seniors' education to improve their quality of life' (<http://www.edusenior.eu>). The project is financed by the European Commission under the Lifelong Learning Programme of the European Union No. 518227-LLP-1-2011-1-ES-GRUNDTVIGGMP

CHOSEN QUALITY OF LIFE MEASUREMENT ELEMENTS

The complexity of conditions of the quality of people's lives usually makes their assessment or possible change very difficult. Assessing quality of life is not an easy task, because there is not one measure that can be used to determine quality of life. This problem can be observed both in domestic and foreign studies [Czapiński & Panek 2013, D'Agostini & Fantini 2008, Inoguchi & Fujii 2009; Narayana 2009, Xiaoling & Yifei 2009]. Researchers from various fields of science describe quality of life by means of different traits, often use different measurement units, which require different measurement methods. For example, when the problem is approached from the angle of economic sciences, methods of multi-criteria taxonomic analysis are used, which are chiefly based on objective indexes [Panek 2014, Wysocki 2010]. Social scientists conduct surveys on the subject. Similarly to economics, management uses multi-criteria methods (e.g. generalised parameter) and the self-assessment method, which relatively precisely determines quality of life [Czapiński & Panek 2013, Dobrowolska 2007]. There are also attempts to apply the idea of evolutionary algorithms to measure and improve quality of life [Grela 2007].

Kolman [2005] proposes the use of different tests to measure quality of life and to identify the real perspective of its improvement. In order to create the quality of their lives consumers need to know which elements have the greatest influence on it, e.g. pro-ecological behaviours⁶. Quality of life can also be considered from the evaluative aspect.

When reviewing different measures of quality of life in reference publications, we can distinguish the subjective and objective approach. In the objective approach authors refer to an external sphere, which is both a source of stimuli and people's experience. Quality of life is measured in an objective way, e.g. with the amount of income, education or lifespan. The objective measures can be used to determine the amount of consumption, assess the structure of consumption or living standard. On the other hand, the subjective approach enables assessment of the quality of an individual's life by comparison of different parameters concerning one's life. The subjective approach enables assessment of consumers' states and emotions, which illustrates perceived quality of life.

Quality of life can be expressed with the Quality of Life Index (QLI), which illustrates the living standard and life satisfaction in individual countries more adequately than traditional methods (the GDP growth rate or GDP per capita). The Human Development Index (HDI) is another index used to measure quality of life. The HDI can be accompanied by supplementary indexes of social development, i.e. the Gender-related Development Index (GDI), the Gender Empowerment Measure (GEM), which indicates the share of men and women in social development, the Human Poverty Index (HPI) and the Human Development Index in urban and rural areas. There is also the Well-Being Index (WBI), which consists of the Human Well-Being Index and the Ecosystem Well-Being Index. These indexes enable the measurement of traits of socioeconomic development in a particular country.

At present researchers are working on the construction of a uniform index comprising different aspects affecting quality of life.

CONSUMERS' BEHAVIOUR AND THEIR QUALITY OF LIFE – IMPLICATION FOR CONSUMERS' RESEARCH

Studying the relations between behaviours and habits connected with the consumption of food and quality of life may be useful for the construction of a theoretical model describing the influence of consumers' behaviours on quality of life. According to the authors of this article, consumers'

⁶ For example, following ecological criteria in consumption requires that consumers should have appropriate knowledge and awareness, which are the basis of pro-ecological attitudes. The development of lifestyles with an ecological attitude to consumption (e.g. slow life) is evidence given by consumers, which shows that they want to live according to the idea of sustainable development, which exposes quality of life.

assessment of quality of life in terms of satisfying nutritional needs depends not only on the sense of food safety, but also on the satisfactory quality of food or on the condition and organisation of labour in the household. This study concentrates on the analysis of consumers' behaviours and habits in terms of quality of life. The following elements can be assumed as consumers' behaviours and habits which might affect quality of life:

- market behaviours, e.g. consumers' choice of food by the country of origin of food, buying behaviour, the degree of satisfying consumers' needs,
- organisation of nutrition in the household (according to the qualitative and quantitative approach), e.g. quality, safety, food processing, culture of consuming and preparing meals,
- consumers' attitude to the innovation, e.g. adoption of innovation, i.e. the scope interest in the innovation and the speed with which they accept the innovation, the premise for buying innovative products, emotional approach to innovation,
- consumers' nutritional awareness, e.g. the awareness of rational nutrition, methods of preparation and storage of food products, culinary techniques,
- the system of values, e.g. health, safety, religion, family, friendship, money, order, culture, patriotism, travel, adventure, career, fashion, sports,
- lifestyle, e.g. the way of spending free time, household equipment, the way of acquiring food products, consumption criteria.

A synthetic index approaching quality of life from the point of view of the household (microeconomic level) can be assumed as a determinant of quality of life. The index might consist of the following components:

- economic conditions, e.g. income, distribution of expenses into individual groups of products and services in the household, the amount of self-supply, the value of time,
- sociodemographic conditions, e.g. the size of the household, the stage of the family development cycle, the household duration, the place of residence.
- psychographic conditions, e.g. the lifestyle, nutritional model, sources of information, consumers' opinions concerning the manner and organisation of nutrition.

Figure 1 shows the concept of the approach proposed. Households could be the research subject, whereas consumers could be the research unit (representatives of households).

The authors propose that research and further work on the classification of consumers should be based on four categories: high quality of life vs appropriate behaviours, high quality of life vs inappropriate behaviours, low quality of life vs appropriate behaviours, low quality of life vs inappropriate behaviours. The aforementioned groups of factors used for constructing the model will give a possibility to study and find the relations and dependences between them. Apart from that, they will give a possibility to search for analytical forms of the cause-and-effect model describing the influence of consumers' behaviours and habits on quality of life.

The high diversification of consumers' behaviours within social groups and between each other and the need to identify measurement units is a premise for conducting research on consumers' behaviours in relation to quality of life. This type of research seems to be significant and may bridge the information gap in the methodology and practice of conducting such research. It may also indicate the essence of quality of life, its conditions and assessment. The research findings may be a valuable contribution to economic and social sciences.

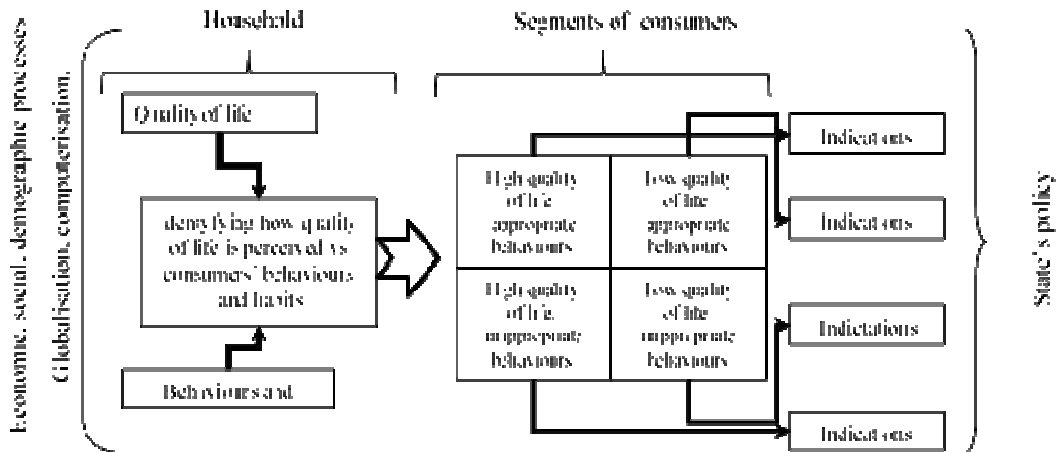


Figure 1. A concept of research on the relation between behaviours connected with food consumption and quality of life

Source: own research.

CONCLUSION

The assessment and increasing quality of life and maintaining its high level is a long-term goal in the development of individuals and the society. It is possible to research the relations between food consumption behaviours and quality of life and their consequences for the state's policy by constructing a theoretical model describing the influence of consumers' behaviours on quality of life. This model may be of high cognitive significance. We can observe non-economic (social) factors influencing quality of life in economically diversified groups of consumers. Consumers' behaviours and habits are one of the conditions of the quality of consumers' lives and its assessment. The aim of the research on the economic and social conditions of quality of life is to indicate the recommendations for the social policy. The research results may provide premises for the health policy and they could be used to modify the adopted assumptions and guidelines for the national health policy. Apart from that, they may also be used for predictive purposes. It is necessary to remember that above all, rich resources of knowledge and, in consequence, greater awareness and responsibility of scientific and public institutions influence the willingness to take actions aimed at increasing quality of life in society.

REFERENCES:

1. Baltes B. B., Zhdanova L. S., Parker Ch., P. (2009), Psychological climate: A comparison of organizational and individual level referents. *Human Relations*, 62(5), s. 669-700.
2. Brewer E., (2009). How Computer Science Serves the Developing World. *Communications of the ACM*, 52(6), s. 76-80.
3. Campbell G., (2009). *Technology Today, Quality*, 48(6), s. 6-8.
4. Czapiński J., (2015). Indywidualna jakość i styl życia. *Diagnoza Społeczna 2015, Warunki i Jakość Życia Polaków - Raport*. *Contemporary Economics*, 9/4, 200-331. DOI:10.5709/ce.1897-9254.190.
5. Czapiński J., Panek T., (2013), *Diagnoza społeczna 2013*. (red) Czapińska J. i Panek T. *Warunki i jakość życia Polaków. Raport główny 2013*. Pobrane 9 listopada 2015 r. z:

- http://analizy.mpips.gov.pl/images/stories/publ_i_raporty/DS2013/Raport_glowny_Diagnoza_Spoleczna_2013.pdf (dostęp: 22.03.2016)
6. D'Agostini L., Fantini A., (2008), Quality of Life and Quality of Living Conditions in Rural Areas: Distinctively Perceived and Quantitatively Distinguished, *Social Indicators Research*, 89(3), s. 487–499.
 7. Dobrowolska A., (2007), Zastosowanie metody uogólnionego parametru do oceny jakości życia [w]: E. Skrzypek (red. nauk.), *Uwarunkowania jakości życia w społeczeństwie informacyjnym*, Wyd. UMC-S w Lublinie, tom II, s. 221-228.
 8. Grela G., (2007), Idea algorytmów ewolucyjnych w doskonaleniu jakości [w]: E. Skrzypek (red. nauk.), *Uwarunkowania jakości życia w społeczeństwie informacyjnym*, Wyd. UMC-S w Lublinie, tom II, s. 229-234.
 9. Inoguchi T., Fujii S. (2009), The Quality of Life in Japan, *Social Indicators Research*, 92(2), s. 227–262.
 10. Kolman R., (2005), Metodyka oceny przemian jakościowych, *Problemy jakości*, nr. 1, s. 12-14.
 11. Kroenke C. H., Kubzansky L. D., Adler N., Kawachi I. (2008), Prospective Change in Health-Related Quality of Life and Subsequent Mortality Among Middle-Aged and Older Women. *American Journal of Public Health*, 98(11), s. 2085–2091.
 12. Kurek A., (2007), Wyżywienie a jakość życia społeczeństwa [w]: E. Skrzypek (red. nauk.), *Uwarunkowania jakości życia w społeczeństwie informacyjnym*, Wyd. UMC-S w Lublinie, tom II, s. 157-173.
 13. Lisiecka K., Czyż-Gwiazda E., (2007), Społeczeństwo informacyjne niebezpieczeństwem dla jakości życia człowieka [w] E. Skrzypek (red. nauk.), *Uwarunkowania jakości życia w społeczeństwie informacyjnym*, Wyd. UMC-S w Lublinie, tom I, s. 49-57.
 14. Mickel A. E., Dallimore E. J. (2009), Life-quality decisions: Tension-management strategies used by individuals whenmaking tradeoffs. *Human Relations*, 62(5), s. 627-668.
 15. Narayana M., (2009), Education, Human Development and Quality of Life, Measurement Issues and Implications for India, *Social Indicators Research*, 90(2), s. 279–293.
 16. Panek T., (2014), *Statystyka społeczna*, wyd 2. zm, Wyd. PWE. Warszawa.
 17. Sompolska-Rzechuła A., (2013), Jakość życia jako kategoria ekonomiczna, *Folia Pomeranae Universitatis Technologiae Stetinensis, Oeconomica* 301 (71), s. 127–140.
 18. Skrzypek E., (2007), Czynniki kształtujące jakość życia, materiały z konferencji, <http://lodz.idn.org.pl/Mken/Mken%202001/Referaty%202001/14.pdf>. (dostęp 80.10.2015).
 19. Wysocki F., (2010), *Metody taksonomiczne w rozpoznawaniu typów ekonomicznych rolnictwa i obszarów wiejskich*. Poznań: Wyd. Uniwersytet Przyrodniczy.
 20. Xiaoling Shu, Yifei Zhu, (2009), The Quality of Life in China, *Social Indicators Research*, 92(2), s. 191-225.
 21. <http://www.edusenior.eu>. (dostęp 03.11.2015).

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PATENTS AS FIRM'S INNOVATIVENESS INDICATOR: ADVANTAGES AND DISADVANTAGES

Abstract: There is undisputed need to properly measure innovativeness and patent data is commonly used in order to achieve that. However, its drawbacks are rarely taken into account. The aim of this article is to identify main advantages and disadvantages of using patents as innovativeness indicators - based on the literature analysis. Authors conclude that patents are valuable innovativeness indicators, which among others are very accessible and easy to use, but on the other hand they cannot be regarded as universal, as they have significant drawbacks and thus may lead to false conclusions. Therefore, it is still advised to use patent data, but only if being fully aware of their limitations.

Keywords: patent, patent management, technology management, innovativeness, innovativeness indicator

INTRODUCTION

The importance of measuring company's technological development and its change is widely emphasized in the literature [Basberg 1987, p.131-132, Archibugi and Pianta 1996, p.451], as it affects strategic decisions made in business and is vital part of technology management. Patent statistics, out of all other tools, are probably the most often used measures to estimate innovation outcomes. This may be the result of the fact that patent rights are perceived as a rich source of knowledge about the technological advancement and the technological change [Guellec and van Pottelsberghe de la Potterie 2004, p.648-651]. However, patent data drawbacks are rarely taken into account. Therefore, the aim of this article is to identify the main advantages and disadvantages of utilizing patents as company's innovation indicators - based on the literature analysis.

INNOVATIVENESS INDICATORS

The issue of patents and other tools being utilized as innovativeness indicators has been under consideration for many years. Researchers have tried to identify and develop a proper indicator of the technological output. However, a universal tool, which would answer all the questions related to the technological innovation measurement, has not been found yet [Griliches 1990, p.1661-1662]. Measuring technological innovativeness is a challenging task, due to a complexity of industrial innovation, which is dependent on various measures. Archibugi and Pianta [1996, p.451-452] listed three main aspects of industrial innovation and the technological change, which prove their variety and complexity. Firstly, technological progress impinges on the implicit and codified knowledge. Furthermore, the innovation may have its source from the inside or the outside of a company. Lastly, innovations might be contained in a product, a capital good or be intangible, i.e. as a know-how, patents, skilled employees, design, licenses, etc.

There are various possibilities enabling an acquisition of information on the enterprises' inventiveness [OECD 2009, p.26-29]. Innovativeness can be determined by the ability to manage sustainable development, being familiar with e-commerce and having the capability of introducing new products at shorter intervals [Terziovski 2007, p.6-13]. Those factors play a dominant role, because they enable converting knowledge and intangible assets into products, processes or services and bring them to market. If a company has ability to continuously transform ideas into goods, it possesses a most desired feature, namely, an innovation capability. According to [Kalanje 2005,

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p.1-2], an innovation may in general be defined as a development of new ideas and their exploitation. To be more specific, innovation relates to creating or changing ideas into more efficient products or processes. Oslo Manual [2005] provides a different one: “An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations”. Furthermore, technological innovation can be grouped in 3 ways: radical or incremental [Frietsch et al. 2010, p.11-14], product or process and sequential or disruptive [Kalanje 2005, p.1-2].

To the most popular and broadly analysed barometers of output belong patent statistics and indicators sourced from innovation surveys [Archibugi and Pianta 1996, p.451-452]. The former tool may be appropriate to protect products or processes against imitating rivals, and measure an inventiveness rate with reference to firms, industries, countries and individual innovators. The latter tool however, can estimate e.g. the effectiveness of innovative products’ or processes’ implementation on the market [Archibugi and Pianta 1996, p.451-452, OECD Frascati Manual 2002, p.25-26;126-136, OECD Oslo Manual 2005, p.20-21]. An impact of R&D on productivity is another applied method, which assesses inventiveness across industries, companies and countries. The total list of output measures would be comprehensive, if a few other tools were additionally mentioned: e.g. bibliometrics, index of globalization, literature-based indicators of technological output (LBITO) or skilled human resources [Archibugi and Pianta 1996, p.451-452]. Nevertheless, it is stressed in the OECD Frascati Manual [2002], that technological output (R&D and S&T) is much harder to determine compared to complementary input data. The report illustrates input-based innovation measures and their utilization. Firstly, measurement of the personnel working on R&D projects enables comparisons of the human resources-based investment outlays across countries or sectors. Secondly, statistics provided by e.g. Eurostat [2012] or OECD [2014] show expenditures on R&D in relation to the national GDP. Last but not least, sometimes the availability of R&D facilities (equipment, laboratories, libraries, etc.) can be applied as an indicator. Those three mentioned tools may be often aggregated and considered collectively [OECD Frascati Manual 2002].

PATENT RESEARCH

It is estimated that the patent literature comprises approximately 60 million documents from all over the world [Gassmann and Bader 2011, p.335]. This makes patent research a complex undertaking, because apart from the expert knowledge, also the acquaintance with systems of the patent categorization is required. Patent data is available in public thanks to numerous databases, provided by patent offices (national or regional) operating in industrialized countries [Schmeisser and Mohnkopf 2008, p.137]. Nonetheless, a comprehensive database, which would include all patent documents ever issued worldwide, has not yet come into being. On the other hand, thanks to the dynamic spread of Internet, patent searching has become easier recently (however is still complex), because an access to the databases can be reached from any place all over the world.

Patent statistics, out of all other tools, are probably the most often used measures to estimate innovation outcomes. Patents rights are perceived as a rich source of knowledge about the technological advancement and the technological change [Guellec and van Pottelsberghe de la Potterie 2004, p.648-651].

ADVANTAGES OF PATENTS AS INNOVATIVENESS INDICATOR

As a very popular way of measuring innovativeness patent statistics have many advantages. One of them is the huge scope of knowledge derived from patent documents. They provide information on the wide range of technologies, for which there are sometimes few other academic dissertations (e.g. nanotechnology). Additionally, researchers can find scientific articles referring to the invention, as well as learn about the rate and the direction of the innovative measures. The



necessity of a public disclosure (a duty to give a detailed description of the technology) is seen as an advantage in the OECD (2009) report and the paper of Archibugi and Pianta [1996]. In contrast to innovation surveys, which results may be kept confidential, all the information included in patent documents has to be published, and thus they contribute to a rise in generally available knowledge on a particular topic.

Another aspect is a common availability of the patent documents. Griliches [1990] and the OECD [2009] point out that an access to them can be obtained with ease from any place all over the world by using internet. An additional advantage is the fact that all the information are collected by patent offices, thus they are available at no expense, without a necessity to conduct cost and time intensive surveys. Archibugi and Pianta (1996) add another advantage: patents' accessibility in "large numbers and for a long time series". Therefore, the patent statistics provided e.g. by WIPO, demonstrate clearly trends of the technological development across countries, companies and industries, and thus make comparisons within these areas possible [Griliches 1990, p.1662-1702]. OECD [2009] as well as Archibugi and Pianta [1996] underline that patent is a direct result of the innovative process, thus patent rights have a close relation to invention. Most of the substantial innovations are patented, whether they are based on R&D or not. Due to a time-intensive and cost-intensive patent application processes, mostly those inventions are patented, which show a big potential for the high economic return from the innovation and can be commercially exploited. As such they are expected to bring an added value to a company. Therefore, patent statistics are expected to incur most significant inventions, as the law requires patentable inventions to be novel according to the state of knowledge.

Many studies prove the high correlation of company's inventiveness, based on the amount of granted patents, with the economic performance [OECD 2009, p.26-29]. In addition, number of patent applications submitted to patent offices reflects very well the level of technological advancement of a company. Moreover, patent data enables categorization of innovativeness, allowing to identify innovators and to make international comparisons, comparisons over time, amongst industrial sectors and technical fields [Pavitt 1985, p.82-94]. In addition, patent statistics can be applied to help recognizing rival's competitive market strategy, identifying the globalization patterns, observing dynamics of the innovation processes including cooperation in R&D and a diffusion of innovations within particular regions or industries. Finally, the OECD report states the chance to track the internationalization of R&D activities, namely, the multinational cooperation on science and technology or the territorial mobility of R&D professionals [OECD 2009, p.26-27].

DISADVANTAGES OF PATENTS AS AN INNOVATIVENESS INDICATOR

Most of the analysed literature harmoniously perceive the fact that patent statistics are not complete, which is the biggest disadvantage of its use as innovation indicator. Due to the fact that numerous inventions cannot fulfil the patentability criteria, patent databases do not reflect all innovative undertakings (e.g. in software industry). On the other hand, inventors of a potentially patentable innovation or managers representing companies which are in possession of such an invention, may simply decide to pursue alternative technology protection strategies, since they are often seen as more effective [Archibugi and Pianta 1996, p.452-455]. The most innovative technologies are sometimes kept as trade secrets. Desrochers [1990] points out in addition that patent applications for many ground-breaking technological innovations are never submitted to patent offices, due to a poor recognition of their quality, excessive costs or long patenting procedures. Therefore, the question occurs if the patent data are in principle credible.

Another aspect, which is mentioned in most of the sources, refers to patent valuation. Patents differ significantly when it comes to their economic value, and an identification of those with the high or low potential stays extremely challenging. Moreover, patent relevance (quality) is not reflected in patent classifications, so patent counts and the patent's expected value may be skewed.

Thirdly, there is strong criticism related to patent researches and categorization. Accordingly, OECD [2009] and Archibugi and Pianta [1996] state that despite international patent agreements, varied patent laws, regional regulations and practices used worldwide have an impact on the protection's effectiveness, costs and length. Additionally, this fact makes comparisons of patent data across sectors more difficult. Moreover, patent law modifications or administrative simplifications over years contributed to changes in patenting patterns. Therefore, trends ought to be analysed carefully with reference to those modifications. On the other hand, according to Desrochers [1998], the administrative and financial burdens for patent rights have evolved over time precluding many small innovators from patenting their inventions. An example for that may be European Union's idea to implement European patent with unitary effect, which on the one hand makes it easier to obtain protection in all EU member states, but on the other hand it may be more expensive to obtain in comparison to patents granted only in a couple of chosen member states [Nowicka 2014]. However, as of 2016 the required number of thirteen EU member states have not ratified the Agreement on Unitary Patent Court, thus it still has not entered into force.

In addition Griliches [1990] points out the difficulties in identifying the source of invention at the firm level, due to numerous mergers and extensive diversifications of corporations. All in all, OECD notices an extremely complex nature of patent data and statistics, since they stem from composited business and legal processes. Therefore, it is easy to draw incorrect conclusions. Another issue is a propensity to file and submit a patent application [Archibugi and Pianta 1996, Desrochers 1998]. The motivation to apply for a legal protection differs according to technical field, industry, type of invention and size of the enterprise. Most often, due to the deterrent, defensive character of excessive patenting (e.g. semiconductors in the electronic industry), some industries experience more patent registrations than others, skewing the view of the innovativeness rate. Additionally, start-ups and SMEs suffer also from the massive patenting, because in contrast to big companies, they experience problems to cover costs of a large number of patents and thus abandon the idea. Mostly activities of large enterprises are examined, whereas SMEs and individual innovators are often ignored, because they lack in funds to file and submit a patent application, and thus seem to be completely non-innovative [Archibugi and Pianta 1996, Desrochers 1998].

Table 1. A brief summary of the most important advantages and disadvantages of patents as an innovation indicator.

Advantages	<ul style="list-style-type: none">• Comprehensive source of knowledge on the specific technical development• Unlimited accessibility to patent statistics and ease of use• Inclusion of ground-breaking, state-of-the-art innovations in patent data
Disadvantages	<ul style="list-style-type: none">• Limitations concerning the scope of innovations included in statistics and actually patented• Unclear (skewed) patent valuation• Non-unified administrative regulations• Skewed rate of innovativeness in various industries

Source: authors' own elaboration, based on aforementioned literature.

A certain obstacle to employ patent statistics in assessing the innovativeness is the inability to get rid of subjectivity when it comes to the evaluation of the patent right's quality. Another problem is a usually biased sample taken for examination of the firm's R&D performance.

CONCLUSION

Desrochers [1998, p.72] underlines that common problem is that many researchers do not notice or simply ignore problems concerning patents, therefore they may finally come to incorrect conclusions. However, this seems not to be the case. The conducted analysis of previous research revealed that patent data is not a universal and sufficient instrument, which could be uncritically applied to evaluate the inventiveness rate of a specific firm. Patent data has significant advantages like ease of use, accessibility of the data and inclusion of state of the art inventions. But the disadvantages (e.g. unclear value of patents, company's strategy not to reveal most innovative inventions) create the need to use them with caution. Therefore, it is advised to exploit patent statistics in order to assess company's innovativeness in a particular area. However, awareness of the aforementioned drawbacks is required.

REFERENCES

1. Archibugi D., Pianta M. (1996): *Measuring the technological change through patents and innovation surveys*, Elsevier Science Ltd., Great Britain.
2. Basberg B.L. (1987): *Patents and the measurement of technological change: A survey of the literature*. In: *Research Policy 16*, Elsevier Science Publishers.
3. Desrochers P. (1998): *On the abuse of patents as economic indicators*. In: *The quarterly journal of Austrian economics*, Vol. 1, No. 4.
4. Frietsch R., et al. (2010): *The value and indicator function of patents*. Studien zum deutschen Innovationssystem, Fraunhofer Institute for Systems and Innovation Research, No. 15.
5. Gassmann O., Bader M.A. (2011): *Patentmanagement: Innovationen erfolgreich nutzen und schützen*, Springer, Heidelberg.
6. Griliches Z. (1990): *Patent statistics as economic indicator*, American Economic Association.
7. Guellec D., van Pottelsberghe de la Potterie B. (2004): *Measuring the Internationalization of the Generation of Knowledge*. In Glänzel W., Moed H.F., Schmoch U. (eds. 2004), *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies on R&D Systems*, Kluwer Academic Publishers, Dordrecht/Boston/London.
8. Kalanje C.M.: *Role of intellectual property in innovation and new product development*, SMEs Division, World Intellectual Property Organization 2005
9. Lemley M.A., Shapiro C. (2005): *Probabilistic patents*, *Journal of Economic Perspectives*, Vol. 19, No. 2.
10. Nowicka A. (2014), *Jednolity sąd patentowy – z perspektywy Polski*, *Ruch prawniczy, socjologiczny i ekonomiczny*, z. 1.
11. OECD (2002): *Frascati Manual: Proposed standard practice for surveys on research and experimental development*, Paris.
12. OECD, Eurostat (2005): *Oslo Manual: Guidelines for collecting and interpreting innovation data*, Paris.
13. OECD (2009): *OECD Patent statistics manual*. OECD.
14. Pavitt K. (1985): *Patent statistics as indicators of innovative activities: possibilities and problems*, *Scientometrics* Vol. 7, Nos 1-2.
15. Schmeisser W., Mohnkopf H. (2008): *Ausgewählte Beiträge zum Innovationsmanagement, zur empirischen Mittelstandsforschung und zum Patentschutz*, Rainer Hampp Verlag München und Mering
16. Stats OECD (2016, April 16): *Innovation Indicators*. stats.oecd.org
17. Terziovski, M. (2007): *Building innovation capability in organizations: an international cross-case perspective*. London: Imperial College Press.

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DIVERSITY OF THE LEVEL OF INVESTMENT OUTLAYS ON FIXED ASSETS IN WOOD SECTOR IN POLAND

Abstract: The article covers research into the diversity of investment layouts on the purchase of fixed assets in particular branches of the wood sector comprising the following: wood, furniture and pulp and paper industries as compared to industrial processing. The analysis presents changes in the level of financial resources incurred to purchase fixed assets in total, as well as their three separate categories: buildings and structures, machinery, technical equipment, tools and transport equipment. The article also covers the analysis of the ROA index in particular branches of wood sector and industrial processing. The research embraces the period between 2007 and 2013. The primary sources of research material are reports compiled annually by the Central Statistical Office (GUS): Financial Results of Economic Entities and Fixed Assets in National Economy.

Key words: industrial processing, wood sector, enterprises, investment outlays, fixed assets

INTRODUCTION

The intensification of competitiveness both at home and on foreign markets illustrates the need for constant improvement in different aspects of economic activity. An important factor which influences the increase and development of enterprise competitiveness is its involvement in the creation and effective realisation of investment activities [Popyk, Lis, Mikołajczak 2014]. Innovation, on the other hand, involves systematic investment in new machinery and devices, new technologies, or new products [Janik, Gałazka 2014]. It particularly refers to industrial sector. In industrial enterprises an important aspect of innovative activity is investment into fixed assets which, as regards this type of economic entities, usually has a significant meaning for the structure of the assets. For the provision of competitiveness and stability of the economic situation of a company it is important to keep investment outlays at a certain level including these that are incurred in order to purchase fixed assets. They are a guarantee of the functioning of the company and influence the opportunities and the level of novelty of the manufactured products [Haus 2003; Karmańska, Walińska 2006]. Thus, this type of investment needs to be referred to as important, both for a single entity and the whole economy [Czerwonka, Jaworski 2014]. The situation in question applies to companies functioning in wood industry, which according to the Polish Classification of Economic Entities (PKD) belongs to section C – industrial processing. Wood sector comprises the following: wood industry (section 16.0 – the manufacture of products made of wood, cork, straw and wicker), pulp and paper (section 17.0 – the manufacture of paper and paper products) and furniture (section 31.0 – manufacture of furniture) [Grzegorzewska 2013]. This paper features change trends in the level of investment outlays in the wood sector in the years 2007-2013.

OBJECTIVE AND RESEARCH METHODOLOGY

The article aims at defining the diversity of the level of investment outlays on fixed assets in enterprises operating in the wood sector. This sector, according to the Polish Classification of Economic Activities, comprises three branches: furniture, wood and pulp and paper. The change trends have been presented as compared to the whole sector of industrial processing. The research covers the years 2007-2013. Horizontal analysis has been carried out which indicates the dynamic of the changes in time as well as the vertical analysis based on defining the share of particular industries in the whole wood sector and in industrial processing.

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According to the terminology of *GUS* investment outlays are those financial or material outlays whose purpose is to establish new fixed assets or the improvement (rebuilding, expansion, development or modernisation) of the existing objects of fixed capital as well as layouts on the so-called initial investments. Investment outlays are divided into outlays on fixed assets and other outlays. The article takes into consideration the change in the level of financial resources which were spent on fixed assets in companies of wood sector. According to *GUS* outlays on fixed assets comprise [Fixed Assets in National Economy in 2013, CSO]:

- buildings and structures (including buildings and places as well as civil engineering works) of which, among others construction and assembly works, design and cost estimate documentations,
- machinery, technical equipment and tools (including instruments, movables and endowments),
- transport equipment,

Other outlays include the so-called initial investments and other costs incurred with the realisation of the investment. The outlays do not increase the value of fixed assets. It needs to be emphasised at the same time that fixed assets comprise complete and ready to use equity elements with predicted usage period longer than a year [Fixed Assets....2013].

The diversity of the level of outlays incurred on fixed assets in particular industries of the wood sector was completed with the analysis of the ROA index which is a relation of the net financial result to the value of fixed assets. Change trends in the level of this index in companies operating in the wood sector were shown as compared to economic entities being part of industrial processing.

RESEARCH FINDINGS

From the research conducted by *GUS* it follows that in the years 2007-2013 in industrial processing companies outlays on fixed assets decreased by almost 11% from 43.7 billion PLN to 39.0 billion PLN (table 1). The greatest fall in this category was noted in the years 2009-2010 (20% and 16% respectively). In 2011 companies of industrial processing spent on fixed assets 18% more than in the year before, however, the growing tendency in the consecutive years was not as visible. The share of financial outlays spent by the wood sector on the purchase of fixed assets was at a similar level of around 10% in the whole analysed period. As regards the share of particular branches in the purchase of fixed assets in the companies of wood sector, in 2007 it was at a somewhat similar level. It amounted to, respectively: 35% in wood industry, 30% in pulp and paper industry and 35% in the production of furniture. However, in the analysed period, on account of the different level of financing of the purchase of fixed assets the situation changed. The share of particular branches at the end of the year 2013 was the following: 25%, 54% and 22%. It is also borne out by the analysis of the change pace in time. As regards furniture industry the value of outlays on the purchase of fixed assets in 2013 was over 1/3 lower than at the beginning of the analysed period and stood at 1 billion PLN. A decreasing tendency in this field was noted as well in the wood industry. As for the level of outlays on the purchase of fixed assets there was a significant rise in this level in companies of the pulp and paper industry (from 1.38 billion PLN to 2.45 billion PLN).

In the years 2007-2013 the level of outlays on buildings and structures in the companies of industrial processing decreased by over 20% from 13.3 billion PLN to 10.5 billion PLN (table 2). The greatest falls in this field were noted in the years 2008-2009 (29% and 21% respectively). The share of outlays on buildings and structures of the wood sector amounted to 9% and 12% incurred in industrial processing, whereby it needs to be emphasized that the share of its particular branches was somewhat similar.

Table 1. The level of outlays on the purchase of fixed assets in the companies of wood sector as compared to industrial processing [million PLN].

Itemisation	2007	2008	2009	2010	2011	2012	2013
Industrial processing	43667.9	47990.9	38355.3	32120.5	38087.9	36775.8	39024.2
Wood sector, incl:	4545.4	4780.0	3796.8	3195.8	4029.5	3901.5	4610.9
Wood industry	1590.4	1303.4	858.6	745.5	1375.3	999.7	1153.1
Pulp and paper industry	1376.9	1744.9	1873.3	1524.2	1634.0	1953.3	2446.6
Furniture industry	1578.1	1731.7	1064.9	926.1	1020.2	948.5	1011.2

Source: own study on the basis of GUS reports - Fixed Assets in National Economy covering the years 2007-2013.

Over the analysed period there was a visible decrease in the amount of financial outlays on buildings and structures in companies manufacturing wood and wood products. Their level dropped by almost a half from 552.9 million PLN to 272.1 million PLN. A similar situation was visible in furniture sector where the level of these outlays fell from 663.0 million PLN to 393.9 million PLN. However, a dissimilar tendency was observed in the pulp and paper industry. In these companies financial outlays incurred to buy buildings and structures rose by over 45% from 415.5 million PLN to 606.4 million PLN and finally they were almost twice higher than in wood industry and 1.5 times higher than in furniture industry.

Table 2. The level of outlays on buildings and structures in companies of wood sector as compared to industrial processing [million PLN]

Itemisation	2007	2008	2009	2010	2011	2012	2013
Industrial processing	13333.6	14790.2	10536.4	8419.2	10293.1	9887.3	10549.9
Wood industry	552.9	414.6	196.8	160.0	354.6	257.0	272.1
Pulp and paper industry	415.5	550.7	580.8	249.6	358.7	435.3	606.4
Furniture industry	663.0	748.5	434.2	325.0	302.5	413.2	393.9

Source: own study on the basis of GUS reports - Fixed Assets in National Economy covering the years 2007-2013.

Another category of fixed assets comprises machinery, technical equipment and tools. The level of outlays on the purchase of them in companies operating in industrial processing decreased by 5% from 28.0 billion PLN to 26.6 billion PLN (table 3). A dissimilar tendency was noted in the wood sector – an increase by 18% from 2.6 billion PLN to 3.1 billion PLN. It needs to be noted, however, that in the years 2007-2013 only in the pulp and paper industry the outlays on the purchase of machinery, technical equipment and tools increased almost twice (from 921.3 million PLN to 1766.9 million PLN). In other branches there was a drop in financing destined for this purchase, and in the case of furniture production it decreased even by over 30%. At the end of 2013 the level of outlays in furniture industry on these categories of fixed assets stood at 542.2 million PLN (which constituted 56% of all financial resources incurred by the wood sector) and it was almost three times lower than in pulp and paper industry and by 1/3 lower than in companies manufacturing wood and wood products. It has to be emphasised that the share of financial

resources spent on the purchase of machinery, technical equipment and tools in the wood sector in the outlays of industrial processing stood at a similar level of 1% in the analysed period.

Table 3. The level of outlays on the purchase of machinery, technical equipment and tools in the companies of wood sector as compared to industrial processing [million PLN]

Itemisation	2007	2008	2009	2010	2011	2012	2013
Industrial processing	28048.1	30457.0	25919.8	21499.1	25483.5	25008.0	26645.2
Wood industry	923.1	773.5	613.8	526.6	947.3	675.5	801.5
Pulp and paper industry	921.3	1146.8	1247.1	1191.8	1227.6	1465.1	1766.9
Furniture industry	791.8	874.4	558.5	476.5	644.7	509.4	542.2

Source: own study on the basis of GUS reports – Fixed Assets in National Economy covering the years 2007-2013.

In 2007 the level of financial outlays on the purchase of transport equipment in industrial processing stood at the level of 2073.6 million PLN (table 4). At the end of the analysed period it was by 18% lower and amounted to 1707.9 million PLN. A similar situation was observed in companies of the wood sector (a drop by 17% from 251.5 million PLN to 208.4 million PLN).

Table 4. The level of outlays on the purchase of transport equipment in the companies of wood sector as compared to industrial processing [million PLN]

Itemisation	2007	2008	2009	2010	2011	2012	2013
Industrial processing	2073.6	2113.5	1474.5	1865.6	1866.4	1759.3	1707.9
Wood industry	100.2	75.5	38.9	56.1	69.9	63.9	75.2
Pulp and paper industry	34.3	38.0	35.5	78.3	41.4	47.1	62.0
Furniture industry	117.0	97.0	58.2	120.1	69.7	60.5	71.2

Source: own study on the basis of GUS reports – Fixed Assets in National Economy covering the years 2007-2013.

The share of financing incurred for the purchase of transport equipment in the wood sector in the outlays of the industrial processing amounted to 10-12%. In 2007 among the companies of the wood sector the greatest part of financial resources incurred for the purchase of transport equipment was noted in furniture sector – 117.0 million PLN. As regards wood industry the sum was not much lower and it exceeded 100 million PLN. However, three times smaller outlays on the purchase in question were incurred in companies of the pulp and paper industry. At the end of the analysed period the differences in the area were not as meaningful. In 2013 outlays on the purchase of transport equipment amounted to: 71.2 million PLN in furniture industry, 75.2 million PLN in companies manufacturing wood and wood products and 62.0 million PLN in pulp and paper industry.

Research into the diversity of the level of outlays on the purchase of fixed assets was extended with the analysis of the changes in the profitability of fixed assets since one of the key ingredients of fixed assets are tangible fixed assets which comprise buildings and structures, machinery and

technical equipment and transport equipment. Change trends noted in the area have been shown in companies of the wood sector as compared to the changes in industrial processing.

From the research it follows that in 2007 the greatest profitability of fixed assets (17.2%) was noted in companies of pulp and paper industry (figure 1). It was higher by 0.9 pp compared to the average achieved by industrial processing.

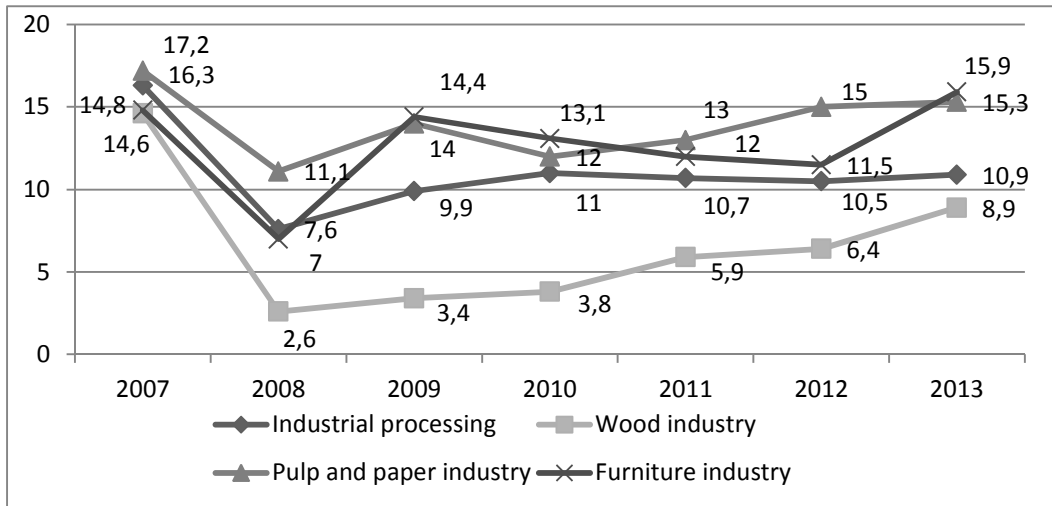


Figure 1. Profitability index of fixed assets in the wood sector in the years 2007-2013 [%].

Source: own study on the basis of GUS report – 'Financial results of economic entities' covering the years 2007-2013.

As regards companies operating in furniture and wood industries ROA index was lower and it amounted to 14.8% and 14.6%. In 2008 in all of the analysed branches there was a considerable fall in the relation in question. From the following year increasing tendencies have been visible in companies of the wood sector. At the end of the analysed period the greatest ROA was noted in furniture industry – 15.9%. A similar level (15.6%) of the analysed index was achieved by companies of pulp and paper industry. A significantly lower ROA was noted in companies of the wood industry. In 2013 the percentage relation of the net financial result and fixed assets was achieved in companies of the pulp and paper industry. A significantly lower ROA was noted in companies of wood sector. In 2013 the percentage relation of the net financial result and fixed assets amounted to 8.9% and it was lower by 5.7 pp than at the beginning of the analysed period.

CONCLUSIONS

From the reports published annually by GUS it follows that in the years 2007-2013 in companies of industrial processing outlays on fixed assets decreased by almost 11% to the level of 39.0 billion PLN. The greatest fall in the category was noted in the years 2009-2010 (20% and 16% respectively). In the analysed period the value of outlays incurred to purchase fixed assets in furniture industry decreased by 1/3 and in 2013 it was at the level of 1 billion PLN. Similar tendencies in the area were also observed in wood industry. Pulp and paper companies noted a significant rise in the level of outlays on the purchase of fixed assets (from 1.38 billion PLN to 2.45 billion PLN).

In the wood sector, similarly to industrial processing the greatest part of investment outlays was incurred to purchase machinery, technical equipment and tools. In the analysed period the level

of these outlays in companies of industrial processing fell by 5% from 28.0 billion PLN to 26.6 billion PLN. A dissimilar tendency was observed in the wood sector – a rise by 18% to 3.1 billion PLN. It is caused by a significant increase of outlays on the purchase of machinery, technical equipment and tools (to 1766.9 million PLN) only in the pulp and paper industry. In other branches there was a decrease in the expenditure incurred on this purchase, as regards the manufacture of furniture it fell even by over 30%. Similar tendencies were noted concerning buildings, structures and transport equipment.

To sum up, the greatest falls in the level of investment outlays on the purchase of fixed assets were observed in the years 2009-2010. The situation applied to all of the branches of the wood sector as well as to the whole industrial processing. The lowest ROA which comprises tangible fixed assets was noted in the year 2008. The tendencies were by all means triggered by the crisis events which took place both in the country as well as in the whole world economy. The global financial crisis which began at the turn of the years 2007 and 2008 in the United States influenced Polish economy to a great extent as well.

REFERENCES

1. Czerwonka L., Jaworski J. (2014), Inwestycje polskich podmiotów gospodarczych w środki trwałe i źródła ich finansowania w latach 2001–2010, Zeszyty Naukowe Uniwersytetu Szczecińskiego, Finanse, Rynki Finansowe, Ubezpieczenia, No. 67
2. Financial results of economic entities in 2013, CSO, Warsaw 2014
3. Financial results of economic entities in 2012, CSO, Warsaw 2013
4. Financial results of economic entities in 2011, CSO, Warsaw 2012
5. Financial results of economic entities in 2010, CSO, Warsaw 2011
6. Financial results of economic entities in 2009, CSO, Warsaw 2010
7. Financial results of economic entities in 2008, CSO, Warsaw 2009
8. Financial results of economic entities in 2007, CSO, Warsaw 2008
9. Fixed Assets in National Economy in 2013, CSO, Warsaw 2014
10. Fixed Assets in National Economy in 2012, CSO, Warsaw 2013
11. Fixed Assets in National Economy in 2011, CSO, Warsaw 2012
12. Fixed Assets in National Economy in 2010, CSO, Warsaw 2011
13. Fixed Assets in National Economy in 2009, CSO, Warsaw 2010
14. Fixed Assets in National Economy in 2008, CSO, Warsaw 2009
15. Fixed Assets in National Economy in 2007, CSO, Warsaw 2008
16. Grzegorzewska E. (2013), Innowacyjność przedsiębiorstw sektora drzewnego na tle przemysłu przetwórczego, Współczesne koncepcje zarządzania w sektorze drzewnym, Wydawnictwo SGGW w Warszawie, Warszawa.
17. Haus B. (2003), Inwestycje i dywesticje gospodarcze przedsiębiorstw, „Prace Naukowe Akademii Ekonomicznej we Wrocławiu”, nr 974.
18. Janik W., Gałązka K. (2014), Inwestycje małych i średnich przedsiębiorstw na przykładzie województwa lubelskiego, Economics and Management, No. 3
19. Karmańska A., Walińska E. (2006), Środki trwałe w prawie bilansowym i podatkowym, A.D. Drągowski, Warszawa.
20. Popyk W., Lis W., Mikołajczak E. (2014), Innovativeness of wood industry enterprises in the years 2010-2013, Intercathedra, No. 30/3

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EXPERIMENTAL ECONOMICS AND MANAGEMENT SCIENCE

Abstract: Carrying out experiments constitutes a special kind of empirical study of reality. Experimental economy is a process of internal transformation of knowledge applied to economical systems concerning methods of production, decision-making and consumer behaviour. The elements which used to be considered as fixed parameters in the neoclassical approach constitute an object of analyses and clarification of ongoing processes in the evolutionary approach. This paper presents experimental economy, which is becoming more and more popular. The purpose of the first part of the article is to present the essence and meaning of the term “experimental economy” and to reveal the development of this discipline. The second part of the paper is concerned with management as a scientific discipline, with which the author deals on a day-to-day basis. In the final part of the article the author presents a possibility to use experimentation as a tool that can be applied also in management science.

Keywords: experimental economy, EU project management, management science

INTRODUCTION

The study focuses on the process of decision-making under risk, examining the behaviour of people in the situations of strategic interaction, i.e. it focuses on experimental economics and its application in management sciences. It is widely known that people are interested in the world around them and the laws that govern it. Conducting experiments is a particular kind of studying reality. Experimental economics is a process of inner transformation of the knowledge applied in economic systems pertaining to production methods, decision-making, consumer behaviour, and psychology of the managing units [Kopczewski, Malewski 2007]. Elements which in neoclassical terms were considered solid parameters, in experimental terms are the subject of analysis and explanation of the processes [Kopczewski, Malewski 2007]. This mechanism is of interest to economists in the field of experimental economics.

This study presents experimental economics, which is a subject of growing popularity. The first part of the article aims to present the theory of the essence and notions of experimental economics, and to show the development of this discipline. In the second part, the author presents management as an everyday scientific discipline. In the last part, the author presents the possibility of employing experiment as a tool which can also be used in management science.

THE NATURE AND CONCEPT OF EXPERIMENT

Until a few decades ago, economy was considered non-experimental science due to the argument that the regularity of economic behaviours is not suitable for testing in the laboratory [Krawczyk 2012]. In a work published by John von Neumann and Oscar Morgenstern, entitled *Theory of Games and Economic Behaviour*, game theory has validated the application of the experiment [Kalinowski 2006]. The authors presented a hypothesis that individuals choose options that maximize their expected value in conducting a rational choice and risk avoidance. Although experimental economics is a new study, we must remember that it has been developing more dynamically in recent years.

Edward Hastings Chamberlain, who together with a group of students attempted to determine market imperfections using a controlled experiment, is considered to be a pioneer of the experimental method in economics [Krawczyk 2012]. With a series of simple actions, Chamberlain divided the participants into buyers and sellers, where each person knew their maximum acceptable

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price, and transactions were done through negotiations; he wanted to see if free, decentralized market would naturally achieve equilibrium. The test results were surprising, as the average transaction price was lower, while the trading volume was higher than in the theoretical equilibrium. The results of the experiment were published in 1948 as “An Experimental Imperfect Market” in the *Journal of Political Economy* [Krawczyk 2012]. However, it was Vernon Smith who received the Nobel Prize in 2002 for his contribution to the work on experimental economics by introducing a number of research methods and treating an experiment as a tool for enriching knowledge. Smith was also involved in the use of simulation of economic projects, which were used for the deregulation of energy markets.

In 1993, Alvin Elliot Roth identified three areas of application for experimental economics [Jabłońska 2013]:

- "experiments to test the hypothesis of utility theory
- experiments to test the hypothesis of game theory,
- experiments on different forms of organization and structure of the market."

These types of experiments highlight the meaningful links between economic theory and experiment. New hypotheses become the beginning of new research, and this in turn allows for the emergence of new trends in the economy.

It is therefore necessary to answer the question – what is an experiment? The word *experiment* comes from the Latin word *experimentum*, which means experience, study. In the social sciences, experiment means activities which create certain relationships and phenomena in an environment where the relevant factors can be controlled and the phenomena can be observed [<http://pl.wikipedia.org/wiki/Eksperyment>, dostęp 02.06.2015].

“In economics experiment is carried out on game terms, where decision-makers are rational egoists seeking to maximize their profits and they know the rules of the game” [Jabłońska 2013]. In general, most experiments can be divided into two basic categories, namely [Krawczyk 2012]:

- *basic research*, which primarily seeks lasting and constitutive behaviour patterns of human nature. In this category one can distinguish: the attitude towards risk, experiments on strategic interaction, and “assumptions about selfishness against various models of social preferences.”
- *applied research*, which facilitates the answer to more specific, individual questions. In this category there are most experiments in marketing, as well as “tests of the effectiveness of particular market institutions.”

Smith considered the abovementioned division as imperfect and he suggested a more accurate division of functions of experiments [Krawczyk 2012]:

- “testing predictions of theoretical models, especially those that distinguish individual theories,
- examining the reasons for not fulfilling the predictions of theory in the real world,
- establishing empirical regularities constituting the basis for new theories
- comparing the behaviour under different conditions in order to determine the boundary conditions of the applicability of a particular theory
- comparison of institutions,
- simulating the effects of changes in economic policy,
- experimenting with new institutions.”

The abovementioned division demonstrates the presence of a strong correlation between experiment and theory of economics. Such a significant use of experiment in various fields of science is determined by a large number of advantages of this tool. The division of the experiment according to method is presented in Fig. 1.

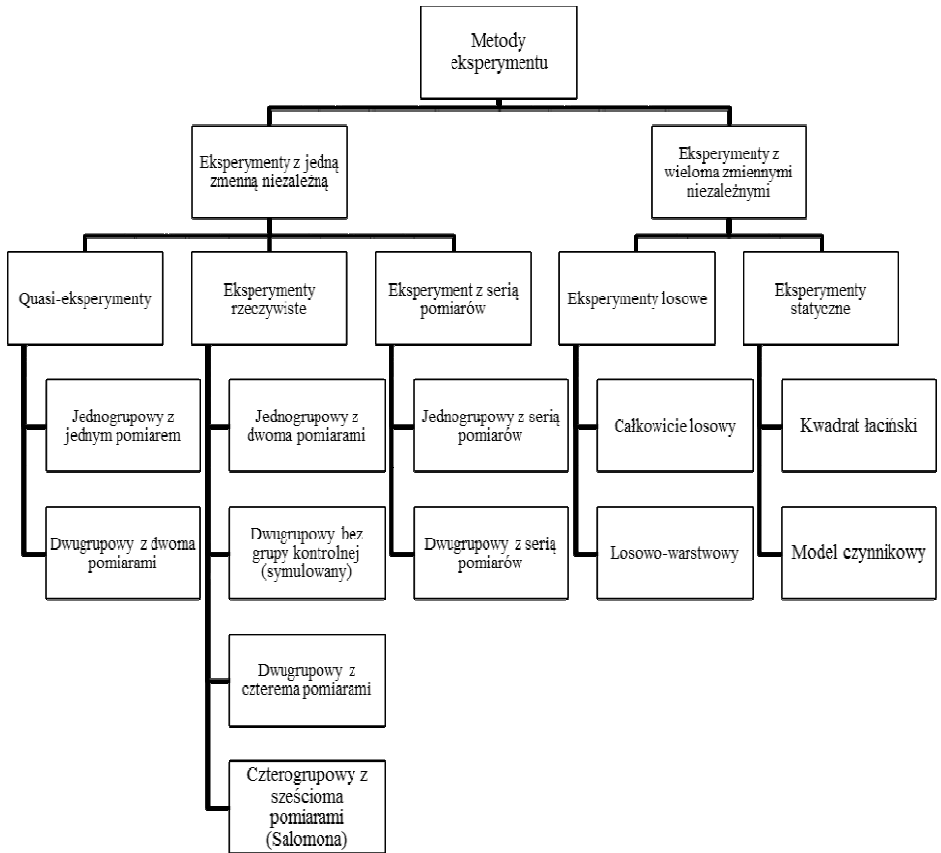


Fig. 1 Division of the experiment according to method

Source: own study based on S. Kaczmarczyk, *Marketing research. Methods and techniques*, Polish Economic Publishing House, Warsaw 2003, p. 239.

The experiment shows the change of the dependent variable value due to changes in the independent variable. Naturally, the number of independent variables may differ, i.e. one, two, or even a dozen. The result is a division into such a large number of experiments as presented in the first diagram. Moreover, the experiment can be carried out under artificial and natural conditions. However, in the latter case, the researcher does not have control over the independent variables. The natural experiment can be divided into standard and controlled. In contrast, an artificial experiment can be divided into a laboratory and simulated one [Kaczmarczyk 2003].

The advantages of an experiment include observation. The researcher can observe the change in value of the dependent variable. It stems from the aforementioned independent variables. However, this tool is not without drawbacks. Experiment is frequently accused of situational realism



(the researcher knows the situation from everyday life), and psychological realism (the researcher becomes involved and makes informed decisions) [Krawczyk 2012].

MANAGEMENT

Regardless of the type of organization and the purpose of its operation, the management process can be defined using four basic steps, which are: planning, organizing, leadership, and control [Robbins, DeCenzo 2002]. Management can be defined as the process behind the operation of the organization towards the achievement of its objectives in an efficient and expeditious manner. The effectiveness is perceived as performing planned activities and the efficiency is understood as a beneficial expenditure ratio compared to the results (minimizing the losses). In the literature, the resources used in the management process are divided into four basic types: tangible, financial, human and informational [Kozłowski 2001]. First of all, management aims to identify ways to achieve strategic, tactical and operational goals.

Management science has a universal character, hence it is possible to use different research methods. Experiment is also important in management science, since, as it was previously mentioned, it is a tool of experimental economics. The most radical experiment in the history of management is considered the SEMCO company, which was the subject of dozens of case studies in various respectable academic centres. Despite intensive work on transferring its business model and organizational culture to other companies, so far it has proven impossible.

It all began in 1982 in Brazil, when then 23-year-old Ricardo Semler took over a small company after his father. The company was manufacturing high-quality industrial equipment and supplied the market with specialized engineering services. At that time the company employed nearly 90 employees; currently Semco consists of ten business units and over 3,000 employees. After taking over as president, through his radical decisions Semler began one of the most thorough and spectacular experiments in the history of personnel management. He [Semler 1998]:

- dismissed 2/3 of the old board,
- allowed all employees to individually set their working hours and the length of their working time,
- abandoned inner audits and approval of cost reports,
- allowed a number of employees to determine their own salary; the information about wages is available for all team members,
- resigned from a strategic plan, purpose and mission of the company and long-term financial planning.

With such an organizational culture, for 25 years the annual turnover rate of the employees in Semco has been 1-2%, and since 1994 the company has recorded double-digit growth almost every year [Semler 1998].

The abovementioned example confirms that in the field of management science, economic experiment also plays an important role and allows for a more thorough understanding of the nature and methods of research.

APPLICATION OF THE EXPERIMENT IN PROJECT MANAGEMENT

As it turns out, the convergence of economics and management science in the case of experimental economics is not far-fetched, even though it might seem that economics as a discipline focuses its attention on the allocation of resources between companies (within the industry), while management science is concerned with the allocation of resources inside the company, and that experimental economics escapes this definition because its main methods and tools cease to pertain

solely to definition strictly in the theoretical dimension. Undoubtedly, due to its high correlation with business practice management science also takes into account other aspects of the world economy - psychology, sociology, the legal issues, and in this sense it is more practical, because it perceives the world as multifaceted; however, it cannot be concluded that experimental economics is not increasingly important in these fields as well.

The importance of the experiment in management science is proven by the field of expertise of the author of this work, namely management of projects co-financed by European funds. In order to be able to explain the link between experiment and project management it is important to define the project. Usually, the project is understood as “any enterprise undertaken with the intent to achieve the goal within a specified time, using available resources and within budget” [Wirkus, Roszkowski, Dostatni, Gierulski 2014], whereas, according to the definition by the Project Management Institute, the project is an action “undertaken to create a unique product or service [Duncan 1996]”. Another definition is presented by G.D. Oberlander, namely the project is an “action taken to produce the results intended by the contracting authority [Oberlander 2000]”. In the literature, there is a number of other definitions of the project, but for the purpose of this paper let us assume that the project is an enterprise with a specific start date, objectives to be realized, a certain level of implementation of indicators, planned activities, budget and a completion date [Tarczydło 2009].

EU projects are a very specific type of projects. They are characterized by the fact that they are carried out within the framework of policies and with the cooperation of the European Union. They focus not only on the EU countries, but are also implemented in countries that aspire to participate in the European Union, but are not part of it yet. As is well known, in the European Union countries there is a considerable difference in socio-economic development; in order to reduce these disparities, for many years there has been implemented an EU cohesion policy, a regional policy, and international regional cooperation.

During the implementation of EU projects, an important role is played by the public procurement law; and here is where the first similarities can be observed. Tenders are governed by similar laws as shares in the example by V. L. Smith. Another important similarity is the fact that often in the analysis of indicators established in the prospectuses projects there are used econometric tools, as it is the case in experimental economics. Additionally, a number of experiments can be employed in EU projects; below, there are described the most significant ones.

The Kaizen method, which is a philosophy which boils down to lifestyle and behaviour - to a never-ending process of improvement. The experiment could be related to the new “Perspective 2020,” where Poland was one of the biggest beneficiaries of the EU funds. In the companies involved in procuring and settling EU funds, the employees responsible for obtaining funding can be offered financial bonuses for “attracting” new projects. The dependent variable would be the number of acquired projects, while the independent variable would be the financial gratification for these projects.

The Lean Management method, which means providing the customer with a product of the highest quality, but without incurring additional costs. The experiment could rely on testing the steps of business processes related to the implementation of a EU project before the start of the project in order to use as few resources as possible.

CONCLUSION

After elaborating on experimental economy and the science of management, the author tried to demonstrate that experiments play greater and greater role not only in the development of economy, but also in other disciplines from the point of view of social science. The paper proposes methods of applying experimentation in management science and possibilities of their use in the management of projects financed by the European Union. It shows that experimental economy and management are two strictly related concepts, and goes as far as to claim that they even overlap and are

complementary. Additionally, it ought to be pointed out that the emergence of a new discipline, which is experimental economy, have allowed the removal of barriers obstructing the development of mainstream economy and allowed a better understanding of methods employed in decision-making, individual behaviours or competition on the market.

REFERENCES

1. Duncan W. R. (1996), *A Guide to the Project Management Body of Knowledge*, Project Management Institute, Four Campus Boulevard, P.4.
2. Jabłońska E. (2013), Application areas for experimental economics, *Studies and Work of the Faculty of Economics and Management*, No. 32, p.38-39.
3. Kaczmarczyk S. (2003), *Marketing research. Methods and techniques*, Polish Economic Publishing House, Warsaw, p. 235-249
4. Kalinowski S. (2006), The origin and significance of experimental methods in economics, "Scientific Papers of the University of Economics in Poznan", no. 77, p. 88.
5. Kopczewski T., Malawski M. (2007), *Experimental economy: and the introduction of the latest research*, *Decisions* 8/2007, P. 79-100.
6. Koźmiński A. K., Piotrowski W. (red.) (2001), *Management – theory and practice*, PWN, Warsaw, p. 62.
7. Krawczyk M. (2012), *Experimental economy*, Oficyna a Wolters Kluwer business, Warsaw, p. 10.
8. Oberlander G. D. (2000), *Project Management for Engineering and Construction*, McGraw-Hill, Boston, p. 4-5.
9. Robbins S. P., DeCenzo D. A. (2002), *Introduction to Management*, Polish Economic Publishing House, Warsaw, p. 32.
10. Semler R. (1998), In spite of stereotypes: the secret of the success of the most remarkable companies in the world, *ABC*, Warszawa, s. 55-57, s. 176.
11. Tarczydło B. (2009), Participation in EU Projects and changes in the organisation, [w:] *Change as a prerequisite for success. Change and development in SME*, collective work edited by J. Skalik, *Scientific Papers of the University of Economics in Wrocław*, Wrocław University Press, Wrocław, p. 92.
12. Wirkus M., Roszkowski H., Dostatni E., Gierulski W. (2014), *Project management*, PWE, Warsaw, p. 11.
13. <http://pl.wikipedia.org/wiki/Eksperyment> (ACCESS 02.06.2015)

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FOOD WASTE – FOUR DIMENSIONS OF SECURITY: ECONOMIC, SOCIAL, ENERGY AND ENVIRONMENTAL

Abstract: The industrial civilization and a global nature of economic events is characterized by irrational use of food and, as a result, its waste. On a global scale avoidable food waste has adverse impact on the environment and leads to economic losses. Locally it entails the necessity of managing growing quantities of waste and extra expenses related thereto. The purpose of this study is to identify consequences of waste in a food chain in the economic, social, energy and environmental security dimensions estimated based on data in reference literature and the authors' own research. Research results show that waste reduces food security both nationally and locally, poses a significant hazard to the environment (by increased consumer waste), results in the irrational use of water, the waste of energy cumulated in discarded commodities and at the same is an important barrier to satisfying societies' needs related to nutrition.

Key words: food losses and food waste, security, environmental, economical and social hazard

INTRODUCTION

Food is a central and necessary element of human life and proper growth, however, access to food remains to be a global problem. The combination of many economic factors, including volatile market prices, resulted in as many as 16m EU citizens relying on food assistance. On the other hand nearly 90m tons of food throughout Europe are wasted. Consumers are primarily responsible for that phenomenon [<http://foodrecoveryproject.eu/pl/>].

Food security should be analyzed in three major dimensions: the first one is related to sustaining human life by ensuring food in appropriate quantity and time. The second dimension pertains to unlimited food supplies, namely, broadly understood food availability to everyone. The last element is adequacy understood as a balanced food ration. That dimension also pertains to supplying food free from diseases and contamination, to markets. The said three dimensions should be analyzed at the level of a single household, on a national and international scale [Krasiuk 2015].

The concept of food self-sufficiency is closely related to food security, i.e., the capability of producing the whole or majority of food needed. At the national level, it involves food availability (in economic and physical terms) without labeling its country of origin (domestic or imported). From a global perspective food self-sufficiency depends not only on the level of agricultural production and freedom to trade but also on the development of processing and distribution. Currently global food production is sufficient to feed the entire human population, however, errors

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in distribution, poor institutional and political solutions result in high-scale malnutrition [Mikuła 2012]. Due to the above, one of the main tasks faced by, among others, EU member states is to ensure food security in those countries, in conditions respecting the environment and maintaining spatial balance. The EU policy should also support the prevention of global food crises and strategies for building up stocks [Leśkiewicz 2012].

CONSEQUENCES OF FOOD WASTE IN FOUR SECURITY DIMENSIONS

Taking into account the global problem of hunger and poverty, food waste is unethical. Its negative consequences can be considered from the four dimensions of security: economic, social, power and environmental (Fig. 1).

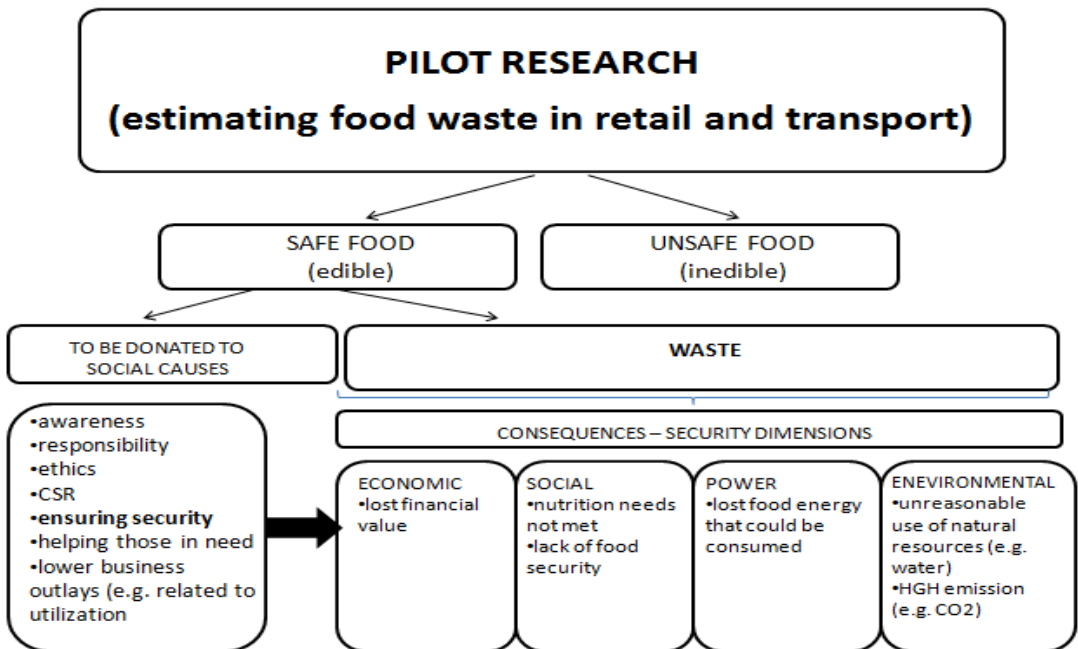


Fig. 1. Consequences of food waste in four security dimensions

Source: own study

ECONOMIC SECURITY

In food management the economic dimension of that process is vital and is determined by food waste. It is estimated that global financial losses resulting from avoidable food waste total approx. USD 1 quintillion [FAO, 2014]. Taking into account the regional structure of food waste from a global perspective, Europe generates approx. USD 57bn, North America and Oceania - USD 33bn, while the industrialized part of Asia - approx. USD 29bn [Gustavsson et al. 2011]. Based on products' life cycle model, food waste at the stage of food distribution, retail and consumption can be defined as a negative financial value flow and/or commodity mass. The resulting difference in an economic balance sheet is a sum total of losses made at those stages. Based on flow graphs Venkat analyzed 134 food commodities in regard of which he calculated food losses. The study shows that the following commodities in the USA are responsible for the highest losses per lost financial value (in turn): vegetables, meat (in turn: pork, beef, poultry), fruits and juices, sweets, grains, butter, fats

and oil. Total retail value per capita amounted to USD 643.95/year. The research shows that losses are made mostly at the consumption stage (62.7% of total losses), followed by retail (32.6%) and distribution (4.7%) [Venkat 2012].

For comparison, based on the 2010 research by Buzby et al. [2014], the retail stage and household consumption in the USA lead to food losses being the equivalent of approx. USD 161.6bn. Losses made throughout retail stages totaled USD 46.7bn accounting for approx. 29% of total financial impact whereas household consumption losses amounted to USD 114.9bn (71.1% of total losses). Food groups which resulted in the highest losses were (in turn:) meat, poultry, fish (in total USD 48bn), vegetables (USD 30bn), dairy products (USD 27bn), fruit (USD 19.8bn), grain products (USD 11.2bn). The study shows that in 2010 an annual income per capita in the USA amounted to USD 36,016 of which 11.2% (approx. USD 4,016) comprised spending on food (consumption in households and elsewhere). Annual financial losses in USA per capita resulting from food waste approximated USD 522 which accounted for 1.44% of the annual income. Similar research was conducted in USA in 2009 by Venkat [2012] showing that the financial losses made by the American society due to avoidable food waste total approx. USD 400/per person/per year which amounts to nearly USD 200bn at an aggregate annually.

SOCIAL SECURITY

Social aspect is another problem directly linked to food waste and losses. Approx. 870 million of people starve and 2 million are malnourished which may be connected to economic and geographical conditions or irrevocable loss of edible food due to irrational management [FAO 2013]. Among EU members Poland is one of the countries characterized by a high risk of poverty and/or social exclusion. Its average level was 24.2% (120 m people) for the entire EU in 2011, whereas for Poland it was estimated at 27.2% [Europe 2020 National Reform Program]. Discarding considerable amounts of edible food given such high number of the poor means that measures are needed aimed at compensating those areas. Food security involves unlimited physical and economic access to safe and valuable food that will fully satisfy nutrition needs, however, the problem of global hunger prevailing over the last decades evidences food insecurity [Kraciuk 2015]. Global food production totals approx. 4.5bn tons. Such quantity is nearly twice the global demand for food, however, due to, *inter alia*, the problem of food losses and waste reaching 1.3bn tons of food, considerable shortage has been observed. Papargyropoulou [2014] states that the problem in question is larger in industrialized countries than in the developing ones. In the industrialized countries consumers are responsible for over 40% of food losses. The above stems from lacking knowledge, attitudes, preferences and errors made at the stage of planning and shopping [Monier et al. 2010]. In developing countries losses occur mostly at the initial stages of food chain and are connected with a low level of a harvesting technology and transport errors combined with disadvantageous climate conditions. Accordingly, an ethical problem related to connecting food losses and waste with such a large scale of hunger and malnourishment should be pointed out. [Papargyropoulou 2014].

ENERGY SECURITY

From the economic perspective food waste does not only mean financial losses but also irrevocably lost energy that could have been consumed. Lipiński et al. [2013] estimated that the presented amount of food losses (1.3bn of food per year) is the equivalent of $1.5 \cdot 10^{24}$ kcal (1.5 septillion of kcal). The losses in terms of a calorific value can be ranked as follows: grain products (53%), root and tuberous vegetables (14%), vegetables and fruits (13%), edible oils (8%), meat (7%), milk and dairy products (4%), fish and seafood (1%). The following regions are responsible for losses of the greatest energy value of foods (in kcal): the industrialized Asia (28%), the south and southeast Asia (24%), North America and Oceania (14%), Europe (14%), Sub-Saharan Africa (9%), North Africa and West and Central Asia (7%) and Latin America (6%). Analyzing the

structure of food losses along the food chain, the highest losses are caused by consumers (35%), basic agricultural production (24%), initial preparation and storage of raw materials (24%), retail and distribution (in total 12%) and processing (4%) [Lipiński et al. 2013].

Similar calculations of a calorific value lost with the food were made in 2010 by Buzby et al. [2014] estimating the annual food losses in retail and final household consumption in USA at 141 quintillion kcal. The said figure totaled 1,249 kcal/per person/per day, which means the loss of approx. 32.9% of a total energetic value that could be used for consumption purposes. Food groups recording the highest losses were (in turn): meat, poultry, fish (in total 30%), vegetables (19%), dairy products (17%).

ENVIRONMENTAL SECURITY

The results of the research show that food waste had adverse impact on the natural environment. The above is related to the increased amounts of waste resulting in the emission of greenhouse gases, the irrational use of water and the waste of energy accumulated in products being discarded. Moreover, food waste is landfilled in areas that could be used for other purposes [FAO 2013].

Total amounts of food waste resulting from wasted foods in 27 EU member states in 2008 amounting to 89m tons accounts for the emission of 170m tons of CO₂ equivalent into atmosphere, that is, 3% of the EU's total gas emission. Approx. 45% of the emitted gases (78m tons of the equivalent) can be ascribed to irrational activities at the household level. The research conducted in households in Finland shows that the annual amount of greenhouse gases emitted by final consumers is 350m kg which figure is comparable to the annual CO₂ emission by 100,000 cars [Katajajuuri 2014]. Bernstad and Andersson [2015], however, point out that reducing the avoidable food waste by one ton may contribute to the GHG reduction even by 800-1400 kg of CO₂.

Water is a basic resource used in food production throughout all stages of the food chain. The research shows that grains are characterized by the highest demand for water. To produce 1 kg of white rice 1,550 liters of potable water are used ["Environmental impacts"]. Water shortage is the most noticeable problem in countries where agriculture has developed on a very large scale and is the main source of income for citizens. For example, Andalusia is the poorest region in Spain where vegetables and fruits' production consumes up to 82% of the region's potable water [Bielski 2012].

Another aspect is using farm land for landfilling consumer waste. Global food waste landfill sites in 2007 occupied the area of 1.4 trillion ha accounting for 28% of the total global cropland. The maximum use of land for production, processing and storage of food waste is observed in Russia, Canada, USA, China, Brazil and Australia [FAO 2013].

ESTIMATING SECURITY DIMENSIONS IN OWN RESEARCH

The research shows that food waste means not only lost quantities, but also (apart from the losses of funds, natural goods, human labor), unnecessary greenhouse gas emission. Based on the analyses performed and cause-and-effect diagrams, reasons for food waste were identified. Donating safe food whose sale is limited or impossible to social causes was the most rational and ethical way of managing it [Bilska et al., 2015, Wrzosek et al., 2014a, Wrzosek et al., 2014b].

As part of own research, apart from calculating losses in the dairy industry, locations were identified where it is possible to donate food that is still safe and healthy to social causes. As regards retail, 117 retail facilities were surveyed that were located in the Mazovian and Podkarpackie Voivodeships and 4,446 dairy products were analyzed in regard of which it was demonstrated that mechanical damage of packaging (60%) and the lapse of the use-by-date (40%) were the most important reasons of food waste. Pursuant to the Security of Food and Nutrition Act, only safe food without defects can be marketed, hence, based on the authors' own research, as little as 40% of the food recorded could be redistributed provided that it is has been withdrawn well ahead of an appropriate date [Wrzosek et al. 2014a].

As regards transport, the sample of 46 hauliers was researched in the Podlaskie Voivodeship. The research showed that the most frequent reasons for rejecting products and discontinuing their marketing include mechanical damage to their packaging. If barrier properties of unit packaging are disrupted, the food commodity's health safety is compromised, and as a result such product is unfit for reuse and cannot be donated to social causes. It should be emphasized that frequently only a part of the goods is damaged in such way, however, the entire batch is then utilized.

The research shows that due to the need to ensure the health safety of a part of products and the necessity of washing the packaging which entail financial outlays due to lost time, hired staff and consumed water, such measures are not taken, hence, the food is not donated to social causes. Damage to collective packaging that does not result in disrupted barrier properties of unit packaging is another case which does not make the product ineligible for continued marketing. Such product is hardly attractive to retail facilities and, in consequence, to consumers. The above can lead to growing stock inventories in warehouses or stores and allowing the products to expire. Following the authors' own research that was conducted, it was shown that there is large potential for donating food at the retail and transport stages to social causes.

Based on authors' previous research studies available in the reference literature, it can be concluded that in the case of food products that are not past their "use-by date" and whose safety was not compromised in transport, it is rational and ethical to donate such food to social causes. Preventing food expiry not only allows to act ethically (by supporting combat against hunger and reducing rampant poverty in the world), but also helps protect the natural environment against negative effects of organic waste storage and utilization. It should be emphasized that an economic value is a measurable effect of reducing avoidable food waste that would be lost following food products' expiry, hence, leading to the loss of the possibility of their consumption by people.

CONCLUSIONS

The results of the authors' own research and the analysis of reference literature show that avoidable food waste may compromise food security on the national and local scale, is a significant hazard to the environment (increased amounts of waste), leads to the irrational use of water and waste of energy accumulated in products being discarded and at the same is an important barrier to satisfying societies' needs related to nutrition in total accounting for four basic dimensions of security. Some losses incurred along the food chain are unavoidable even despite the proper management and marketing of food commodities due to temperature sensitivity, the specific nature of ingredients and necessity of ensuring keeping hygienic conditions.

Many countries have been pondering over the problem of food waste, its consequences and potential possibilities of preventing that phenomenon which is irrational in many aspects. However, given the magnitude of the problem discussed in the reference literature, it should be said that joint action and awareness of the processes that as a result impact the economy, energy management and natural environment as well as social aspects of the entire globe and those countries seem to be of key importance.

Reducing food waste and donating recovered batches of products to charity organizations may contribute to producing desirable social effects. The research confirmed that the problem of wasting food is a systemic one and requires multi-criteria analyses and application measures throughout the market space to guarantee food security in a broad understanding of the term.

REFERENCES

1. Anonymous (2013), Europe 2020 National Reform Program. Available at: http://ec.europa.eu/europe2020/pdf/nd/nrp2013_poland_pl.pdf (accessed 21 Nov 2015).
2. Bernstad A., Andersson T. (2015), Food waste minimization from a life – cycle perspective. *Journal of Environmental Management* 147, pp. 219-226.

3. Bielski P. (2012), Kto nam spuścił wodę? Gospodarowanie zasobami a zrównoważony rozwój. [Who let water out? Resources management and sustainable growth Available at: <http://www.ceo.org.pl/pl/energia/news/woda> (accessed 20 Nov 2015).
4. Bilaska B., Wrzosek M., Kołożyn-Krajewska D., Krajewski K. (2015), Food Losses and Food Waste in the Context of Sustainable Development of the Food Sector. *Chinese Business Review*, September, vol. 14 9, pp. 452-462.
5. Buzby Jean C., Farah-Wells H., Hyman J. (2014), The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States. *USDA-ERS Economic Information Bulletin* 121.
6. Environmental impacts. Available at: <http://www.lovefoodhatewaste.nsw.gov.au/love-food/environmental-impacts.aspx> (accessed 20 Nov 2015).
7. FAO (2013), Food wastage footprint. Impacts on natural resources. Summary Report. Natural Resources Management and Environment Department. Available at: <http://www.fao.org/docrep/018/i3347e/i3347e.pdf> (accessed 20 Nov 2015).
8. FAO (2014), SAVE FOOD: Global Initiative on Food Loss and Waste Reduction Viale delle Terme di Caracalla 00153 Rome, Italy. Available at: <http://www.fao.org/save-food/en/> (accessed 21 Nov 2015).
9. Gustavsson J., Cederberg C., Sonesson U., Van Otterdijk R., Meybeck, A. (2011), Global food losses and food waste. Food and Agriculture Organization of the United Nations, Rome.
10. Available at: <http://foodrecoveryproject.eu/pl/> (accessed 5 Jan 2016).
11. Katajajuuri J., Silvennoinen K., Hartikainen H., Heikkilä L., Reinikainen A. (2014), Food waste in the Finnish food chain. *Journal of Cleaner Production* pp. 322-329.
12. Kraciuk J. (2015), Bezpieczeństwo żywnościowe z perspektywy krajów słabo i wysoko rozwiniętych [Food security from the perspective of less- and highly developed countries]. *Stowarzyszenie Ekonomistów Rolnictwa i Agrobiznesu (the Polish Association of Agricultural and Agribusiness Economists)* pp. 205-209. Volume XVII. Issue no. 3.
13. Leśkiewicz K. (2012), Bezpieczeństwo żywnościowe i bezpieczeństwo żywności – aspekty prawne [Food security - legal aspects]. *Przegląd prawa rolnego*, no. 1(10), pp. 179-198.
14. Lipiński B., Hanson C., Lomax J., Kitinoja L., Waite R., Searchinger T. (2013), Reducing food loss and waste. *World Resources Institute Working Paper*, June.
15. Mikuła A. (2012), Bezpieczeństwo żywnościowe Polski [Food security in Poland]. *Roczniki Ekonomiki Rolnictwa i Rozwoju Obszarów Wiejskich* vol. 99, Z. 4, pp. 38-48
16. Monier V., Mudgal S., Escalon V., O'Connor C., Gibon T., Anderson G., Montoux H. (2010), Preparatory study on food waste across EU 27. Final Report. Available at: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf (accessed 21 Nov 2015).
17. Papargyropoulou E., Lozano R., Steinberger J., Wright N., Zaini U. (2014), The food waste hierarchy as a framework for the management of food surplus and food waste, *Journal of Cleaner Production* 76, pp. 106-115.
18. Venkat K. (2012), The climate change and economic impacts of food waste in the United States. *International Journal on Food System Dynamics*, 2(4), pp. 431-446.
19. Wrzosek M., Bilaska B., Kołożyn-Krajewska D., Krajewski K. (2014b), Ograniczenie strat produktów mleczarskich w handlu detalicznym jako element społecznie odpowiedzialnego biznesu [Reducing dairy products' losses in retail trade as an element of corporate social responsibility], *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, 2014, vol. 16, z. 6, pp. 541-546.
20. Wrzosek M., Bilaska B., Kołożyn-Krajewska D., Krajewski, K., Kondraszuk A. (2014a), Określenie skali i przyczyn strat żywności w handlu detalicznym na przykładzie mleka i jego przetworów [Determining the magnitude and reasons of food losses in retail trade based on milk and its products]. *Żywność Nauka Technologia Jakość*, 21(2), pp. 225-238.



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INEQUALITY AVERSION AND USING FOREST AS A COMMON POOL RESOURCE

Abstract: The aim of the paper is to investigate the models of forest use as a common-pool resource, with users driven by three different motivations: egoistic one, inequality-aversion and forest-sensitivity. The stationary states of the forest were found analytically for pure strategies and numerically for mixed communities. It was shown that the communities of forest-sensitive and inequality-averse individuals are to some degree stable against intruding breaking rules players. However, this stability breaks down for a certain percent of breaking rules individuals, and the stationary state of the forest may change with this percent quite abruptly.

Key words: common-pool resource, inequality-aversion, forests; biophilia

1. INTRODUCTION

The problem of governing and avoiding depletion of the common pool resources has become recently a burning issue, also on the global scale. On one hand some “local” resources, such as forest rains in Amazon, serve as the “lungs” and reservoir of biodiversity for the whole globe; on the other hand – the whole atmosphere and cosmic space may be regarded as common pool resources.

Governing of the commons has been recently a subject of intensive studies (e.g. [Ostrom 1990, Sigmund et al. 2010]) and were even awarded with Nobel Memorial Prize in Economic Sciences in 2009 year (Elinor Ostrom).

It appears that the predicted by G. Hardin “the tragedy of the commons” [Hardin 1968] is not unavoidable. There are some circumstances – apart from postulated by Hardin either privatization or nationalization (which turned out to be not so efficient [Ostrom et al. 1999] – under which the communities can manage the use of the common resource and avoid its depletion. The key elements that have to be present have been determined by investigating the communities which succeed and which failed to govern the commons in favor for both the community and the resource. Identifying the elements that were present in all (or most) of successful cases and were absent in unsuccessful ones, appointed some factors that promote sustainable use of the commons [Ostrom 2005]. In the context of our paper it is worth to mention two of them: 1) monitoring users and the state of the resource: the community members are able to get knowledge about both the current state of the resource and about the actions of the other members; 2) sanctions for rules violations: the community is able to put some sanctions on individuals who do not play according to the agreed rules. In particular, a specific kind of such a punishment may be a pressure of public opinion, which appears to be a strong motivator for most of individuals (conformism).

In this paper we will investigate the models of the forest use as a common pool resources. The forests have two specific features that distinguish them from the other natural resources, e.g. fisheries. First, they have some natural dynamics of growth and regeneration which makes some parts of them inefficient in economic sense to be exploited and are easy to be left apart. Second, forests serve not only as the source of wood, but may be treated as the source of other kinds of goods as well: brushwood, berries or tourist-attractions. Thus, it gives space for the policy to arrange such system of incentives (e.g. in the form of payments for preserving the forests: these payments may come from the richer societies to the poorer ones that govern the forests – what is

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sometimes postulated as the “historical justice” of contribution of developed countries to the less developed ones).

2. MODEL

In modeling the use of a common pools resource there are two main possible approaches. We may assume either that individuals control the amount of good that they extract from the common pool or that they control the efforts invested in “harvesting” this good. The latter is more suitable for fisheries [Gordon 1954] and this situation is usually modeled by a specific function of effectiveness [Daly, Farley 2004; Ostrom et al. 1994]. On the other hand, considering cutting trees it is probably more suitable to assume that individuals control the amount of wood acquired – of course, up to the maximum possible amount, not exceeding the total state of the forest, and the capabilities of the woodcutter (e.g. time). In this situation the gain from the unit of harvest is constant, in contrast to the gain from the unit of effort.

In this paper we investigate the situation where n individuals use the forest, which maximum possible state will be denoted by F (it may be conceptualized as the total area available for the forest). The forest will be modeled as a two-stage resource (in fact, there should be at least a few more stages, to make the model more realistic, see [Chazdon 2008]. However, here we will restrict ourselves to two stages to simplify the model, leaving making it more complex for the future work). That is, while a tree is cut it has no chance to regenerate in the very next step. In the next step it may eventually recover to some intermediate state, not suitable to be cut yet, and only in the still next step it may grow to the useful form. The state of the “mature” forest in time-step t will be denoted by F_{2t} , while the state of the “intermediate” forest by F_{1t} . Note, that besides of “mature” and “intermediate” forest we have also a fallow land – without any trees, and this area will be denoted by F_{0t} . For any moment of time it holds:

$$F = F_{0t} + F_{1t} + F_{2t}. \quad (1)$$

We will assume that “intermediate” trees appear in the fallow land according to regeneration rate, r , while these “intermediate” ones become “mature” according to some flow rate, α .

As for the amount of wood taken from the forest, our model will depend on the following assumption. Each individual makes his decision, d_{it} , according to some utility function (to be specified yet). If the total sum of all decisions will not exceed the mature forest state, each individual harvest as much as he wishes. However, if this total demand cannot be met, each individual acquire the amount of wood, h_{it} , that is proportional to his share in the total demand:

$$h_{it} = \begin{cases} d_{it} & \text{if } \sum_{i=1}^n d_{it} \leq F_{2t} \\ \frac{d_{it}}{\sum_{i=1}^n d_{it}} \cdot F_{2t} & \text{if } \sum_{i=1}^n d_{it} > F_{2t} \end{cases}. \quad (2)$$

We can thus write the formulae for all stages of the forest as follows:

$$F_{0(t+1)} = F_{0t} - r \cdot F_{0t} + \sum_{i=1}^n h_{it}, \quad (3a)$$

$$F_{1(t+1)} = F_{1t} + r \cdot F_{0t} - \alpha \cdot F_{1t}, \quad (3b)$$

$$F_{2(t+1)} = F_{2t} + \alpha \cdot F_{1t} - \sum_{i=1}^n h_{it}. \quad (3c)$$



Now we have to specify the basis on which individuals make their decisions.

There are different types of strategies identified in the literature concerning common-pool resources users. They are grounded both in the analysis of real case-studies and economic games (e.g. [Velez et al. 2009; Fischbacher et al. 2001; Bowles 2003]). Generally, individuals are driven by more than one strategy, using mixed ones. We will take into account here three possible pure strategies, investigating both pure-strategy choices and mixed strategies. Namely, we will consider here the following motivations:

- self-interest. This is the most obvious economic incentive for exploring any resource. Driven by only this motivation each individual tends to extract as much as possible from the common pool, what leads to the so-called “tragedy of the commons”, as predicted by G. Hardin [Hardin 1968]. However, as is well known for at least half of the century, people are not *homo oeconomicus*, at least most of them. There are other motivations that drive the human behavior. Those which appear to be most important in the context of using and depleting common-pools are as follows:

- inequality aversion. This motivation implies that an individual regards not only his own payoff but also payoffs of the others. He puts negative utility on any deviations of others’ payoffs from his own, while usually payoffs exceeding his own arise stronger response than lower payoffs. There are two other motivations, with regard to the others’ choices or payoffs. They are: reciprocity and conformism (see e.g. [Velez et al. 2009; Fischbacher et al. 2001]). Reciprocity differs from inequality aversion with putting negative utility on deviations of others’ choices (not payoffs), and again choices exceeding own choice arise stronger response than the choices lower. Conformism means that an individual feel uncomfortable when his choice deviate from the average choice of the others, thus puts a negative utility on such a deviation. These three motivations: inequality aversion, reciprocity and conformism are generated by different psychological mechanism and can be conceptually well distinguish. However, at the level of utility function they generate quite similar responses, as shown by Falk et al. [Falk et al. 2001]. Thus we will restrict here to the strategy of inequality aversion.

- “biophilia”. This is a term introduced by E.O. Wilson [Wilson 1984] who suggested, that human beings have internal inclinations to natural environment and its preservation. It is obvious that people are willing to sacrifice a part of their income to preserve natural state of the environment, as shown by practice (donations for ecological organizations, etc.) and willingness-to-pay experiments (e.g. [Kahneman, Knetsch 1992; Champ et al. 1997]). That is, we will assume here that forest-sensitive individuals put a positive utility on a state of the forest.

3. PURE STRATEGIES

Each type of the above strategies have its associated utility function that is a base for decision making. The simplest case is self-interest (egoist) strategy. According to this strategy, an individual harvests as much as possible, without regard to the state of the resource and the decisions of the others. Assuming that the maximum possible (due to some technical restriction, e.g. time needed to harvest) is equal to h_{max} , the utility function for egoists will be as follows:

$$U_{it}^e = g \cdot d_{it}^e, \quad (4)$$

where g denotes the gain that a unit of harvesting generates.

Together with the condition of maximizing utility and restriction $d_{it}^e \leq h_{max}$ that gives:

$$d_{it}^e = h_{max}. \quad (5)$$

It is obvious, that if all the individuals were only egoistic, they would sooner or later lead to the almost total depletion of the forest, avoided only by the natural regeneration from the immature states, which are unavailable to be harvested. The stationary states can be found from (3a)-(3c) by requiring:

$$F_{nt} = F_{n(t+1)} \Rightarrow \Delta F_n = 0 \text{ for } n = 0, 1, 2. \quad (6)$$

Together with (5) the condition for stationary states for all egoistic individuals gives:

$$F_0^e = r \cdot \frac{F}{\frac{1}{r} + \frac{1}{\alpha} + 1} \quad (7a)$$

$$F_1^e = \frac{1}{\alpha} \cdot \frac{F}{\frac{1}{r} + \frac{1}{\alpha} + 1}, \quad (7b)$$

$$F_2^e = \frac{F}{\frac{1}{r} + \frac{1}{\alpha} + 1}. \quad (7c)$$

As for inequality-aversion, we will adopt the following utility function (cf. [Fehr, Schmidt 1999]):

$$U_{it}^{Ia} = - \sum_{j \neq i} \frac{\gamma_{ij}}{n-1} (d_{it}^{Ia} - h_{j(t-1)})^2, \quad (6)$$

where

$$\gamma_{ij} = \begin{cases} \gamma_{i1} & \text{if } d_{it} < h_{j(t-1)} \\ 0 & \text{if } d_{it} = h_{j(t-1)} \\ \gamma_{i2} & \text{if } d_{it} > h_{j(t-1)}, \end{cases} \quad (7)$$

and γ_{i1} , γ_{i2} are positive constants such as $\gamma_{i1} \geq \gamma_{i2}$ (this condition means that none individual prefers welfare of others than his own).

For the homogenous case ($\gamma_{i1} = \gamma_{i2} = \gamma_i$) the solution of the maximizing utility condition, $\frac{\partial U_i}{\partial d_i} = 0$, is simple:

$$d_{it}^{Ia} = \bar{h}'(t-1), \quad (8)$$

where the bar over h denotes the average, while prime – that averaging takes place over all individuals but i .

It may be deduced that – if all individuals start with the same value of harvesting – this uniformity will be hold during the whole time. If the total amount of harvest exceed the natural capacity of forest recovery, this value will evolve toward the value obtained for all egoistic individuals. Although decisions laying behind may be different (egoistic individuals always want to harvest as much as possible, but are restricted by the state of the forest, while inequality-averse individuals may want to harvest less), both egoists and inequality-averse are limited by the state of the forest and harvest as much as is possible in the stationary state defined by (7). On the other hand, if the starting value is beneath the forest capacity to recover, this value will be stable during the whole time-evolution. However, these latter situations are highly unstable – if any individual occur once to harvest more, this fragile state will collapse and the system will obtain the stationary state defined by (7).

Finally, we are to specify the utility function associated with the forest-sensitive strategy, that takes into account the state of the forest. In general such a strategy assumes that a unit of harvest has the smaller utility for an individual the worse the state of the forest is. In other words, the worse the



state of the forest the higher utility of it being not harvested. Thus, instead of fixed gain, g , assumed in (4), a gain from the unit of harvest for forest-sensitive individuals will depend on the forest state:

$$U_{it}^f = -g(d_{it}^f, F_{2(t-1)}) \cdot d_{it}^f, \quad (9)$$

where $g(d_{it}^f, F_{2(t-1)})$ is a nonlinear function of mature forest in previous time-step, $F_{2(t-1)}$, taken here in the form:

$$g(d_{it}^f, F_{2(t-1)}) = g_0 \cdot \left[d_{it}^f - 2\lambda \frac{F_{2(t-1)}}{n} \left(\frac{F_{2(t-1)}}{F} \right)^k \right] \quad (10)$$

$0 < \lambda < 1$

with λ and k being the shape parameters, and $k > 1$.

Together with maximizing condition, $\frac{\partial U_i}{\partial d_i} = 0$, (9) and (10) give the following choices of forest-sensitive individuals:

$$d_{it}^f = \lambda \frac{F_{2(t-1)}}{n} \left(\frac{F_{2(t-1)}}{F} \right)^k. \quad (11)$$

That is, each forest-sensitive individual decides to harvest such fraction of maximum possible harvesting which is dependent on the fraction of maximum possible state of the forest.

If all the individuals were forest-sensitive with the same values of parameters λ and k , the state of the forest would tend to some stationary state, in which the state of the mature forest, F_2^f , is defined by the solution of the equation:

$$(F_2^f)^{k+1} \left[\frac{1}{r} + \frac{1}{\alpha} \right] + \frac{F^k}{\lambda} F_2^f = \frac{F^{k+1}}{\lambda}, \quad (12)$$

while F_0^f and F_1^f subsequently:

$$F_0^f = \frac{\lambda (F_2^f)^{k+1}}{r F^k}, \quad (13)$$

$$F_1^f = \frac{\lambda (F_2^f)^{k+1}}{\alpha F^k}. \quad (14)$$

Figure 1 presents an example of time evolution of three states of the forest until reaching the stationary state, for values of parameters: $k = 4$, $\lambda = 0.9$, $\alpha = 1.5$, $r = 0.01$, $F = 100$.

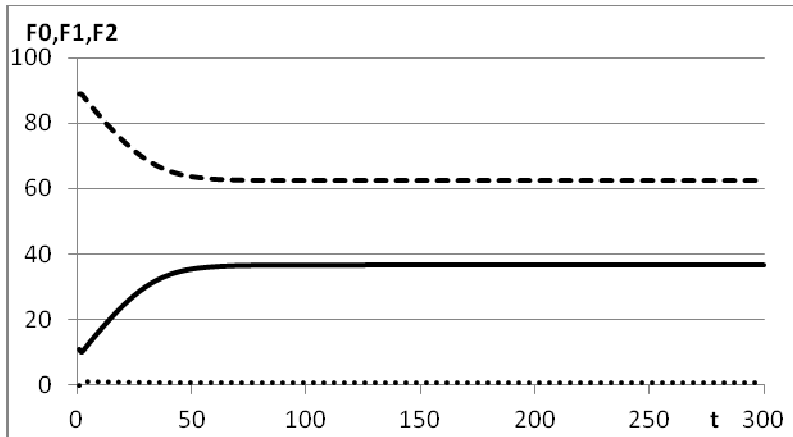


Fig. 1. An example of time evolution of three states of the forest (F_2 - solid line, F_1 - dotted line, F_0 - dashed line) until reaching the stationary state, for values of parameters: $k = 4$, $\lambda = 0.9$, $\alpha = 0.8$, $r = 0.01$, $F = 100$, for all forest-sensitive individuals.

Source: own calculations.

4. MIXED STRATEGIES

In the above section we have investigated three possible pure strategies of forest users. However, such pure strategies may be argued to never appear in real situations. Although the notions of “inequality-aversion” and “forest-sensitiveness” suggest some inner motivations of the individuals, the very same conduct may be forced on them by the outer pressure. As shown by E. Ostrom and other researchers (see e.g. [Ostrom 2005]) there are some conditions under which the governing of the commons turns out to be very efficient in self-regulated way. Namely, in the relatively small groups within which the reputation plays a significant role there is a social pressure on preserving some rules. This may be called conformity rather than inequality-aversion, however, it manifests itself just like inequality-aversion and is quite indistinguishable from the latter. Similarly, the outer punishments (“moral” or more practical, whatever the rules of the given community allow) for forest destroying mimic at the observed level (and at level of mathematical formalism of utility function) the inner motivation of biophilia. It is thus reasonable to investigate the behavior of individuals driven by mixed motivations. We will start with adding egoistic motivation to the inequality averse one. The utility function of an individual driven by these two motives will be in the form:

$$U_{it}^{ela} = g \cdot d_{it}^{ela} - \sum_{j \neq i} \frac{\gamma_{ij}}{n-1} (d_{it}^{ela} - h_j(t-1))^2 \quad (15)$$

and if we assume that i -individual does not make a difference between all the others ($\gamma_{ij} \equiv \gamma_i$) the maximizing condition gives:

$$d_{it}^{ela} = \bar{h}^i(t-1) + \frac{g}{2\gamma_i} \quad (16)$$

It may be noticed from (16) that – unless gain is zero ($g = 0$) or inequality aversion is infinite ($\gamma_i \rightarrow \infty$) the decisions will faster or slower drift toward the maximum possible decision, h_{\max} , and will be executed until the forest state will be good enough, afterwards lowering to the level of

regeneration capacity of the forest. The degradation of the forest state will be however much slower than in the case of only egoistic motivation. There are obvious advantages of this slow down of degradation of natural resources. It gives time to either local government or outer authority to implement some policy of preserving the forest. One of such possible policies are payments for the ecosystems' services (e.g. [Jack et al. 2008; Farley, Costanza 2010]).

Apart from the outer pressure from the other members of the community there are two other factors that may mimic the forest-sensitiveness of the individuals. One is just the policy of some outer authorities to pay the community for the good state of the natural resource which in fact serve not only this community (like rain forests).

The other mechanism is when the community derive some advantages not only from extraction of the resource but also from its preservation – e.g. it may be collecting brushwood and berries from the forest or tourism. Such motivations to preserve the good state of the forest mimic at operational (and mathematical) level forest-sensitiveness. As it is quite realistic to implement this motivation into individuals behavior let us investigate utility function of individuals which are driven by both gain depending on the forest state and inequality-aversion.

The utility function will take the form:

$$U_{it}^{Iaf} = - \sum_{j \neq i} \frac{\gamma_{ij}}{n-1} (d_{it}^{Iaf} - h_{j(t-1)})^2 - g(d_{it}^{Iaf}, F_{2(t-1)}) \cdot d_{it}^{Iaf} \quad (17)$$

with $g(d_{it}^{Iaf}, F_{2(t-1)})$ defined by (10).

The choices obtained by finding the maximum of utility (17) are the following:

$$d_{it}^{Iaf} = \frac{\gamma_i \bar{h}'_{(t-1)}}{\gamma_i + g_0} + \frac{g_0 \lambda \frac{F_{2(t-1)}}{n} \left(\frac{F_{2(t-1)}}{F} \right)^k}{\gamma_i + g_0}$$

In homogenous case (all individuals equivalent, $\gamma_i \equiv \gamma$), stationary states of the forest may be found from $d_{it}^{Iaf} = \bar{h}'_{(t-1)}$ and appear to be exactly the same as in the case of only forest-sensitive individuals and given by (12)-(14). That is intuitively understood, as adding inequality-aversion to the forest-sensitivity, for all individuals exactly the same, changes nothing – as the choices of forest-sensitive individuals were already the same (see (11)). The result still holds for different values of inequality aversions, $\gamma_i \neq \gamma_j$.

We may expect, though, that the situation will change if within the community of forest-sensitive and inequality-averse individuals there will exist some number of egoists, inequality-averse or not. It was shown [Fehr, Schmidt 1999] that in some situations even one individual not playing according to some rules may change the overall result. As it is hardly to expect that the cooperation in the whole community will be perfect – common-pool resources are well known to yield the temptation to free-riding, let us investigate not mixed strategies now, but mixed communities.

5. MIXED COMMUNITIES

The communities to which individuals who differ in their strategies belong are not easy to deal with analytically. Thus, we will investigate such situations numerically, with simulations. It is again clear that adding even one individual who again and again fell the same trees, what exceeds his “share” in the forest will cause an inevitable upward flow of average fell if other individuals are inequality-averse (or at least some of them). We will investigate here more complicated – and alongside more realistic – situation of community that consists of individuals of different motivations and of different strengths of attitudes. That is, both inequality-aversion parameter, γ_i , and maximum fell, that characterize egoistic individuals, g_0 are random variables within some

range. The variability of maximum fell may be ascribed to different capabilities of felling by different individuals and/or in different time-steps.

As it was shown above, for the case of all forest-sensitive and inequality-averse individuals – even for different values of inequality aversion – the state of the forest will evolve toward stationary one defined by (12)-(14). Now we will investigate how this evolution is affected by subsequent replacing some forest-sensitive and inequality-averse individuals by egoistic ones, with different (random within some range) strengths of egoistic attitudes. Figure 2a shows time evolution of mature forest, F_{2t} (as a fraction of the maximum possible state) for $x = 0\%$, 5, 10 and 20% of egoistic individuals. Obviously, $x = 0\%$ gives the result which may be analytically obtained from (12) by substituting proper values of parameters. It turns out, that for $x = 16\%$ (and for all values of $x > 16\%$) the result is the same as obtained in the case of all individual egoistic, which again may be obtained analytically by inserting proper values of parameters into (7) – note, that this result does not depend on the value of the strength of egoistic attitude. For the intermediate values of percent of egoistic individuals it is not easy to calculate the stationary state analytically. Thus, we will restrict to find them numerically. The stationary state of the mature forest (again, as a fraction of the maximum possible state) for different shares of egoistic individuals is presented in Figure 2b.

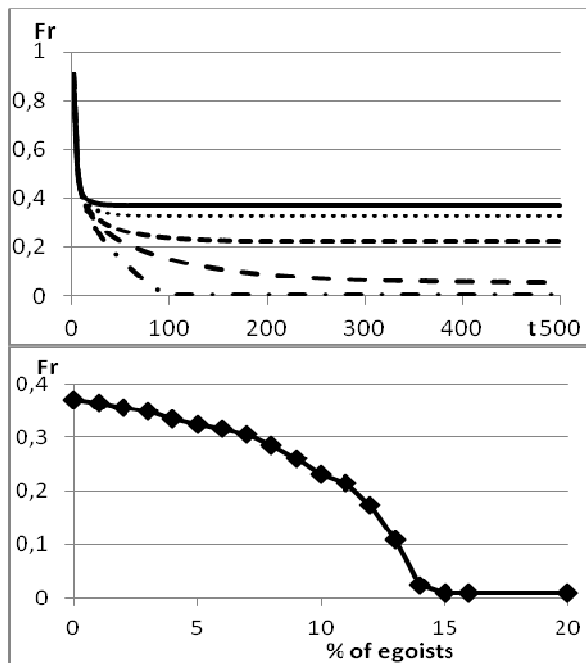


Fig. 2. (a) Time evolution of relative state of mature forest for $x = 0\%$ (solid line), $x = 5\%$ (dotted line), $x = 10\%$ (dashed line), $x = 15\%$ (long-dashed line) and $x = 20\%$ (dash-dotted line); (b) Relative stationary state of the mature forest as a function of a fraction of egoists within the community.

Source: own calculations



The striking feature in Figure 2b is quite abrupt drop of the final state of the forest from some intermediate value to the “egoistic” one. As this pattern appear also for quite different parameters’ values (not shown here) it might be suspected that such a non-continuous changes are common.

6. SUMMARY AND CONCLUSIONS

We have investigated here the evolution of two-stages of forest with its users driven by three different motivations, which might be either inner or imposed by a proper outer policy. As might be expected, all egoistic individuals contribute to forest degradation. Inequality-aversion might serve as a stabilization force, however, this state is very sensitive to even single individuals that are tempted to break rules. On the other hand, communities of forest-sensitive individuals are able to avoid the degeneration of the forest, adopting cutting trees to the current state of the resource – and thus achieving a non-degraded stationary state of the wood with stable long-term profits from forest clearing. However, as in all common-pools dilemmas, such communities are susceptible to breaking rules invaders. We have shown here, that forest-sensitiveness together with inequality-aversion seems to be a stabilizing factor. Communities in which there are a majority of such individuals appear to be resilient – up to some degree – to breaking rules by egoistic individuals. The danger of relaying on this observation is that the stationary state of the forest is a highly nonlinear function of percent of breaking rules individuals, and cannot be predicted by simple extrapolation. Thus, the mechanisms of monitoring and sanctioning breaking rules individuals have still to be highly efficient (although there is no need of perfectness), as pointed out by Ostrom and other researchers.

REFERENCES

1. Bowles S. (2003), *Microeconomics: Behavior, Institutions and Evolution*, Princeton University Press.
2. Champ P.A., Bishop R.C., Brown T.C., McCollum D.W. (1997), Using Donation Mechanisms to Value Nonuse Benefits from Public Goods, *Journal of Environmental Economics and Management* 33, p. 151-162.
3. Chazdon R. L. (2008), Beyond deforestation: restoring forests and ecosystem services on degraded lands, *Science* 320, p. 1458-1460.
4. Daly H.E., Farley J. (2004), *Ecological Economics*, Island Press, Washington.
5. Falk A., Fehr E., Fischbacher U. (2001), Appropriating the Commons - A Theoretical Explanation, CESifo Working Paper No. 474.
6. Farley J., Costanza R. (2010), Payments for ecosystem services: from local to global, *Ecological Economics* 69, p. 2060-2068.
7. Fehr E., Schmidt K.M. (1999), A Theory of Fairness, Competition, and Cooperation, *The Quarterly Journal of Economics* 114, p 817-868.
8. Fischbacher U., Gächter S., Fehr E. (2001), Are people conditionally cooperative? Evidence from a public goods experiment, *Economics Letters* 71, p. 397-404.
9. Gordon H.S. (1954), The Economic Theory of a Common-Property Resource: The Fishery, *The Journal of Political Economy* 62, p. 124-142.
10. Hardin G. (1968), The Tragedy of The Commons, *Science* 162, p. 1243-1248.
11. Jack B.K., Kousky C., Sims K. R. (2008), Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms, *Proceedings of the National Academy of Sciences* 105 9465-9470.
12. Kahneman D., Knetsch J.L. (1992), Valuing public goods: The purchase of moral satisfaction, *Journal of Environmental Economics and Management* 22, p. 57-70.
13. Ostrom E., Burger J., Field C.B., Norgaard R.B., Policansky D. (1999), Revisiting the Commons: Local Lessons, Global Challenges, *Science* 284, p. 278-282
14. Ostrom E., Gardner R., Walker J., Rules (1994), *Games, and Common-Pool Resources*, The University of Michigan Press, Ann Arbor.



15. Ostrom E. (1990), *Governing the commons: The evolution of institutions for collective action*, Cambridge University Press.
16. Ostrom E. (2005), *Understanding Institutional Diversity*, Princeton University Press, Princeton.
17. Sigmund K., De Silva H., Traulsen A., Hauert C. (2010), Social learning promotes institutions for governing the commons, *Nature* 466, p. 861-863.
18. Velez M. A., Stranlund J. K., Murphy J.J. (2009), What motivates common pool resource users? Experimental evidence from the field, *Journal of Economic Behavior & Organization* 70, p. 485-497.
19. Wilson E.O. (1984), *Biophilia*, Harvard University Press.

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THE INFLUENCE OF OAK WOOD DIMENSIONS ON ITS VALUE AT SUBMISSION SALES

Abstract: Submission sales and auctions are used in special turnover of valuable wood material. The growing demand for wood material increases its price. Oak wood is the most common material sold. Oak wood assortments have considerable industrial significance. The interest in this type of wood is caused by its high quality and technical parameters. In order to optimise the management of this wood it is very important to determine the influence of its quality and dimensions offered on the increase in its market value. The article indicates the influence of dimensional parameters of special wood on average oak wood prices at submissions in the Katowice Regional Directorate of State Forests.

Key words: oak, wood sales, submission, dimensional parameters

INTRODUCTION

Oak is a major deciduous tree species in Poland. The volume of oak wood offered and sold by the National Forest Holding 'State Forests' is increasing gradually. In 1978 its share amounted to 5.5%. It increased to 7.8% in 2013. At the same time the volume of pinewood dropped from 71.6% to 69.3%. It was caused by changes in forest management in Poland. In general, it consists in matching tree species with the types of habitats (Jaworski 1995, Andrzejczyk 2009, Report on State Forests 2014). There are plans to continue afforestation with deciduous trees and increase their share among afforesting species. This will reduce forest productivity, i.e. the possibility to acquire raw material per hectare.

Oak was an important tree in the culture of many nations. It also had symbolic significance. In Scandinavian countries it was a sacred tree of Thor, the god of storm and lightning. For early Germanic tribes it was the Cosmic Tree. In the Slavic culture oak was related with Perun, the god of thunder and lightning. When Christianity was introduced, the first Piasts cut sacred oaks and oak groves.

As Constantine VII Porphyrogenetos wrote, in the 10th century Rus' people had their ceremonies under an oak tree (Dzieduszycki 2009). According to Pliny and the memoirs by Julius Caesar, Celtic druids celebrated their rituals in oak forests. In Greek mythology the oak was the tree sacred to Zeus, whereas in Roman mythology it was sacred to Jupiter (Kopaliński 1987).

In the Bible, an oak tree is mentioned in the Book of Genesis (35,8). Deborah, Lapidoth's wife of the Tribe of Naphtali was buried under an oak tree. She was a prophetess of the Israelites and the only woman judge in Israel. The Israelites' victory over the Canaanites is described in the Book of Judges as the song of Deborah and Barak. According to the sacred tradition, the authorship of this song is ascribed to Deborah the prophetess. In Arabic culture leaders were often buried under oak trees. The most famous oak tree in the Bible was **the Oak of Abraham**. As we can read in the Book of Genesis (13, 18), 'So Abram went to live near the great trees of Mamre at Hebron, where he pitched his tents.' This kermes oak tree is venerated by the Jews and Christians. It is 2 km away from the biblical place named Mamre in the Hebron. The oak tree would have to be about 5,000 years old. The Oak of Abraham died in 1997. At present a new shoot is growing next to it.

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In general, oak trees symbolise durability and longevity. They are the longest living species of deciduous trees in Poland. Oak wood is also the most expensive.

THE BEST-KNOWN OAK TREES IN POLAND

The oak tree is still a symbol of strength and nobility, to which Reverend Piotr Skarga referred in his sermons. **The Bolesław Oak** is the oldest oak tree in Poland. It stands in Kołobrzeg Forest, the Commune of Ustronie Morskie, about 15 km southeast of Kołobrzeg. It is considered one of the oldest natural monuments in Poland. Its age is estimated at 800 years. Its girth at a height of 1.3 m is 691 cm. It stands 32 m tall with the crown diameter of 20 m. The Warcisław Oak stands nearby. Before the 'rediscovery' of the Bolesław Oak (its position was wrongly marked on German maps) by Hieronim Kroczyński the Chrobry Oak of Piotrowice was considered to be the oldest in Poland (740 years). The best-known Bartek Oak of Zagnańsk is 680 years old. On 19 August 2000 the oak was named Bolesław to commemorate King Bolesław the Brave, who established the bishopric in Kołobrzeg in 1000.

The Chrobry Pedunculate Oak is about 740 years old and it probably germinated during the reign of Duke Bolesław the Chaste (born on 21 June 1226 in Stary Korczyn, died on 7 December 1279). Its girth at breast height is 10.08 m and it stands 29 m tall. The tree can be found in Lubusz Voivodeship, in a clearing near houses in the village of Piotrowice. The oak has a conspicuous cylindrical trunk and a relatively high crown. Before the war its name was Grosse Eiche. The legend has it that Emperor Otto III and King Bolesław the Brave met there in 1000. It cannot be true because the tree is 250 years younger than the event. It is considered the oldest pedunculate oak tree in Poland. In 2003 acorns collected from the tree were blessed by Pope John Paul II. More than 500 seedlings were bred from these seeds and they were planted in all forest districts in Poland.

The Bartek Pedunculate Oak is estimated to be 680 years old. Probably it germinated during the reign of King Casimir the Great (its age is also estimated at 700-1200 years). It stands 2 km away from Zagnańsk in Świętokrzyskie Voivodeship. Its girth is 985 cm and its height is 30 m. The best-known Polish oak tree was first mentioned in *Sylwan* scientific journal in 1929. In 1934 the Bartek Oak won the contest for the most conspicuous tree in Poland (within the then territory), which was organised by Prof. Władysław Szafer and *Rynek Drzewny* journal. For this reason for many years (and sometimes even now) the tree was thought to be the oldest and thickest in Poland. At the time the girth of the Bartek Oak was 832 cm, the height – 22 m and the estimated age – 1150 years. Its circumference at the ground level was 13.4 m and the volume was 78 m³. In 1954 the Bartek Oak was recognised as a natural monument. In 1920 it underwent conservation – the hollow was filled with stone and cement. 58 years later the filling was removed. On 3 June 1991 the healthy tree was struck by lightning. As a result, one of the most conspicuous boughs and part of the trunk were damaged. It was then that the decision to place additional supports under the boughs was made. In April 2009 the tree was examined with the latest non-invasive methods to make the optimal concept of placing more supports. At present the tree is 30 m tall, its girth at a height of 1.30 m is 9.85 m, whereas at the ground level it is 13.4 m. The span of the tree crown is 20 m x 40 m, the tree crown hood – 720 m³, the diameter at breast height – 314 cm. The total tree volume is about 72 m³; the total large tree volume – about 65 m³, including the trunk volume – about 46 m³. Since 1952 the Bartek Oak has been a natural monument.

On the bank of the Warta River (in the oxbow lake) stand the **Oaks of Rogalin** (Rogalin oak forest). They are natural monuments. It is the largest group of ancient pedunculate oaks in Europe (a fragment of formerly immense riparian forests). The oak forest is located in Rogalin Landscape Park. There are 1,435 oaks in it. The girth of nearly a thousand of them is greater than 2 m. These trees are protected by law. 860 of them have the status of natural monuments. The girth of the biggest trees is 9 m. The best-known trees stand in the English section of the park surrounding the palace. Their names are: Lech, Czech and Rus with girths of 635, 726 and 926 cm, respectively. There is



also an oak tree named Edward. Its girth is 650 cm. It stands alone at the edge of the park, on the slope of the Warta River valley. The oak trees are about 700 years old (before dendrochronological examinations their age was estimated at nearly 1,000 years). They are infested by the great capricorn beetle. The pest is a few centimetres long and it is protected by law. The trees attacked by the insect cannot be saved. The Bartek Oak is also infested by the pest.

OAK WOOD APPLICATION

Motifs with oak trees or seeds can be found in coats-of-mail of cities, on distinctions and coins.

Oak wood is commonly used for production of floors, wood panelling, Venetian blinds, shutters, stairs and veneers. It is a very valuable raw material in cooperage, boatbuilding, furniture building and carpentry (Kokociński 2005).

Oak wood is heavy, tough and very durable. It turns black when kept in water for a long time. It becomes even more durable then. This form is called 'black oak wood' or Polish ebony.

WOOD PROCESSING AND MATERIAL PRODUCTIVITY

Optimisation of wood processing should ensure maximum use of its quality, which should be reflected by end products. It involves the need to prepare rational rules of log processing, allowing for the existing technical, technological and organisational conditions of a wood processing enterprise. It should stimulate motivating actions to achieve the optimal technical and economic effects (Buchholz, Krutel 1988, Ratajczak 2011).

Material productivity is one of basic determinants of the cost-effectiveness of an enterprise. The price of material is influenced by the market, where fixed costs usually do not exceed 20%. For this reason enterprises should chiefly concentrate on the improvement of technological conditions, leading to better productivity indicators. Productivity, efficiency and rationality of material processing can be increased by digital methods of measurement and their analysis. As a result, processing can be optimised. These methods enable correlation of measurement data with quality and quantity indicators at different stages of production until the final product. Digital methods enable technological optimisation and increased efficiency of processing (Hruzik et al. 2004).

The structure of material sawn is a factor with direct influence on the wood processing enterprise. At this stage of production, it is important to sort the material appropriately according to its diameter at the thinner end of the log and according to qualitative traits, i.e. curviness or knottiness (PM-79/D-01011, Hruzik et al. 2005).

To sum up, material productivity is often the factor that justifies the sense of an enterprise's operation. Continuous improvement of material productivity is a basic determinant of competitiveness of an enterprise and its advantage on the market.

SPECIAL WOOD SALES

Wood auctions and submissions have become a regular element of the activity of the National Forest Holding 'State Forests'. The search for new forms of product distribution and profit intensification are desirable actions in market economy. For many years some regional directorates of the 'State Forests' have been taking this challenge and preparing sales of special wood for domestic and foreign clients (the term 'special wood' is the best name describing the nature of timber offered at auctions and submissions; according to PN-93/D-02002, special wood is the wood material with special quality and dimensional characteristics, which are crucial for its further use). This special way of treatment concerns both wood itself – its quality and dimensions, and its preparation – setting exact dates of its presentation and sales at special places. It is noteworthy that special wood comes from planned cutting. This means that it is a deliberate business activity based on the knowledge of nature and resulting from due care of state possessions. At most regional directorates of the 'State Forests' enterprise wood for submission sales is prepared by supervisory

services (colloquially called sorting services). This is a group of workers with very narrow specialisations who are in charge of optimal wood management and its best use. This task requires good knowledge of the wood market and clients' requirements concerning the technical properties (dimensions and quality) of material prepared for sales (Zastocki et al. 2015).

The selection of special wood depends on the methodology applied in a particular regional directorate of the 'State Forests'. At the final stage of preparatory procedures the wood selected for sales goes to the depot (one or more depots, depending on the character of the market and experience of the people in charge of preparation of this form of wood sales). There, the wood is measured and described (it is necessary to use special numbering and description, which can be found in the submission catalogue) according to applicable standards: PN-93/D95000 and PN-EN 1309. It enables verification during the sales procedure. The selection of types of round wood offered for sales depends on the possibility of its acquisition in a particular regional directorate in a given period of time and on the market demand. There are usually 1-10 types of wood offered.

SUBMISSION SALES OF OAK WOOD

Oak wood is a basic type offered at submission sales. The wood sold in the largest amounts is oak wood and it has the highest average prices. Among other types of valuable wood, sycamore wood is noteworthy. In 2006 at the Krosno Regional Directorate of 'State Forests' its value exceeded 27,000 zlotys per m³. However, it was an exceptional situation, because wood of such outstanding quality can be found only locally and in very small amounts (Paschalis-Jakubowicz et al. 2015).

On a national scale, especially at the Katowice Regional Directorate of 'State Forests', oak wood has been the basic type offered since the beginning of submission sales of special wood. It is also the main type of wood affecting the submission sales value (among all types of wood offered for sales the share of oak wood is greater than 50%). Apart from high quality, oak wood is characterised by a considerable range of dimensions, both in the log lengths and diameters (Seneta, Dolatowski 2004). This fact is of primary importance for the use of oak wood and for potential recipients of the material.

RESEARCH RESULTS AND ANALYSIS

The data presented in further sections of this study come from the documents of submission sales organised by the Katowice Regional Directorate of 'State Forests' between 2008 and 2015 (the last submission sales included in the study took place in spring 2015). The results of the study on price variability depending on varying dimensional parameters apply only to the wood from oak trees native to Poland (*Quercus robur* and *Quercus petraea*). At submission sales the Katowice Regional Directorate of 'State Forests' also offers wood from the Łódź Regional Directorate of 'State Forests'. This fact was included in the materials under analysis.

Between 2008 and 2015 6,626 m³ of oak wood was sold at 13 submission sales events (Table 1).

During the eight years of submission sales of special wood organised by the Katowice Regional Directorate of 'State Forests' a total of 6,626 m³ of oak wood was offered for sales (oak wood made 57% of all types of wood offered). During the period under analysis the value of oak wood sold amounted to about 75% of the total value of wood sold by submission at the Katowice Regional Directorate of 'State Forests'. Such large disproportion between the quantitative share of oak wood and its share in the income was caused by high average price of this material. The average price of oak wood at the submission sales under analysis was 1,764 zlotys per m³, whereas the average price of all types of wood offered during that period (including oak wood) was 1,349 zlotys per m³ (source: the author's calculations based on the documentation of the Katowice Regional Directorate of 'State Forests'). Oak wood was about 31% more expensive than the average price of all types of wood offered at the submission sales between 2008 and 2015.

Table 1. The oak wood sold by submission at the Katowice Regional Directorate of 'State Forests' between 2008 and 2015.

Date of submission	Volume of wood [m ³]	Net value [zloty]	Average price [zloty per m ³]
7.03.2008	417	775 176	1 861
20.02.2009	437	596 204	1 363
19.02.2010	530	784 883	1 481
19.11.2010	115	211 449	1 834
18.02.2011	525	887 598	1 692
18.11.2011	109	234 434	2 149
17.02.2012	537	922 988	1 718
30.11.2012	261	508 887	1 948
15.02.2013	816	1 351 360	1 657
29.11.2013	394	787 161	1 999
21.02.2014	726	1 283 464	1 769
21.11.2014	672	1 389 197	2 067
19-20.02.2015	1 088	1 957 261	1 799
Total	6 626	11 690 063	1764

Source: The author's calculations based on the documentation of the Katowice Regional Directorate of State Forests

The analysis of the dependence between the price and length of oak wood also shows favourable results. The Katowice Regional Directorate of 'State Forests' offered logs of different length, beginning with 2.5 m and scaled at intervals of 0.5 m. There were also trace amounts of logs with different dimensions. The fact that these logs were offered for sale resulted from random events and it was an attempt to maximize the use of valuable raw material.

Table 2 shows the dependence between the length of oak wood and its sales price. As can be seen, there was a considerable share of 4-metre logs (1,107 logs – 20%). They were followed by logs of 3.0 m and 4.5 m in length (910 pieces and 908 pieces, respectively). Other significant lengths were: 6.0 m – 10% (568 pieces), 2.5 m – 8% (467 pieces) and 5.0 m – 7% (407 pieces). There were also small amounts of oak wood logs offered at the following lengths: 7.0 m – 3% (173 pieces), 5.5 m and 8.0 m – 2% each (85 pieces and 113 pieces) 6.5 m and 7.5 m – 1% each (65 pieces and 34 pieces). Other lengths of logs amounted only to 2% of the total amount of oak wood offered.

The results show that there was a tendency to acquire the lengths of logs which would maximise the use of characteristic traits of the tree trunk shape. The shape limits the possibilities of technological use of oak wood. As much as 64% of oak wood offered for sale was not longer than 4.5 m. Attempts to increase the share of long pieces (longer than 6 m) remain at the discretion of institutions in charge of forests. They depend on genetic and habitat-related conditions and breeding procedures. In general, they result from the genetics and long growth of oak trees (from planting to cutting). They are also influenced by independent factors (e.g. weather conditions and humidity).

Table 2. The length of oak wood sold by submission at the Katowice Regional Directorate of 'State Forests' between 2008 and 2015.

Length	Amount	Average price	Length	Amount	Average price
[m]	[piece]	[zloty per m ³]	[m]	[pieces]	[zloty per m ³]
2,4	4	1 673	6,4	1	2 090
2,5	467	1 748	6,5	65	1 903
3,0	910	1 619	7,0	173	1 878
3,4	1	680	7,5	34	2 024
3,5	669	1 591	8,0	113	1 936
4,0	1 107	1 694	8,5	5	2 114
4,3	1	1 610	9,0	25	2 071
4,4	1	620	9,5	2	3 274
4,5	908	1 819	10,0	7	2 202
5,0	407	1 787	11,0	8	1 967
5,5	85	1 946	11,5	1	2 410
6.0	568	1,811	Average		1,764
			Total	5,562	

Source: The author's calculations based on the documentation of the Katowice Regional Directorate of 'State Forests'

Table 3. The influence of the log diameter on variation in the prices of oak wood at submission sales at the Katowice Regional Directorate of 'State Forests' between 2008 and 2015.

Diameter [cm]	Amount [piece]	Average log volume [m ³]	Average log value [zloty]	Average price per m ³ [zloty per m ³]	Share by volume [%]
≤40	14	0,5	675,97	1326	0,1
41-50	1489	0,75	1072,26	1402	16,8
51-60	2001	1,04	1745,21	1642	31,4
61-70	1236	1,42	2628,33	1816	26,5
71-80	576	1,84	3656,21	1947	16,0
81-90	190	2,24	4657,11	2051	6,4
91-100	45	2,9	5259,85	1746	2,0
≥101	11	4,55	10517,43	2026	0,8
Total	5562				100

Source: The author's calculations based on the documentation of the Katowice Regional Directorate of 'State Forests'.

The comparison of average prices in the length categories under analysis gives a possibility to verify clients' demand, or in broad sense – the market demand for particular length assortments. The analysis of the dependence between average prices of 1 m³ of oak wood and its length shows that 9.5-metre logs were sold at the highest price (3,274 zlotys), whereas 4.4-metre logs were sold at the lowest price (620 zlotys). The average price of the wood length sold in the largest amounts (modal length – 4.0 m = 1,107 pieces) was similar to the average price of oak wood (1,764 zlotys).

The thickness of oak wood material is an important parameter in the assessment of variability in its value. As there were only assortments of the third class of thickness (the minimum diameter of 35 cm, measured at half of the log length), oak wood was divided into dimensional groups differing in diameter scaled at 10 cm (Table 3).

Table 3 shows the dependence between the average price of oak wood sold by submission and its diameter as well as average values per 1 m³ of material. There is a noticeable increase in the value of thick wood. The average price ranged from 1,326 to 2,051 zlotys per m³. In the 91-100 cm diameter category there was a difference of about 305 zlotys per m³, as compared with the highest price.

The share of the 51-60 cm diameter category in the volume exceeded 30%. There was a high share of wood with the diameter of 61-70 cm (26%). It was followed by the 41-50 cm and 71-80 cm diameter categories with shares of 17% and 16%, respectively. The oak wood assortments with diameters below 40 cm and over 91 cm amounted to barely about 3% altogether.

SUMMARY

The indicators of the oak material value justify the analysis in relation to the dimensional variability. In spite of some qualitative defects in the oak wood offered for submission sales by the 'State Forests' (e.g. a high share of material with the internal sapwood defect), there is high demand for it. The occurrence of an individual defect does not disqualify large-diameter timber, because it is a rare material of considerable value on the market. Oak wood has high economic importance in the wood industry. Due to wide possibilities of application and dedicated processing technologies oak wood is a valuable material used in the production of veneers, furniture, floors or lamellas for cladding materials. These possibilities cause rationalisation of processing.

As far as technology is concerned, greater diameters and lengths of assortments increase both the usefulness and material efficiency at consecutive stages of processing. As a result, the production efficiency increases.

Wood offered at submission sales organised by the Katowice Regional Directorate of 'State Forests' (and at auctions and submission sales organised by other regional directorates) is usually thicker than 50 cm (the diameter measured in the middle of the log, without the bark). Thinner logs are rarely offered. The dimensions of wood increase proportionally to its price.

The share of wood defects is a particularly important factor influencing material efficiency. The amount and range of the defect are not always important in estimation of the material price. However, the distribution of the defect (e.g. knots distributed along the wood axis cause fewer problems than the same number of knots scattered all over the side surface) and its location are important (e.g. internal sapwood near the pith is a lesser problem than at half of the diameter). Apart from the diameter and distribution of defects, the wood value is also influenced by its length (the longer the log is, the more useful and valuable it is). These parameters are the most significant determinants of the price of wood. In addition, the price of wood also depends on its physical properties such as: colour, structure and uniform arrangement of annual growth rings.

At present there is high interest of domestic and foreign clients in oak wood offered at auctions and submission sales.

The analysis of the data leads to the following conclusions:

- Selection and appropriate preparation of oak wood gives a chance to sell it at high prices, as compared with the average price of WB0 wood in the third class of thickness. It results from the fact that about 90% of wood offered at submission sales organised by the Katowice Regional Directorate of 'State Forests' has the internal sapwood defect (PN-92/D-95008).
- The prices of oak wood at submission sales organised in autumn are noticeably higher (the demand is higher) than in spring. The purchase limit of wood guaranteed for sale on the forest and wood portal is exhausted and at the end of the year there is greater supply of wood offered at submission sales.
- The analysis shows that between 2008 and 2015 the average prices of oak wood ranged from 1,363 to 2,149 zlotys per m³.
- The average price of oak logs shorter than 4.5 m was lower than the average price of oak wood offered at submission sales organised by the Katowice Regional Directorate of 'State Forests'. There was a noticeable increase in the value of 4.5-metre and longer oak logs, expressed as the average price per m³.
- The average price of 4.0-metre oak logs (the largest group – 1,107 pieces) was similar to the average price of oak wood, because it had the greatest influence on it.
- The highest price was bid for 9.5-metre oak logs (3,274 zlotys), whereas the lowest price was bid for 4.4-metre logs (620 zlotys).
- The wood value tended to increase along with its thickness (the average price increased from 1,326 to 2,051 zlotys per m³).
- The highest share by volume was observed in the group of oak logs with diameters of 51-60 cm (30%). There was a minimal share of oak logs with diameters below 40 cm and over 91 cm (about 3% in total).

REFERENCES

1. Andrzejczyk T., Aleksandrowicz -Trzcńska M., Żybura H. (2009): Wpływ cięć rębnych na zagęszczenie, wzrost i stan zdrowotny odnowień naturalnych sosny w warunkach Nadleśnictwa Tuszyma, *Leśne Prace Badawcze* 2009, Vol. 70, nr 1, 5-1.
2. Biblia Tysiąclecia (2014): *Księga Rodzaju* (35,8); (13,18). Wydawnictwo Pallottinum, Poznań
3. Buchholz J., Krutel F. (1988): Optymalizacja przerobu drewna tartacznego na materiały tarte i okleinę, *Folia Forestalia Polonica, Seria B, Zeszyt 19*, Poznań.
4. Dzieduszycki W. (2009): Człowiek i przyroda w średniowieczu, ESUS 2009.
5. Hruzik G., Gotycz W., Marciniak A., Szyszka B. (2004): Zastosowanie metod numerycznych do optymalizacji wtórnego przerobu drewna. *Przemysł Drzewny* nr 3, 26–28.
6. Hruzik G.J., Gotycz W., Wieruszewski M. (2005): Efektywność produkcji przykładowych wyrobów tartacznych na rynek krajowy i europejski. *Przemysł Drzewny* nr 5, 18-21.
7. Jaworski A. (1995): *Charakterystyka hodowlana drzew leśnych*, Wyd. Gutenberg Kraków.
8. Kokociński W. (2005): *Anatomia drewna*, Poznań.
9. Kopaliński W. (1997): *Słownik mitów i tradycji kultury*, PWN Lublin.
10. Paschalis-Jakubowicz P., Kulik P., Lachowicz H. (2015): Kształtowanie cen oraz metody sprzedaży surowca cennego w Polsce. *Sylwan* 159 (4): 267-277.
11. PM-79/D-01011 – Drewno okrągłe. Wady.
12. PN-92/D – 95008 – Surowiec drzewny. Drewno wielkowymiarowe liściaste. Wspólne wymagania i badania.
13. PN-93/D-02002 – Surowiec drzewny. Podział, terminologia i symbole.
14. PN-93/D95000 – Surowiec drzewny. Pomiar, obliczenie miąższości i cechowanie.
15. PN-EN 1309 – Drewno okrągłe i tarcica – Metoda oznaczania wymiarów.
16. Raport o stanie lasów w Polsce 2014. Lasy Państwowe.



17. Ratajczak E., Bidzińska G., Szostak A. (2011): Foresight w drzewnictwie – Polska 2020. ITD, Poznań.
18. Zastocki D., Moskalik T., Sadowski J. (2015): Ocena submisji jako formy sprzedaży drewna najwyższej jakości. *Sylwan R.* 159 (9), 707-713.

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ENVIRONMENTAL ASPECTS AND THEIR SIGNIFICANCE FOR BUSINESSES IN THE LUMBER INDUSTRY

Abstract: The consequences of implementing and upholding environmental protection standards have visible effects in many areas of the economy. However, they are most immediately pertinent to industry, which has the greatest opportunity to positively affect its surroundings.

This work aims to identify factors which can bring about a significant improvement in environmental standards in organisations, to point out how producers can benefit from the newly introduced environmental regulations and finally to indicate the possible direction of the future development of the lumber industry taking into account current trends towards environmentally friendly production.

Key words: Environment, certifications, wood materials, innovations.

INTRODUCTION

New challenges and the growing needs of the global market present businesses in the lumber industry with great opportunities for growth. Similarly to the countries of Western Europe, a trend towards environmentally friendly practices can increasingly be observed in Polish businesses.

Care for the environment relates to both the functioning of companies as a whole and the actions of individual employees who carry out their work duties in appropriately prepared facilities. Based on these principles, modern enterprises try to conduct their activities in such a way, so as not to have a negative effect on their immediate environment.

The general consensus is that environmentally friendly business practices are becoming increasingly important. The issue has also been taken into account in the Polish constitution, specifically in article 86: *“Each individual is responsible for the care of the natural environment and is responsible for any damage to the environment they personally cause”*

THE SIGNIFICANCE OF ENVIRONMENTAL ASPECTS FOR THE FUNCTIONING OF BUSINESS

Poland's membership in the EU brings with it the obligation to accept the body's principles and regulations. This applies to all areas, including environmental protection standards. The new rules apply to all spheres of activity, to the economy in particular, and non-compliance with regulations results in heavy fines. For that reason, business owners go to great lengths to avoid being penalised. They invest in programs which improve the firm's economic position, and also allow for better environmental results to be

Apart from investing in modern technologies which produce a lower level of pollution and waste, companies also introduce new norms that describe environmental management systems. Environmental management, as it is defined in the ISO 14000 quality norms *„consists of aspects of the wider management function, which relate to the development, implementation and realisation of policy, as well as environmental goals in the organisational unit”* [PN-EN ISO 14001:2005].

The ISO quality management benchmarks are becoming the standard in environmental management. In the western countries that are members of the EU, the implementation of these standards is recognised as a stage in the development of a company, and an environmental management certificate constitutes a standard during bidding for contracts or negotiations. A certificate is an indicator of a company's position in the market, and the execution of pro-environmental policies in an organisation is necessary because of a consumer base that in

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increasingly environmentally conscious. A consequence of holding an appropriate certificate is having easier access to capital [Sokołowicz W, Szradnicki A, 2006].

Caring for the environment also relates to how organisations function, and to their employees and the conditions in which they work. Based on these guidelines, modern businesses

attempt to realise their goals and policy and develop in a way that does not have a damaging effect on the surroundings.

Upholding environmental standards is also extremely important from the perspective of improving production efficiency. For that reason, many businesses implement systems of environmental management that are in accordance with ISO 14000 standards, which is a confirmation of good care of the company's surroundings and an interest in accepting current environmental standards and regulations.

Investments in new technologies, aside from improving environmental standards, also can affect an improvement in the quality of finished products. From the point of view of customer expectations, for whom environmentally responsible production is a key concern, the improvement of these parameters constitutes a competitive advantage and leads to an increase in trust between both parties. This is one reason for the implementation of ISO 14001 standards by production companies, norms which describe practices of environmental management. Production companies, aiming to continuously reduce their negative impact on the environment, also participate in a European system of management and audit called EMAS (Eco-Management and Audit Scheme). This is a system, which is counted among the most important instruments of realising the ecological policy of the European Union, and in which the effect of an economy on the natural environment has been analysed since the 1990s. Companies that are members of EMAS have the responsibility to make all statements and pledges regarding the environment publicly accessible, which lends them further credibility [www.emas.mos.gov.pl].

Systems of management that are in accordance with international ISO norms of the 14000 series adapt the functioning of a business to the expectations of the global economy. They encourage or even force the use of techniques and tools, which allow for the improvement of processes taking place in a business and ensure their smooth functioning in accordance with the principles of environmental protection.

THE ISO 14000 NORMS

A system of environmental management is one component of the overall management system. In essence, this is the identification of the environmental aspects of a given organisation. The ISO 14000 family of benchmarks ensures practical tools and all necessary information for entrepreneurs, who want to incorporate environmental practices into the management of their organisations. However, before the ISO 14000 norms were developed, individual EU member states made use of their own standards of related to the issue of environmental management.

The basic benchmarks of the ISO 14000 series include standards relating to environmental management systems, specifically ISO 14001 and ISO 14004. The ISO 14001: 2004 „*Systems of environmental management. Requirements and guidelines of use*” is the most important benchmark of the ISO 14000 series, because it defines the system itself. Based on this benchmark, firms implement a System of Environmental Management. This is a norm, that has been applied to legislative processes relating to the environment all over the world. It allows organisations to define goals and set out an action plan, taking into account current regulations and data pertaining to the environmental impact of business activities [www.iso.org]. Amendment of the International Standard ISO 14001:2015 was published in September 2015. It will officially come into force after a three year changeover period. After that time, certificates for the ISO 14001:2004 will no longer be valid. In accordance with ISO/FDIS 14001:2015, the systemic approach to environmental management may affect a company's contribution to balanced development [www.pkn.pl].

The second benchmark is the ISO 14004: 2004 „*Systems of environmental management. General guidelines regarding policy, systems and support techniques*”. This benchmark includes guidelines for environmental management policy, that allow for the further fine tuning of the company's environmental management system and ensure effective interplay with other management systems. To meet the needs of the lumber sector the ISO/TR 14061 standard was developed, which includes information and guidance directed to businesses in the lumber industry that use ISO 14001 and ISO 14004 benchmarks. This standard has been recalled, however and currently does not function. Apart from the two basic benchmarks from the ISO 14000 series, there are other norms in force, which include environmental guidelines that pertain both to organisations and their products. In particular, we can make mention of a group of benchmarks that relate to auditing, product life cycle analysis or labelling of finished goods. The groupings of various ISO 14 000 benchmarks have been shown in table number 1.

Table 1. The groupings of various ISO 14 000 benchmarks have been shown

Category	Number and title of standard
Environmental management systems	PN-EN ISO 14001:2005 - Environmental Management Systems – requirements and guidelines for use. PN-EN ISO 14004:2010 – Environmental Management Systems – General guidance regarding principles, systems and support techniques.
Environmental audits	PN-EN ISO 19011:2012 – Guidelines regarding the audit of management systems.
Ecolabelling	PN-EN ISO 14020:2003 – Environmental labels and statements - general principles PN-EN ISO 14021: 2002/A1:2012 – Environmental labels and statements – own observations (environmental labelling type II) PN-ISO 14024:2002 – Environmental labels and statements – Environmental labelling type I – principles and procedures PN-ISO 14025:2010 – Environmental labels and statements – Environmental statements type III – principles and procedures
Product life cycle	PN-EN ISO 14040:2009 – Environmental management – Life cycle appraisal – principles and structure. PN- EN ISO 14044:2009 – Environmental management – Life cycle appraisal – Requirements and guidelines ISO/TR 14049:2000 – Environmental management- Life cycle appraisal – Examples of applying ISO 14041 to define objectives and scope, as well as to analyse yields
Appraisal of the effects of environmental activity	PN-EN ISO 14031: 2014-01 – Environmental management – appraisal of the effects of environmental activity - guidelines
Vocabulary and definitions	PN-EN ISO 14050:2010 – Environmental Management - Terminology

Source: Own research paper based on data from the Polish Normalisation Committee.

The ISO-14000 standards have been widely used in many organisations. The task of those organisations is to declare constant improvement in the area of environmental management systems, which constitutes a guarantee of care for the development of the business and production of goods in accordance with environmental norms, an obligation to uphold current legislation and preventing negative environmental impacts in all possible aspects [www.pkn.pl].



Production companies, which implemented Environmental Management Systems generally require their subcontractors to follow suit. In effect, the number of firms that possess environmental certificates is growing, which leads to an improvement in environmental indicators.

BENEFITS TO BUSINESSES IN THE LUMBER INDUSTRY RESULTING FROM THE IMPLEMENTATION OF ISO 14000 SERIES STANDARDS

Businesses that decide to implement environmental standards are conscious of the fact that the benefits they reap in the future are only made possible by defined financial outlays.

In the area of management and finance, the benefits that can be gained by implementing ISO 14000 series standards include reduction of energy costs, reduction in raw material use or a smaller amount and lower cost of removing waste. In lumber production facilities, many important gains can result from simple procedures such as switching off fume extractors and room lighting during breaks and production stoppages, the sorting of waste at its source or recycling wood designated for burning. However, achieving greater gains requires investment. The type and scale of benefits are dependent on the technical-technological capabilities of the facility. The practices that are easiest to implement are: verification of raw materials standards, which can have an effect on the normative reduction of the normative use of a raw material or noise reduction in work areas that can be achieved by properly locating the housings of wood processing machines. However, larger financial outlays are required, for instance to install a recycling system for water used to mist veneer log, which results in a reduction of the volume of water used, as well as the installation of cauldrons for the burning of sawdust and wood chips. From the perspective of lumber production facilities that use binding and enriching agents, the introduction of water soluble paints leads to a reduction in emissions of gaseous organic compounds, and in the process of gluing using newest generation glues, it is possible to reduce emissions of unbonded formaldehyde. In impregnation facilities it is recommended to use impregnants that are environmentally friendly. Among the investments that have a direct effect on the benefits achieved in lumber businesses is the activation of mechanised technological lines, which limits the number of work stations and as a result leads to lower labor costs in the production department. The use of an energy saving lighting system leads to a reduction in costs, as does the reduction of emissions of sawdust and wood shavings, which also limits or even eliminates waste of that raw material [www.ikmj.com.pl].

Better use of employee time and effort and full use of available resources are two additional benefits that can be observed in the area of management and finance.

Apart from direct benefits, which firms receive from the environmental changes that are affected, equally important are indirect benefits. Although they are often difficult to calculate, they are still an important reason to implement an environmental management system in businesses. Among the main benefits that result from implementing norms from the ISO 14000 series, are an improvement to the company's image in the eyes of customers and potential investors due to the company being shown to be reactive to environmental issues [Lisowska-Mieszkowska E. 2007].

CONCLUSION

The implementation of standards from the ISO 14000 series in companies in the lumber industry can bring about both short and long term gains. By taking environmental aspects into account in the management strategy, companies are perceived as modern and having a genuine concern for their surroundings. Companies that rationally manage natural resources and waste show the ability to limit costs and a general direction for the company, generally are perceived in Europe and the world, as being responsible. The implementation of environmental management in a company also universally raises environmental awareness amongst employees.

The constantly growing number of businesses, which implement certificates of the ISO 14000 series confirms their usefulness in businesses and guarantees benefits to business that make use of them.

REFERENCES

1. Sokołowicz W., Szradnicki A. - ISO. *The Quality Management system and other norm-based systems*. Published by C.H.Beck, Warsaw 2006.
2. E. Lisowska-Mieszkowska – *Systems of Environmental management - development and functioning in Poland*. Protection of the environment and natural resources journal, issue 30, Gliwice, 2007
3. PN-EN ISO 14001:2005 – Environmental Management System
4. www.emas.mos.gov.pl
5. www.pkn.pl
6. www.iso.org
7. www.ikmj.com.pl

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CHANGES IN THE STRUCTURE OF FRUIT PRODUCTION AND CONSUMPTION AFTER POLAND'S ACCESSION TO THE EUROPEAN UNION

Abstract: The aim of this article was to present changes in fruit production and consumption during Poland's membership in the European Union. The analysis was based on secondary data. An extended resource base of the Polish horticulture provides ideal conditions for the development of food processing. Pomiculture and fruit processing offer domestic and foreign consumers a wide selection of high quality products. Fruit export and consumption are significant factors stimulating the development of domestic fruit production and they are increasingly important issues in economics.

Key words: fruit market, cultivation area, yield, production potential, consumption.

INTRODUCTION

The current economic situation in Poland results from the long history of stormy and frequent radical changes of the economic doctrine and practice. Let us just mention key changes in the economy that have taken place in the last one hundred years, since Poland regained independence in 1918. Some of these changes were positive, others were negative. The positive changes were, for example, the post-partition economic integration, the construction of new economic centres in Poland before World War II, the marketisation of the national economy in 1989, the process of preparations for accession to the European Union and finally, the accession to the EU. The negative changes were, for example, overexploitation during the occupation of Poland and extremely inefficient nationalisation of the Polish economy during the communist times. In the entire chain of these economic changes the most important event was Poland's accession to the European Union on 1 May 2004. The economic surroundings of Poland changed radically, causing comprehensive transformations and positive effects in the entire economy, including fruit production and consumption.

After integration with the European Union and abolition of customs duties, entry prices and other administrative limitations there is high potential for the development of production and export of fruit [Kapusta 2005]. The aim of this article is to present changes in fruit production and consumption during Poland's membership in the European Union. Secondary data for 2000-2014 were used for this purpose. The data from 2000 and 2003 symbolise the state of fruit production and consumption before accession to the European Union. The data from 2013 show the effect of membership in the EU. The data from 2004-2014 illustrate specific tendencies.

This article presents four analyses: a) the cultivation area of fruit trees and bushes and the area of blueberry plantations, b) fruit yield, c) total fruit consumption per head, d) the structure of food and vegetable consumption.

THE CULTIVATION AREA OF FRUIT TREES AND BUSHES

Fruit production is an important branch of agricultural production in Poland. In 2013 fruit plantations occupied 362,600 ha, i.e. 2.5% of farmland. It was 19,400 ha more than in 2012. Fruit trees in orchards were grown on 128,000 farms. Berries were grown on about 200,000 farms. In 2013 the share of fruit in the commodity value of fruit production was 15.2% [Statistical Yearbook of Agriculture 2014]. In comparison with 2012, in 2013 there were no considerable differences in the fruit cultivation area (Table 1) except the decrease in the cultivation area of other fruit trees (apricots, peaches, walnuts) to 7,400 ha. If we compare 2013 with the period before Poland's

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accession to the EU (2000 and 2003), we can see that the cultivation area of all fruit trees decreased, especially plum-trees and pear-trees (by 30-40%). Only the cultivation area of apple-trees increased by about 20%. There was a significant increase in the cultivation area of raspberries and other fruits, i.e. chokeberries, blue huckleberries, hazels and grapevines, whereas the cultivation area of gooseberries decreased.

The types of fruit produced depend on a country's climate, geographical location and socioeconomic conditions affecting the trends, scale and intensity of production in agricultural enterprises [Ryś-Jurek, Stefko 2015].

Table 1. The cultivation area of fruit trees and bushes and berry plantations in Poland in 2013 (thousand ha)

Specification	2000	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Volatility index 2013/2000	Volatility index 2013/2003
Fruit trees:														
Apples	165.1	159.3	175.2	169.7	162.0	175.6	172.0	173.6	170.4	183.5	194.7	193.4	1.17	1.21
Pears	18.3	14.5	14.5	12.6	12.5	13.0	13.0	13.2	8.4	11.7	10.9	10.2	0.56	0.70
Plums	31.7	25.0	25.4	20.8	21.1	22.2	21.1	21.0	17.9	20.2	19.3	18.2	0.57	0.73
Sour cherries	39.3	37.8	39.1	34.4	36.6	37.6	36.2	35.5	33.0	34.0	33.7	33.7	0.86	0.89
Cherries	12.1	11.0	10.9	9.5	9.7	10.3	9.9	10.6	12.0	11.6	11.6	10.9	0.90	0.99
Others ^a	10.3	9.0	8.4	7.1	11.1	24.4	24.4	25.3	32.7	30.6	21.5	7.4	0.72	0.82
Fruit bushes, berry and hazel plantations:														
Strawberries	62.0	43.9	52.4	55.1	55.6	52.3	54.2	53.6	37.1	50.5	46.8	55.0	0.89	1.25
Raspberries	12.6	13.3	14.2	17.8	17.0	20.6	20.0	20.2	29.6	27.1	28.4	28.9	2.29	2.17
Currants	33.5	38.9	38.9	47.1	43.0	45.8	43.3	43.1	45.2	39.9	44.7	45.9	1.37	1.18
Gooseberries	5.9	3.6	3.6	3.1	3.0	3.1	2.9	2.8	3.2	3.1	3.1	2.7	0.46	0.75
Others ^b	3.4	7.6	7.8	9.7	9.1	12.6	11.9	11.0	19.2	15.3	17.0	18.0	5.29	2.37

^a Apricots, peaches, walnuts.

^b Chokeberries, blue huckleberries, hazels, grapevines and others.

Source: The author's calculation based on data from the Central Statistical Office.

Figure 1 shows a detailed structure of fruit trees cultivation in Poland in 2000, 2003 and 2013. As can be seen, in 2013 apple trees were the most common as they made as much as 70% of all fruit trees cultivated. Sour cherry-trees were the second most common fruit trees cultivated (13%). In comparison with 2000 and 2003, the cultivation area of apple-trees increased, whereas the cultivation area of plum-trees and pear-trees decreased. Figure 2 shows the structure of berry fruits grown in Poland in 2000, 2003 and 2013. As can be seen, from the moment of Poland's accession to the EU to 2013 the share of strawberries and raspberries increased, whereas the share of gooseberries decreased. The share of strawberries and currants each amounted to more than 30% of the total area of all berry fruits grown. The share of raspberries amounted to about 20%. The structure of fruit grown depends on the cost-effectiveness of production, trends in consumers' consumption, the demand of fruit processing enterprises and the support of state institutions.

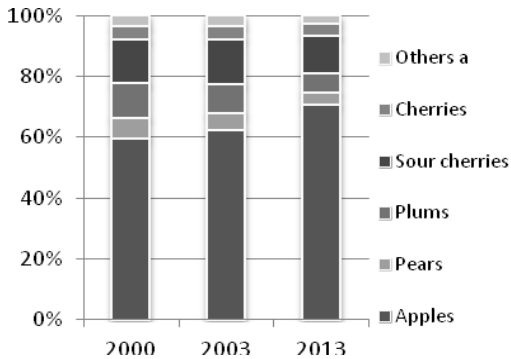


Fig. 1. The structure of fruit trees grown in Poland in 2000, 2003 and 2013.

¹ Apricots, peaches, walnuts.

Source: The author's calculation based on data from the Institute of Agricultural and Food Economics and the Central Statistical Office.

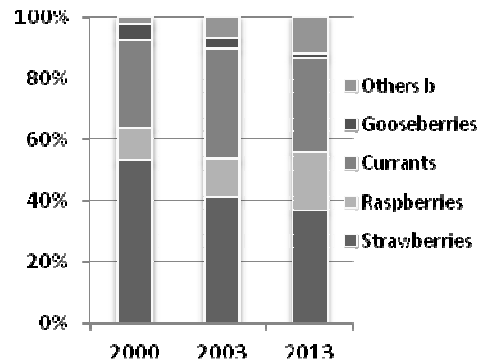


Fig. 2. The structure of berry fruits grown in Poland in 2000, 2003 and 2013.

^b Chokeberries, blue huckleberries, hazels, grapevines and others.

Source: The author's calculation based on data from the Institute of Agricultural and Food Economics and the Central Statistical Office.

PRODUCTION – FRUIT YIELD

Table 2 shows the yield of fruit. Between 2004 and 2013 the yield of apples increased dynamically. There were fluctuations in the yield of plums, cherries and pears. Likewise, there were fluctuations in the yield of fruit harvested from bushes and berry plantations. In 2013 the yield of raspberries (121,000 tonnes) was much higher than in 2004 (56,800 tonnes). On average, the yield of berry fruits amounted to 16% of the total fruit yield. There was a rising tendency in berry fruit production. In 2013 the production volume amounted to 606,800 tonnes, i.e. 21% more than in 2004. This phenomenon can be explained with the growing demand of processing plants for fruit. Every year these enterprises processed from 1.5 million to more than 2 million tonnes of fruit. The demand of foreign markets for fruit also increased. Between 2004 and 2013 on average Poland exported 26% of fresh fruit produced. Between 2004 and 2013 the yield of Polish fruit amounted to 5-11% of the total fruit production in the EU. In 2013 the yield reached an unparalleled amount of 4.13 million tonnes, which was 29% greater than the average yields between 2004 and 2012 [Statistical Yearbook of Agriculture 2014]. The increase in fruit production could be explained with sufficient land resources and with producers' association into groups with high specialist knowledge. It is noteworthy that fruit producers quickly recovered from losses caused by weather changes, e.g. frost in orchards, and they modernised many important branches of fruit production [Kapusta 2005]. Since Poland's accession to the EU the yield of apples increased considerably (Table 2). In comparison with 2003, in 2013 the yield of fruit from trees increased by 22%, whereas the yield of berry fruits increased by 40% (especially raspberries and strawberries).

The analysis of the structure of the yield of fruit from trees shown in Figure 3 reveals that in 2013 apples had the greatest share, i.e. almost 90%. The share of apples had been increasing since 2000 and in consequence, the share of other fruits decreased. Figure 4 shows the structure of the yield of berry fruits. As can be seen, in 2013 the share of strawberries and currants in the yield structure became equal and amounted to about 30%.

Table 2. Fruit yield in Poland (thousand tonnes)

Specification	2000	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Volatility index 2013/2000	Volatility index 2013/2003
Total fruit	2246.5	3308.8	3521.5	2921.6	3210.9	1694	3840.9	3646.2	2743.5	3414.6	3843.2	4128.4	1.84	1.25
Fruit from trees														
Apples	1450.4	2427.8	2521.5	2075	2304.9	1040	2830.9	2626.3	1877.9	2493.1	2877.3	3085.1	2.13	1.27
Pears	81.6	77.2	87.3	59.3	59.3	30.7	72.8	83	46.5	62.8	64.7	75.7	0.93	0.98
Plums	106.9	109.6	133.2	91.4	93.6	53.5	113.6	120.7	83.8	91.8	102.5	102.4	0.96	0.93
Sour cherries	139.6	191.1	201.7	139.9	194.9	107.7	201.7	189.2	147.2	175	175.4	188.2	1.35	0.98
Cherries	38.6	44.1	48.4	37.5	38.4	20.2	40.8	50.6	40.1	38	41.1	47.6	1.23	1.08
Others ^a	20	25.7	27.4	18.6	14.4	11.1	27.8	30.1	21.9	23.2	24.8	22.6	1.13	0.88
Total	1837.1	2875.5	3019.5	2421.7	2705.5	1263.2	3287.6	3099.9	2217.4	2883.9	3285.8	3521.6	1.92	1.22
Fruit from bushes, berry and hazel plantations														
Strawberries	171.3	131.3	185.6	184.6	193.7	174.6	200.7	198.9	153.4	166.2	150.2	192.6	1.12	1.47
Raspberries	39.7	42.9	56.8	65.5	52.5	56.4	81.6	81.8	92.9	118	127.1	121	3.05	2.82
Currants	146.8	192.5	194.5	186.8	194.5	138.6	196.6	196.5	196.7	169.6	194.5	198.5	1.35	1.03
Gooseberries	28.6	20.3	19.9	16.7	16.2	13.7	16.2	15.8	14.2	14.6	16.3	15	0.52	0.74
Others ^b	23	46.3	45.2	46.3	48.5	47.5	58.2	53.3	68.9	62.3	69.3	79.7	3.47	1.72
Total	409.4	433.3	502	499.9	505.4	430.8	553.3	546.3	526.1	530.7	557.4	606.8	1.48	1.40

¹ Apricots, peaches, walnuts.

^b Chokeberries, blue huckleberries, hazels, grapevines and others.

Source: The author's calculation based on data from the Central Statistical Office.

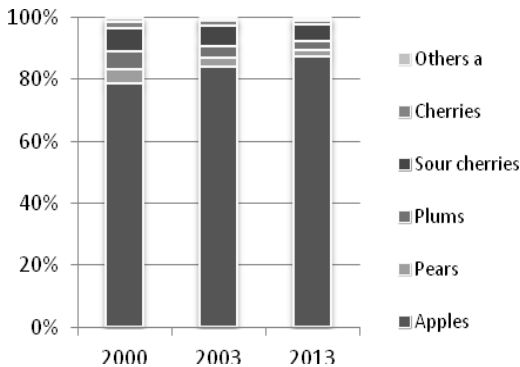


Fig. 3. The structure of the yield of fruit from trees in Poland in 2000, 2003 and 2013.

¹ Apricots, peaches, walnuts.

Source: The author's calculation based on data from the Institute of Agricultural and Food Economics and the Central Statistical Office.

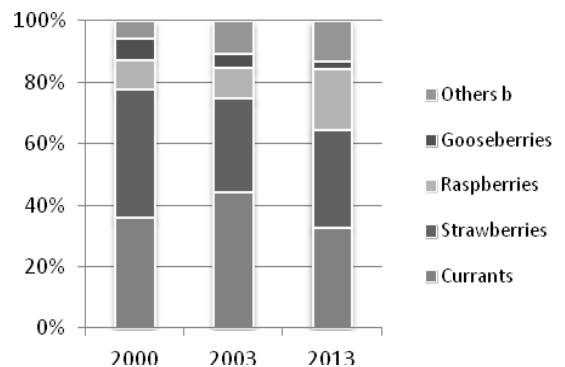


Fig. 4. The structure of the yield of berry fruits in Poland in 2000, 2003 and 2013.

^b Chokeberries, blue huckleberries, hazels, grapevines and others.

Source: The author's calculation based on data from the Institute of Agricultural and Food Economics and the Central Statistical Office.

In comparison with 2000 and 2003 the share of raspberries in the structure of the yield of berry fruits increased considerably, whereas the share of gooseberries decreased. It is noteworthy that the Polish fruit market is structurally dependent on exports and the growing competition of the markets of countries with relatively low costs of production and export prices [Kapusta 2003]. Fruit from Polish producers have a greater chance than other agricultural products to fill demand niches on foreign markets [Kapusta 2005]. Further development of fruit production may be interrupted by insufficient possibilities to sell fruit, especially those for immediate consumption, and by fluctuations in the cost-effectiveness of production. The development of fresh fruit production and export requires appropriate preparation of the sales offer in terms of quality, quantity and continuity of deliveries. Fruit trade on demanding markets is possible only with new technologies, which are used to improve the productivity of factors of production. Another important element is the promotion of fruit produced in Poland, on the domestic market, and on foreign markets [Nosecka 2014].

Poland's accession to the European Union in 2004 facilitated fruit producers' trade expansion on the common market. The use of the EU funds to develop production and storage facilities helped to increase the competitiveness of Polish fruit and processed fruit products. We can say that in consequence of Poland's accession to the European Union in 2004 the trade creation effect occurred in agri-food trade. It consisted in replacing more expensive domestic production in the EU-15 countries with cheaper imports from new member states. In consequence, new trade streams were formed. The demand on the EU markets enabled export of some of the domestic production to former external markets, but the producers of exported goods had an opportunity to sell them at higher prices than on the domestic market [Poczta 2008].

Polish pomiculture is distinguished by more rapid biological, technical and technological progress in production than other branches of agriculture. For example, new cultivars of trees and bushes have been created and they are being promoted in Western Europe. New cultivation technologies are being applied. The processes of concentration and specialisation of fruit production are positive phenomena taking place on the market. In Poland there are 1,173 preliminarily recognised groups of fruit and vegetable producers with 2,600 members and 139 recognised organisations of fruit and vegetable producers with 4,600 members. Fruit producers initiated organic farming, which is becoming increasingly popular in Poland. Therefore, organic food production is expected to have high potential [Agriculture and Food Economics in Poland 2014]. The production and sales potential of Polish producers not only enables them to establish lasting business relationships but also allows them to adjust to contractors' diversified needs so as to meet requirements of the market.

FRUIT CONSUMPTION

According to studies on household budgets conducted by the Central Statistical Office, between 2000 and 2014 fruit consumption in households ranged from 40 to 50 kg per head, whereas juice consumption ranged from 10 to 13 l per head. Figure 5 shows the annual fruit and juice consumption per head between 2000 and 2014. As can be seen, in 2014 fruit consumption in Poland amounted to 43.08 kg per head and it was 9.1% greater than the lowest consumption in 2011 (39.48 kg per head). In comparison with 2000 fruit consumption dropped in favour of juice consumption, but there was a rising tendency in fruit consumption in the last two years. The expected economic upturn and the resulting growth in consumers' wealth may cause an increasing demand for processed fruit products and juices in the nearest years.

Table 3 shows the annual fruit consumption (kg) per head between 2003 and 2013. As can be seen, in 2013 the consumption of citrus fruits and bananas was 25% greater than in 2003 and it amounted to 13.32 kg per head.

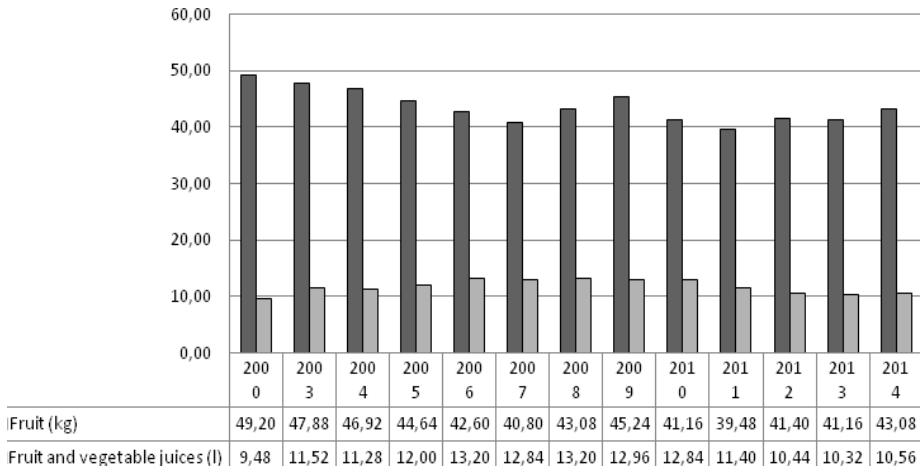


Fig. 5. The mean annual fruit and juice consumption per head between 2000 and 2014.

Source: The author’s calculation based on data from the Central Statistical Office.

The consumption of berry fruits increased by 13% and amounted to 5.16 kg per head. The greatest increase, i.e. 50%, was observed in the consumption of nuts and processed fruit products, whereas the greatest decrease, i.e. 43%, was noted in the consumption of apples – from 23.76 kg per head to 13.56 kg per head. In 2013 the total fruit consumption was 14% lower than in 2003.

Table 3. The annual fruit consumption (kg) per head between 2003 and 2013.

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Volatility index 2013/2003	Volatility index 2013/2005
Total fruit	47.88	46.92	44.64	42.6	40.8	43.08	45.24	41.16	39.48	41.4	41.16	0.86	0.92
Citrus fruits and bananas	10.68	9.24	8.64	10.2	11.64	12	11.4	12.48	12.72	12.24	13.32	1.25	1.54
Apples	23.76	20.88	20.04	17.88	15.72	15	16.2	15	13.2	15.12	13.56	0.57	0.68
Berry fruits	4.56	6.12	6.6	5.76	5.04	6	6.36	5.04	4.68	4.92	5.16	1.13	0.78
Processed fruit products and nuts	1.2	1.08	1.32	1.56	1.68	1.8	1.8	1.8	1.8	1.8	1.8	1.50	1.36
Other fruits	7.68	9.6	8.04	7.2	6.72	8.28	9.48	6.84	7.08	7.32	7.32	0.95	0.91

Source: The author’s calculation based on data from the Central Statistical Office.

Figure 6 shows the structure of the consumption of fruit and processed fruit products. As can be seen, between 2003 and 2013 apples were predominant, but their importance decreased as the years passed by. When the consumption of apples dropped, the consumption of citrus fruits and bananas grew. In 2013 the share of apples in the structure of consumption amounted to 33%, whereas the share of citrus fruits and bananas amounted to 32%. By comparison, in 2003 the share of apples amounted to 50%, whereas the share of citrus fruits and bananas amounted to 22%. This significant change in fruit consumption brought Poland closer to the consumption model in Western Europe. It is undoubtedly the result of Poland's accession to the European Union.

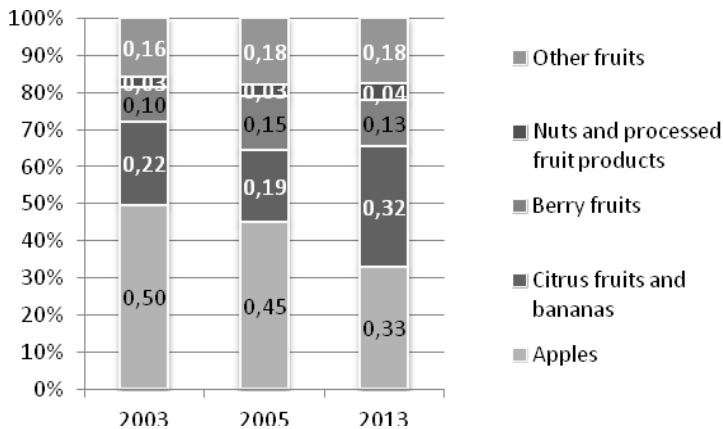


Fig. 6. The structure of the consumption of fruit and processed fruit products in households between 2003 and 2013.

Source: The author's calculation based on data from the Central Statistical Office.

CONCLUSIONS

The following conclusions can be drawn from the analysis above:

1. Poland's accession to the European Union stimulated changes in the fruit branch.
 - a) Fruit consumption dropped (from 49.20 kg per head in 2000 to 41.16 kg per head in 2013) in favour of the consumption of fruit juices and processed fruit products.
 - b) The amount and structure of the consumption of individual fruits changed. The consumption of apples decreased considerably, whereas the consumption of citrus fruits and bananas increased.
 - c) In 2013 the yield of fruit from trees was 22% higher than in 2003, whereas the yield of berry fruits increased by 40%.
 - d) The yield of apples increased considerably. The share of apples in the total structure of the yield of fruit from trees was the greatest, i.e. about 90%. The share of raspberries in the structure of the yield of berry fruits increased.
 - e) In the structure of fruit trees grown there was a noticeable increase in the number of apple trees (as much as 70% of all fruit trees grown) and a decrease in the number of pear-trees and plum-trees. In the structure of berry fruits the share of strawberries and raspberries increased, whereas the share of gooseberries decreased.

- f) There was a noticeable drop in the cultivation area of all fruit trees (except the cultivation area of apple-trees, which grew by about 20%). The cultivation area of raspberries increased, whereas the cultivation area of gooseberries decreased.
2. The development of fruit production is positively influenced by the relative prosperity of the fruit processing industry, which processes from 1.5 million to over 2 million tonnes of fruit per year. The industry is prosperous chiefly due to the production of juices and processed fruit products, as their consumption is increasing.

REFERENCES

1. Budżety gospodarstw domowych 2014, GUS, Warszawa 2014.
2. Kapusta F. (2003): Potrzebna strategia rozwoju polskiego rolnictwa. [W:] Działalność rolnicza oraz jej uwarunkowania w aspekcie integracji z Unią Europejską. Wyd. Akademii Podlaskiej, Siedlce.
3. Kapusta F. (2005): Podstawy strategii zintegrowanego rozwoju wsi i rolnictwa w Polsce (wybrane zagadnienia). [W:] Rolnictwo a rozwój obszarów wiejskich. IRWiR PAN, Warszawa.
4. Nosecka B. (2014): Zewnętrzne uwarunkowania wzrostu eksportu owoców, warzyw i ich przetworów z Polski, RN Ekonomii Rolnictwa i Obszarów Wiejskich, t. 101, z. 3 Warszawa.
5. Poczta W. (2008): Skala korzyści uzyskiwanych przez rolnictwo w wyniku wejścia Polski do UE (analiza uwzględniająca zróżnicowanie regionalne, główne kierunki produkcji rolnej i główne typy gospodarstw rolnych w pierwszym okresie akcesji – lata 2004-2006). [W:] Wpływ integracji z Unią Europejską na polską gospodarkę żywnościową. Raport nr 90. IERiGŻ-PIB Warszawa
6. Rocznik Statystyczny Rolnictwa 2013, GUS, Warszawa 2014.
7. Rocznik Statystyczny Rolnictwa i Obszarów Wiejskich 2006, GUS, Warszawa 2006.
8. Rolnictwo i gospodarka żywnościowa w Polsce, IERiGŻ-PIB, MRiRW, Warszawa 2014.
9. Rynek Warzyw i Owoców nr 42, IERiGŻ-PIB, ARR, MRiRW, Warszawa 2013a.
10. Rynek Warzyw i Owoców nr 43, IERiGŻ-PIB, ARR, MRiRW, Warszawa 2013b.
11. Ryś-Jurek R., Stefko O. (2015): Sytuacja ekonomiczno – finansowa gospodarstw ogrodniczych w Polsce na tle gospodarstw z Holandii i Włoch w 2012 r. [W:] Zagadnienia Doradztwa Rolniczego nr 1/15, CDR, SERIA, Poznań.

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ANGUS DEATON – THE NOBEL PRIZE LAUREATE IN ECONOMIC SCIENCES IN 2015

Abstract: In 2015 Angus Stewart Deaton was awarded the Nobel Memorial Prize in Economic Sciences. The article discusses the Nobel Prize winner's scientific activity and accomplishments for which he was awarded. The Nobel Committee justified their decision to award him the prize by the significance of Deaton's research work for economic development, especially in consumption, welfare and poverty economics. Deaton started his scientific career by studying economics at university. At present he is a professor of economics.

Key words: consumption, welfare, poverty, consumer behaviour, winner of the Nobel Prize in Economic Sciences, Nobel Prize in economics 2015, Angus Deaton.

INTRODUCTION

In 2015 the Nobel Memorial Prize in Economic Sciences was awarded to Angus Deaton. The Nobel Committee acknowledged his research on consumption economics as well as the causes of global welfare and poverty. The scale of consumption of goods and services is a basic determinant of welfare. The analysis and understanding models of consumption are important for the development of a policy promoting welfare and reducing poverty. In view of the increasing gap between the poorest and the richest Deaton's works gain importance and the issues researched by the Nobel Prize winner deserve broader analysis.



Fig. 1. Angus Deaton presents the Nobel medal

Source: Angus Deaton - Photo Gallery. Nobelprize.org. Nobel Media AB 2015. Web. 19 Jan 2016. Photo by Alexander Mahmoud. In: http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2015/deaton-photo.html

ANGUS DEATON'S SCIENTIFIC CAREER

Angus Stewart Deaton was born on 19 October 1945 in Edinburgh, UK. He is a British scientist, organiser of long-term research on the issues of consumption, poverty and welfare. He

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received a scholarship from Fettes College in Edinburgh, which helped him graduate from this prestigious Scottish school. Then he studied economics at the University of Cambridge, where he earned his degrees: B.A. (1967), M.A. (1971) Ph.D. (1974). He received a professorship at the University of Bristol, where he taught econometrics from 1976 to 1983. From 1979 to 1980 he was a guest lecturer at Princeton University in the United States. Since 1983 he has been a professor of economics and international relations at that university [Deaton A. Curriculum Vitae In: <http://scholar.princeton.edu>].

In 2015 Angus Deaton was honoured with the Nobel Prize in Economic Sciences for analyses concerning the issues of consumption, welfare and poverty. He became a member of the US National Academy of Sciences. In 2014 became a member of the American Philosophical Society. Angus Deaton has been awarded honorary doctorate degrees by many universities, i.e. an honorary doctorate in economic sciences from the University of Cyprus (2012), an honorary doctorate in social sciences from the University of Edinburgh (2011), an honorary doctorate degree from the University of Rome Tor Vergata and University College London (2007) [Deaton A. Curriculum Vitae In: <http://scholar.princeton.edu>].

Angus Deaton has received 12 research grants – see Table 1. His latest grant (2011-2016) concerns the issue of subjective well-being: aging, religiosity, and adaptation. His other research projects which received financial support were: ‘Social Determinants of Adult, Ageing, and Elderly Health’ (2004-2009); ‘Poverty, Inequality and Health in Economic Development’ (2001-2006); ‘Economic Status, Economic Inequality and Health Inequality’ (1999-2009); ‘Inequality and Poverty in Broader Perspectives’ (1995-2003); ‘Accumulation, Inequality, and Commodity Prices’ (1995-1998); ‘Saving, Inequality and Ageing in Asia’ (1994-1999); ‘Trying to Understand Commodity Prices’ (1993-1995); ‘Microeconomic Policy and Development’ (1991-1992); ‘Pricing Policy in Developing Countries’ (1988-1991); ‘Economics and Econometrics of Household Behaviour’ (1981-1984). The analysis of Deaton’s grants shows that the researcher is interested in solving research problems concerning social access to health care, poverty, economic status, prices of commodities, savings and household (consumer) behaviour.

Table 1. A. Deaton’s grants – most recent first

Grants, most recent first

2011–2016, National Institute of Aging, through NBER, “Dimensions of subjective well-being: aging, religiosity, and adaptation” (Also part of a successful P01 grant from NBER.)

2004–2009, National Institute of Aging, through NBER, “Social determinants of adult, aging, and elderly health.”

2001-2006, National Institute of Aging and Fogarty International Center, NIH, and Global Development Network: Poverty, inequality and health in economic development.

1999-2009, National Institute for Aging, through NBER: Economic status, economic inequality and health inequality.

1995-2003, John D. & Catherine T. MacArthur Foundation, Inequality and poverty in broader perspectives.

1995-98, National Science Foundation, Accumulation, inequality, and commodity prices.

1994-99, National Institute for Aging, Saving, inequality and aging in Asia.

1993-95, National Science Foundation, Trying to understand commodity prices.

1991-92, Bradley Foundation, Microeconomic policy and development.

1989-92, Pew Foundation, Pricing policy in developing countries

1988-91, Jointly McDonnell and Bradley Foundations, Research on pricing and innovation in developing countries.

1981-84, Social Science Research Council, U.K., Economics and econometrics of household behaviour.

Source: Deaton A. Curriculum Vitae In: <http://scholar.princeton.edu>



ANGUS DEATON'S ACCOMPLISHMENTS

Angus Deaton is a scientist who has contributed to the development of issues concerning consumption. It is noteworthy that he has a broad approach to the problem of consumption. The researcher links consumption with development economics, financial situation of society, econometrics and rationality of consumers' decisions.

In the doctoral dissertation 'The Analysis of Consumer Demand in the United Kingdom 1900-1970' Deaton researched the dependence between prices of commodities (consumer products), consumers' behaviour and demand. He applied an innovative model of consumer demand. In 1980 Deaton and John Muellbauer extended the model by introducing more realistic assumptions than in other models used at the time. The model was called the Almost Ideal Demand System (AIDS). It was challenging to create a system which would be universal enough to ensure a credible image of demand models in society and relatively simple for statistical estimation and application. First estimates based on the model did not give definite answers to questions concerning consumption, but the flexibility of the system, especially the possibility to expand and modify it gave an enormous impulse to research on consumers' behaviour. Thanks to this development it soon became a standard tool for empirical research on consumer demand and the effects of economic policy. It also became a tool for constructing price indices and comparing living standards in different countries and time periods. Deaton's model enables observation how changes in taxation affect changes in the consumption of different products and which social groups benefit from them or experience loss. Deaton's model proved to be useful for making decisions concerning the economic policy. For example, if the government wants to increase VAT on food or reduce income tax for a particular group, it is important to know how these plans will affect the consumption of individual products and which social groups will benefit or experience loss because of these decisions [The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel: Consumption, Poverty and Welfare, 2015; Deaton, A. and J. Muellbauer (1980a)].

In the 1990s Deaton concentrated on researching the dependence between household income and savings. In recent decades he analysed consumer spending in developing countries and assumed that it was a better measure of welfare or poverty than income data. Deaton also researched consumers' savings. He collaborated with Campbell on an empirical analysis and found that consumers' behaviour did not change much even in the face of income shock. In other words, the scale of consumption does not change proportionally to changes in income. According to this observation, it is not obvious that when consumers become poorer, they will suddenly start saving and when they become richer, they will be wasteful. This phenomenon was called the Deaton Paradox. The researcher formulated this contradiction while observing data concerning changes in income and consumption and analysing households' behaviour. Deaton also recommended using studies on households in developing countries, especially data concerning consumption, to measure the living standard and scale of poverty. He showed that the data may shed light on important developmental issues. He explained why even a very violent change in income did not overtly and automatically cause changes in the consumption structure. He claimed that modern development economics should be based on careful microeconomic analysis [Consumption, Great and Small. In: <http://www.nobelprize.org>; Deaton, A. (1992)].

In recent decades Deaton researched health economics, development economics and welfare economics. He conducted comprehensive studies on consumption and poverty in developing countries, using his own approach to the systems of demand and individual consumption over time. He stressed the importance of building extensive datasets of household consumption of various types of consumer products, because data concerning consumption in developing countries are often more reliable and useful than income data [Consumption, Great and Small. In: <http://www.nobelprize.org>; Deaton, A. (1997)].

Consumption contributes to well-being (subjective assessment of consumption) but it is not its only determinant. In some more recent studies Deaton considered other conditions, such as human health, which is also an important element of well-being. Thus, in order to measure and understand well-being it is necessary to grasp the relation between health and income. Deaton made a significant scientific contribution in this respect. He stressed the importance of subjective assessment of welfare, because poverty and wealth do not only refer to the amount of money in one's wallet or bank account, but they are also states of mind and well-being [Deaton, 2003a]. Angus Deaton has remained faithful to this issue up to now. However, as the time passed by he tended to show more interest in researching differences between poverty and richness in the places where they were the biggest.

Deaton made significant improvements in the theories and measurements of three research areas, i.e. demand system, fluctuations in consumption over time and measurements of welfare and poverty in developing countries. In all the three of the research areas he has authored textbooks or important monographs, e.g. Deaton & Muellbauer (1980b), Deaton (1992) and Deaton (1997) (for more see: Appendix. A list of Angus Deaton's publications).

PUBLICATIONS AND PUBLICATIONS SELECTED BY THE NOBEL COMMITTEE

There are more than 200 items on the list of Deaton's publications covering the period from 1971 to 2015. The publications concerned the application of econometric methods to describe and solve various methodological problems. Deaton's publications concerned elasticity, demand, consumer behaviour, life cycle model, price elasticity and cross elasticity. Price analysis was an important aspect. The analysis of key words in Deaton's publications indicates that his studies are society-oriented, where equality, poverty and welfare in poor, developing and rich countries are the areas of special concern. His studies concerned Asia, especially Taiwan, Thailand, India, Indonesia, and Africa, especially Ivory Coast. As far as wealthy countries are concerned, Deaton's studies were concentrated on the US and UK. In each case the researcher studied inequalities resulting from multiple causes, such as poverty, health and ageing. The Nobel Committee carefully selected 33 best publications to justify their decision to award Deaton the Prize. These publications concerned consumption, poverty, prosperity, prices in the UK, India, USA and Ceylon. Deaton published very innovative papers for example: *Understanding Consumption* and *Life-Cycle Models of Consumption*.

THE MAIN THESES OF JUSTIFICATION TO AWARD THE NOBEL PRIZE

The Nobel Committee justified their decision to award the Nobel Prize in Economic Sciences to Angus Deaton. The experts explained that consumption was an important determinant of the financial situation of society, whereas in countries with low income it was a determinant of poverty. The justification of the decision to award the Prize included information that the researcher concentrated on three key issues, i.e.:

- a system of estimating consumer demand for various goods;
- determining the proportion of income society uses for expenditures and savings;
- determining the best method of measuring and analysing welfare and poverty.

The Nobel Committee stressed the fact that the laureate's research was of high practical importance and his theoretical contribution affected political decisions taken in developed and developing countries. Deaton's works comprise a broad spectrum of research, ranging from the implication of a theory to detailed measurement. He has researched consumption over time, putting special emphasis on the application of individual data (at a household level) and careful approach to the aggregation problem. The Committee also stressed the fact that when developing a policy promoting welfare and reducing poverty above all it is necessary to understand individual choices concerning consumption. The consumption of goods and services is a fundamental part of people's

welfare. The laureate extended the knowledge about different aspects of consumption. As results from the justification, Deaton researched dependences between general trends and individual consumers' behaviours so that his analyses would contribute to better understanding of the problem of poverty around the world and influence preparation of a development policy. The Committee stressed the relations between individual decisions concerning consumption and their consequences for the entire economy. The Committee appreciated the researcher's innovative approach to microeconomics, macroeconomics and development economics [Consumption, Great and Small. In: <http://www.nobelprize.org>].

At a press conference, as the Nobel Prize laureate Deaton said that he was interested in the situation of poor people around the world, their behaviour and the things which ensured them good life. [<http://www.theguardian.com/business/2015/oct/12/angus-deaton-wins-nobel-prize-in-economics>]. Figure 1 shows the Nobel medal, whereas Figure 2 shows the diploma from the Nobel Committee.

The Committee justified their decision to award the Nobel Prize in Economic Sciences by writing that the laureate's research comprised a very broad spectrum and discussed a wide range of different aspects of consumption. It also showed impressive depth in approaches to the basic theory, statistical methods, testing theory and profound knowledge of the quality of existing data and selection of new types of data. The common denominator of his research is the pursuit of bridging the gap between theory and data. Angus Deaton's remarks have left noticeable and permanent impressions in the practice of economic policy and modern economic studies [Angus Deaton: Consumption, Poverty and Welfare :<http://www.nobelprize.org>].



Fig. 2. Angus Deaton's Nobel Prize diploma

Source: "Angus Deaton - Diploma". Nobelprize.org. Nobel Media AB 2015. Web. 19 Jan 2016.

In: <http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2015/deaton-diploma.html> Artist: Hasse Karlsson, Calligrapher: Annika Rücker, Book binder: Ingemar Dackéus, Photo reproduction: Lovisa Engblom

SUMMARY – DEATON'S APPROACH TO CONTEMPORARY CONSUMPTION TENDENCIES

The consumption of goods and services is a basic determinant of welfare. The distribution of consumption among people has impact on a wide range of important issues in economic, political and social aspects, including social stratification. In the last century consumption has been the focus of economic research because it is important for economic development.

Angus Deaton is a scientist researching the issues of consumption, poverty and welfare. His ambition is to solve research problems concerning society. In his work he concentrates on three key issues, i.e.: how consumers divide their expenditures for various goods, which part of people's income is spent and which is saved and what the best method of measuring and analysing welfare and poverty is.

Angus Deaton is the co-author of the *Almost Ideal Demand System*. He thinks that consumption is a better measure of welfare than income. He explained why even a very rapid change in income did not overtly and automatically translate into a change in the consumption structure. He pioneered in using economic data concerning consumption in households. Deaton's work is significant for creating a social policy as it helps to determine, e.g. which social groups will be most affected by a higher VAT rate on food.

Angus Deaton said "We should not be concerned with others' good fortune if it brings no harm to us. The mistake is to apply the principle to only one dimension of well-being – money – and ignore other dimensions, such as the ability to participate in a democratic society, to be well educated, to be healthy and not to be the victim of others' search for enrichment" [<http://www.theguardian.com/business/2015/oct/12/angus-deaton-wins-nobel-prize-in-economics>]. The richness of part of society is not harmful to entire society and a subjective assessment of welfare depends not only on money but also other factors, such as health, education and the ability to participate in social life.

REFERENCES

1. Angus Deaton wins Nobel Prize in economics.
<http://www.theguardian.com/business/2015/oct/12/angus-deaton-wins-nobel-prize-in-economics> (accessed 19 December 2015).
2. Deaton A. CURRICULUM VITAE
http://scholar.princeton.edu/sites/default/files/deaton/files/deaton_cv_oct2015.pdf (accessed 30 November 2015).
3. Deaton, A. (1992): *Understanding Consumption*, Oxford University Press, Oxford, UK.
4. Deaton, A. (1997): *The Analysis of Household Surveys: A Microeconomic Approach to Development Policy*, John Hopkins University Press, Baltimore, MD, USA.
5. Deaton, A. (2003a): Health, Inequality, and Economic Development, *Journal of Economic Literature* 41(1), 113-158.
6. Deaton, A. and J. Muellbauer (1980a), "An Almost Ideal Demand System", *American Economic Review* 70(3), 312-326.
7. The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel: Scientific Background on the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2015. Angus Deaton: Consumption, Poverty and Welfare. <http://www.nobelprize.org> (accessed 30 November 2015).
8. The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel: Scientific Background on the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2015. Consumption, Great and Small. <http://www.nobelprize.org> (accessed 12 December 2015).

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ASSESSMENT OF PRACTICAL USEFULNESS OF EQUIPMENT IN MODERN AGRICULTURAL TRACTORS

Abstract: The use of modern tractors and machinery on farms is an indicator of technical change in agriculture, while the application of state-of-the-art technologies determines the level of competitiveness of Polish agriculture. The aim of this study was to assess practical usefulness of equipment for modern agricultural tractors. Analyses were conducted based on 80 agricultural tractors working on 80 farms in the Wielkopolska province, differing in size and specific character of agricultural production.

Key words: agricultural machine, quality of machinery, farm equipment,

INTRODUCTION

Agricultural tractors are basic sources of power on farms. They are used both to perform field operations as aggregates with machines lacking their own propulsion through a three-point hitch and power take-off (PTO) and to perform transport operations. At present we may observe dynamic progress in the design of agricultural tractors, aiming at the maintenance of high technical and performance parameters, improvement of working conditions as well as reduction of operating costs. Presently used tractors are equipped with advanced electronic systems assisting both in the work and routine operation of the machines. The use of on-board computers makes it possible to program work algorithms of machine aggregates by setting the indicated work parameters. The application of GPS technology in agricultural tractors has promoted considerable advances in precise tillage (Durczak 2011; Tylman 2013).

Agricultural tractors are specialist machines, which facilitate the performance of a broad range of field operations, travel over highly diverse surfaces and terrain, drive machines and equipment, as well as perform transport operations (Błaszkiwicz 2012; Lisowski 2008, Rybacki 2012). One of the most important mechanisms in an agricultural tractor is its gearbox, which facilitates movement of vehicles with variable speed during constant rotational speed of the engine, reverse travel and disconnection of drive. The type of the gearbox is the primary criterion when selecting a tractor (Hołownia 2009, Skrobacki and Ekielski 2012, Wiliams 2007).

MATERIAL AND METHODS

As it was shown in the introduction, modern agricultural tractors may differ in their equipment and innovativeness. Producers compete in tractor design, introducing state-of-the-art, unique solutions; for this reason the decision of tractor purchase should be well-thought-out and meet individual needs and requirements of a given farm.

The aim of this study was to conduct a comprehensive analysis of data collected from a survey among farmers using new-generation tractors, concerning practical usefulness of their equipment.

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Analyses were conducted on 80 farms in the Wielkopolskie province. For the purpose of this study it was decided to select respondents using modern agricultural tractors aged max. 15 years.

SURVEY AND ANALYSIS OF RESULTS

Questionnaires returned from 80 farms showed that they had 80 agricultural tractors of 14 brands (Fig. 1), among which the most numerous group comprised John Deere, Fendt and New Holland.

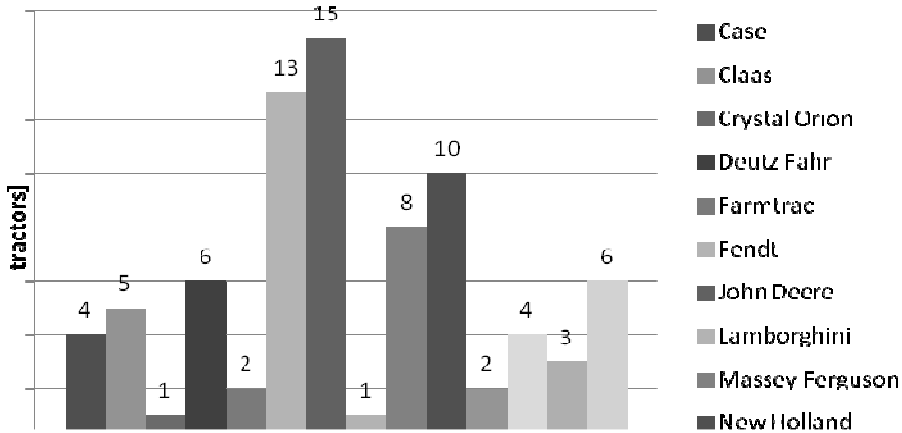


Fig. 1. Numbers of tractors of analysed brands

Source: the author's study

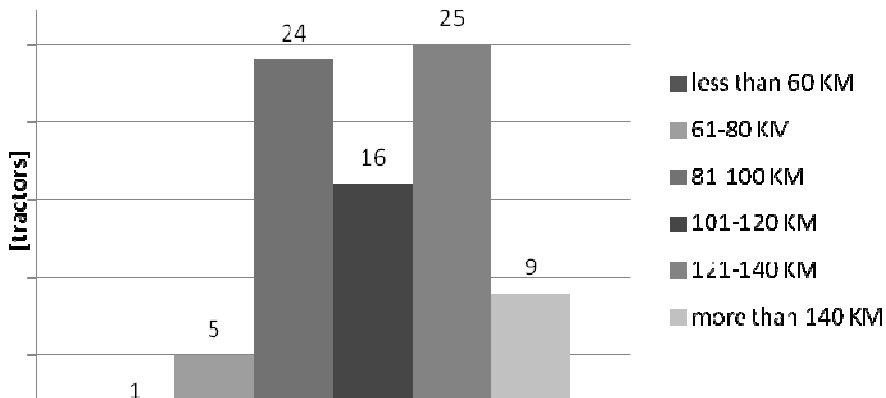


Fig. 2. Numbers of tractors in individual series of types of horsepower

Source: the author's study

Horsepowers of tractors were classified in six series of types. As it is shown in Fig. 2, the most numerous series of types were ranges of 81-100 KM (24 tractors) and 121-140 KM (25 tractors).

A vast majority of tractors, i.e. a total of 53, presented in the questionnaires is less than 5 years old (Fig. 3). The most numerous group comprises tractors produced in 2011 (20), followed by those manufactured in 2010 (19), while 14 tractors were made in 2012. The questionnaires did not mention any tractors produced in 2001, 2003, 2013, 2014 or 2015.

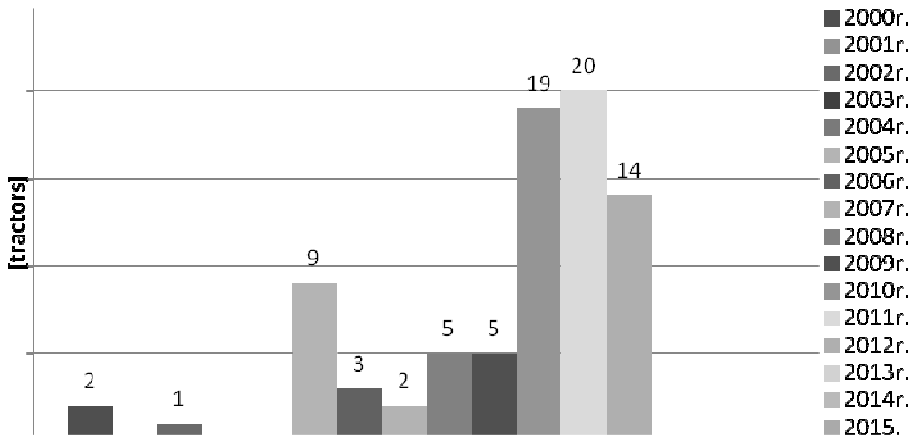


Fig. 3. Numbers of tractors depending on the year of manufacture

Source: the author's study

Figure 4 presents data concerning the intended use of analysed tractors. Most of them are used mainly in operations connected with tillage and transport, a considerable group is used in operations in permanent grassland, some work with front loaders and are used in tending operations.

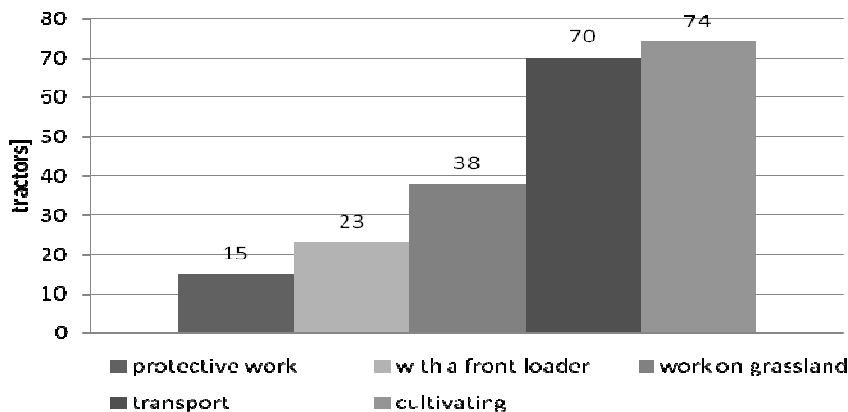


Fig. 4. Types of use of analysed tractors

Source: the author's study

Respondents in their questionnaires also indicated criteria for the selection of a given tractor brand. It turns out that there are several factors affecting this decision, of which the most important include: the opinion on the servicing, sentiment for a given brand, feedback from tests as well as their price, as shown in Fig. 5.

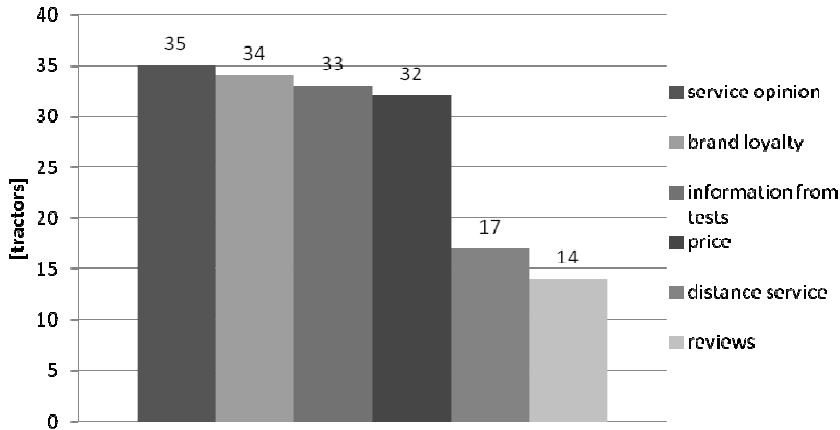


Fig. 5. Factors affecting the decision to purchase agricultural tractors

Source: the author's study

An important role in the use of agricultural tractors is played by their equipment. Among the analysed tractors a majority (80%) was equipped with electrohydraulic regulation (EHR) of the lift, while in 90% tractors additionally the lift may be operated from the fender. While performing operations on grassland, tending operations and certain tillage operations it is necessary to use a front lift (front three-point hitch), which 56% analysed tractors are equipped with. A front power take-off (PTO) is found in 40% tractors, a continuously variable transmission is found in 25% tractors, while 60% tractors are equipped with the front axle shock absorber.

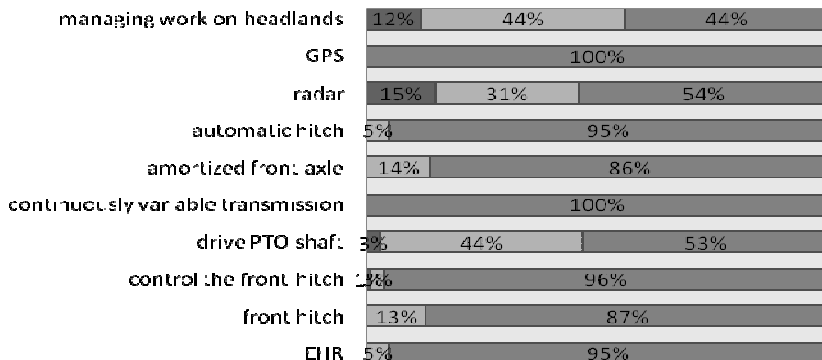


Fig. 6. Usefulness of attachments in agricultural tractors

Source: the author's study

The automatic hitch is found in 75% tractors, 50% tractors are equipped with the electronic stability control system, the GPS is found in 2.5% tractors, while 40% tractors are equipped with the the headland management system.As it may be observed in Fig. 6, attachments in most cases are helpful and useful in the utilisation of tractors. High practical usefulness was found for the GPS in tractors (100%), a continuously variable transmission (100%), three-point hitch fender control (96%) and the EHR system (95%). In the opinion of farmers the electronic stability control system as well as the headland management system were least useful.

Farmers also evaluated the horsepower of their tractors, considering engine horsepower, towing power, fuel and engine oil consumption. Engine horsepower in 68% cases was evaluated as very good and 81% tractors received positive opinions in terms of their engine oil consumption. Diesel consumption was evaluated as the worst parameter, with 47% users being dissatisfied with fuel consumption levels (Fig. 7).

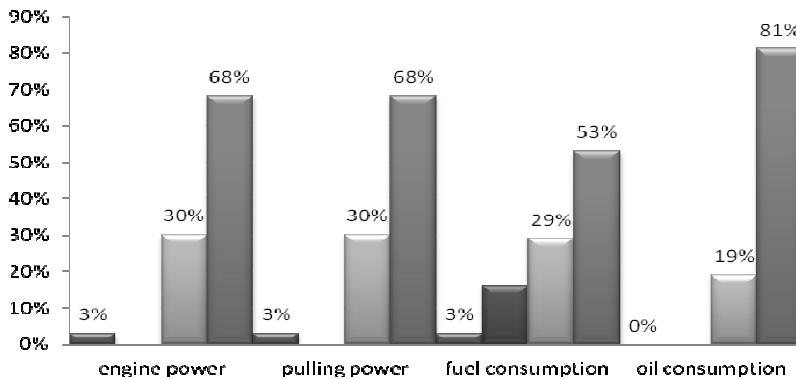


Fig. 7. Evaluation of tractor power units

Source: the author's study

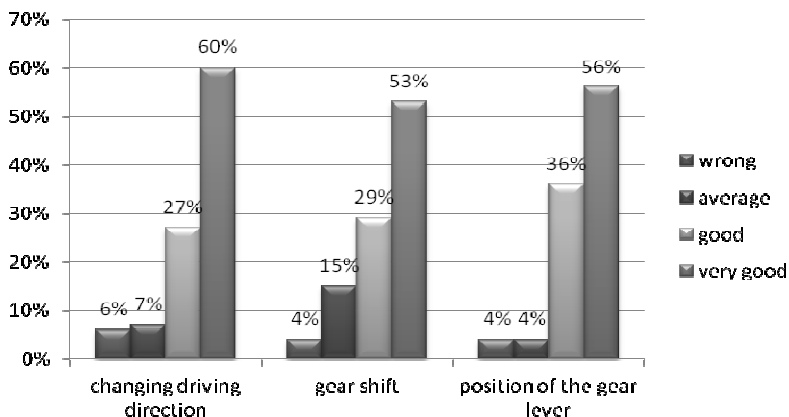


Fig. 8. Evaluation of conventional drive gears of tractors

Source: the author's study

Farmers also evaluated the drive gear. Out of 80 tractors 30 were equipped with a continuously variable transmission, while the others had conventional transmissions. The continuously variable transmission was used in tractors with power over 120 HP. Respondents evaluated the mechanical transmission in terms of turning, changes in individual transmission ratios and the position of the gear change lever (Fig. 8).

Continuously variable transmissions were found in 25 tractors. Analysis showed that they are very easily to operate, which was confirmed by all respondents. The respondents evaluated the position of the speed lever, the cruise control function, and driving in the mode of speed change using the accelerator pedal. Results are presented in Fig. 9.

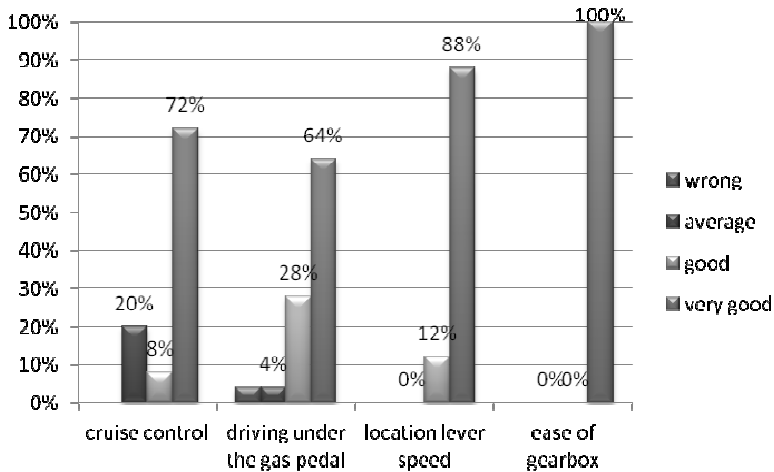


Fig. 9. Evaluation of continuously variable drive transmissions in tractors

Source: the author's study

The hydraulic system is of great importance in the design of an agricultural tractor. Farmers evaluated the external hydraulic system as well as the front and rear three-point hitch. Analysed tractors differed in their hydraulic system control. Some of them had a mechanical control system (67% tractors), while the others had an electrohydraulic system (33% tractors). In the opinion of users the lifting capacity of the rear lift is usually sufficient, in contrast to the lifting capacity of the front lift, which almost 50% respondents evaluated as very poor (Fig. 10).

When analysing the tractor equipment we have to consider its cabin as well. Its ergonomics and comfort of use make it possible to perform operations while not experiencing excessive fatigue. All the 80 analysed tractors were equipped with air-conditioning, heating, cabin lights, external warning lights, additional external lights, the shock absorbance system, blinds for the windshield, lockers and a steering joystick. A CD player and a radio were found in 90% analysed tractors, while 80% tractors had a passenger seat.

In farmers opinion, important elements of the tractor cabin equipment are: air-conditioning and heating (95% respondents) and external warning lights (91% respondents). Heated mirrors and a camera were considered least useful (Fig. 11).

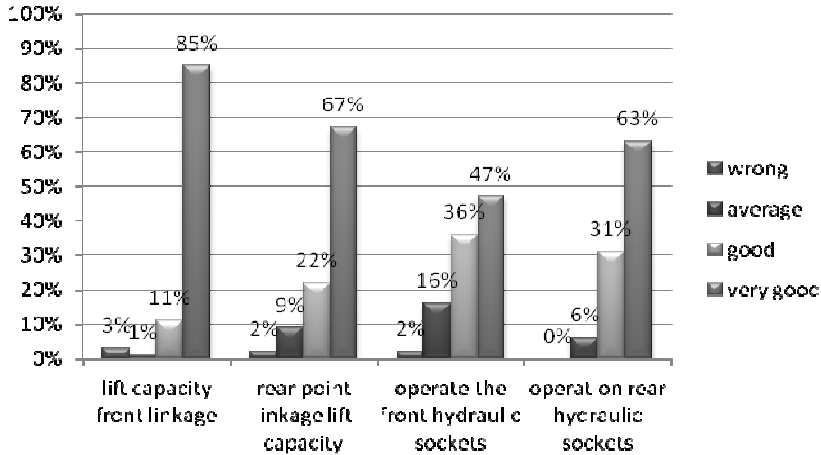


Fig. 10. Evaluation of the hydraulic system and three-point hitch in tractors

Source: the author's study

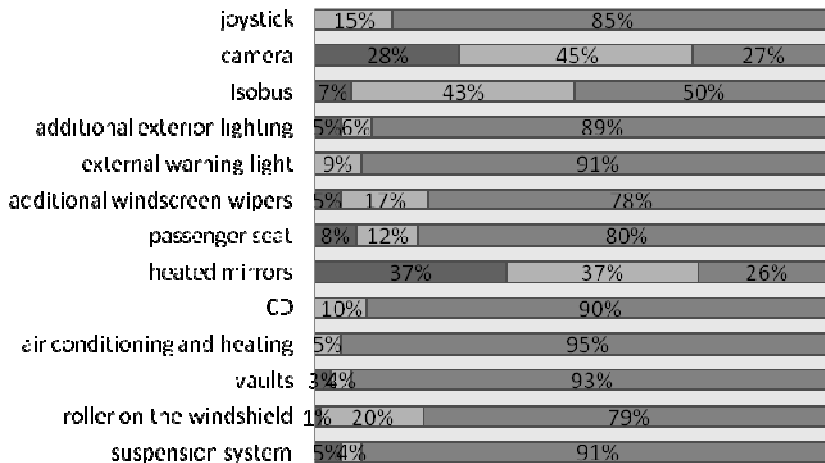


Fig. 11. Usefulness of tractor cabin equipment

Source: the author's study

Moreover, the position of steering elements, legibility and intuitive operation of control panels, the ergonomic character of the driver's seat, cabin finishing and comfortable working conditions were also important. Opinions of the respondents concerning the ergonomic aspects are presented in Fig. 12.

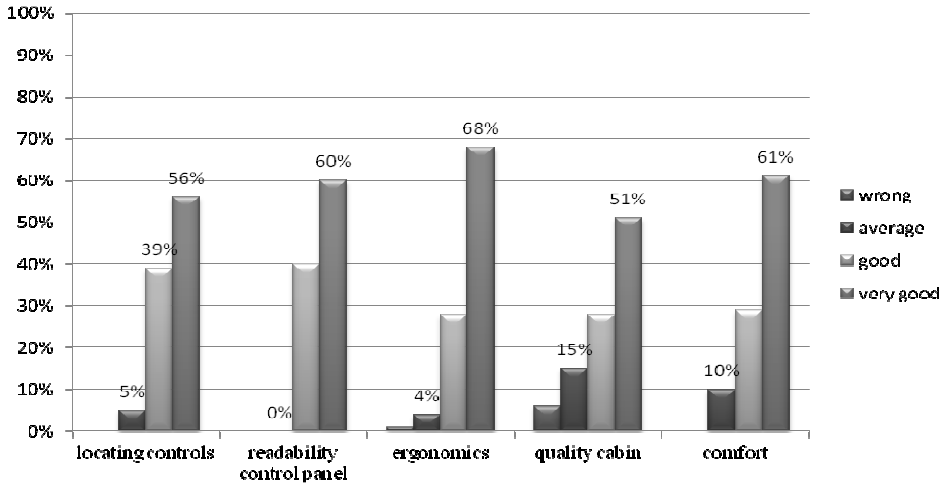


Fig. 12. Evaluation of ergonomic aspects of tractor cabin equipments

Source: the author's study

Operation of agricultural tractors is connected with their routine maintenance. Due to its frequency daily operation of an agricultural tractor is a time-intensive activity. Thus it is important for operating fluid filler holes and other tractor elements requiring daily maintenance to be located ergonomically. Respondents in their questionnaires expressed their opinions on the location of the fuel filler hole, operations during routine maintenance as well as the fuel tank capacity. An insufficient fuel tank capacity may result in an increased frequency of routine maintenance, while in a small number of cases tractors have to be refuelled twice or even three times a day. Results for these evaluated elements are given in Fig. 13.

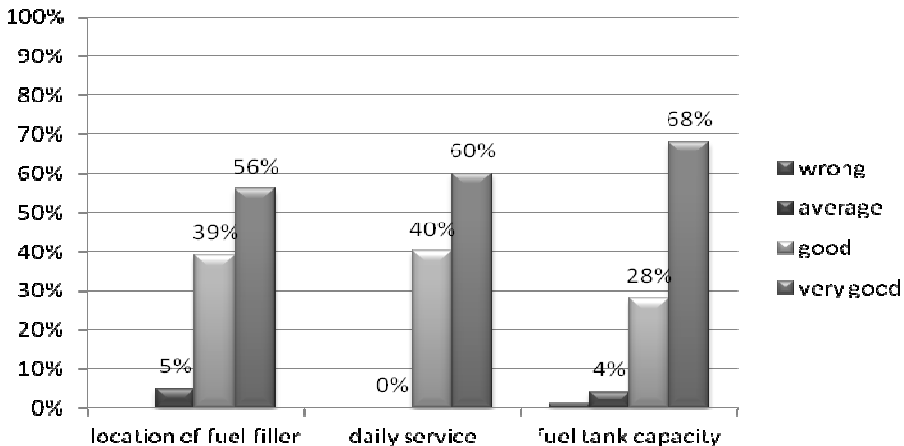


Fig. 13. Evaluation of routine maintenance of tractors

Source: the author's study

Respondents also presented their overall opinions on their tractors, with most respondents (as many as 68%) having a very good opinion on their tractor, 25% having a good opinion, while 8% had a moderate opinion on their tractors. The respondents also answered the question whether in the future they would like to buy the same tractor or a tractor of the same brand. Results are presented in Fig. 14.

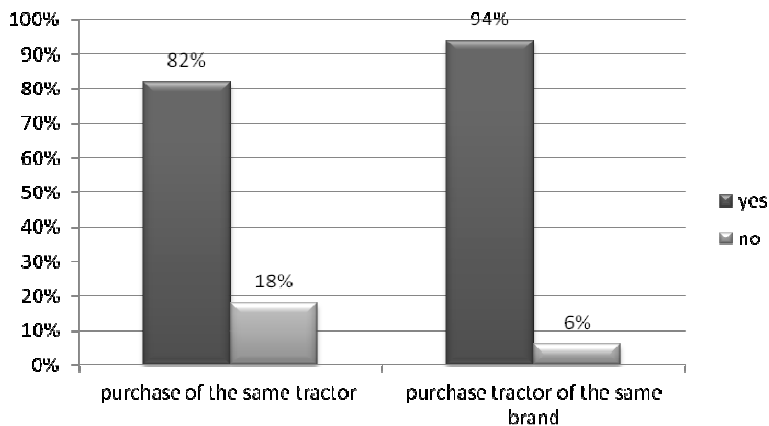


Fig. 14. Preferences for future purchase of a tractor

Source: the author's study

CONCLUSIONS

Conducted investigations and a comprehensive analysis of the results make it possible to formulate the following conclusions:

1. A vast majority of users of analysed tractors have a positive opinion on their machines, which means that at the time of purchase they made a good decision and selected well the brand and equipment for the tractor.
2. Thanks to their greater knowledge, users of agricultural tractors consciously select equipment, considering the need to purchase a machine with adequately selected technical and operating parameters. A rationally selected machine pool will not be an excessive financial burden for the farm, thus promoting its development.
3. Users of agricultural tractors increasingly often focus on the comfort, safety and ergonomics, which may reduce the number of accidents on farms.

REFERENCES

1. Błaszkiwicz Z. (2012): Środki techniczne i energetyczne. Technika Rolnicza. Wydawnictwo Uniwersytetu Przyrodniczego, Poznań, ISBN 978-83-7160-647-2
2. Czechłowski M. (2009): Opcje wyposażenia. Top Agrar Polska nr 9. Polskie Wydawnictwo Rolnicze, Poznań.
3. Durczak K. (2011): System oceny jakości maszyn rolniczych. Rozprawa naukowa nr 418. Uniwersytet Przyrodniczy w Poznaniu. Poznań
4. Hołownia K. (2009): Bezstopniowa zamiast Power Shift. Wydawnictwo Polskiego Towarzystwa Wspierania Przedsiębiorczości, nr 09, Katowice



5. Lisowski A. (2008): *Mechanizacja rolnictwa. Część 1*, Wydawnictwo Hortpress; ISBN 978-83-89211-94-2
6. Rybacki P. (2012): *System oceny jakości serwisowania maszyn rolniczych*. Rozprawa naukowa nr 425, Uniwersytet Przyrodniczy w Poznaniu. Poznań
7. Skrobacki A., Ekielski A. (2012) *Pojazdy i ciągniki rolnicze*. Wieś Jutra, Warszawa, ISBN 978-83-62815-07-4
8. Twardowski P. (2012): *Z biegami czy bez biegów*. Top Agrar Polska, nr 04, Polskie Wydawnictwo Rolnicze, Poznań.
9. Tylman M. (2013) *Ocena praktycznej przydatności wyposażenia nowoczesnych ciągników rolniczych*. Praca Magisterska, Poznań
10. Williams M. (2007): *Traktory Świata*. Program Books Ltd, ISBN 978-1-4075-1014-9

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PRODUCTION ORGANISATION SYSTEMS IN FURNITURE INDUSTRY ENTERPRISES

Abstract: This paper presents production organisation systems applied in furniture industry enterprises along with diagrams describing their operation. Analyses were conducted on six furniture industry enterprises differing in terms of the number of employees and the type of manufactured products. Companies were selected for analyses on a random basis. The dominant production organisation systems were identified based on interviews with sales and planning department employees, thus providing detailed characteristics of these systems. This study shows that all four business models (ETO, MTO, ATO, MTS) are applied in furniture industry. It was observed that the type of the adopted business model was to a considerable degree connected with the type of manufactured products.

Key words: furniture industry, engineering to order, make to order, assembler to order, make to stock, decoupling point

INTRODUCTION

Furniture industry enterprises face strong competition within this sector. We may observe constant pressure to reduce production costs and prices of manufactured products. Demand for offered products fluctuates rapidly. The range of products has to be continuously supplemented with new offers and varied modifications. Due to the decreasing volumes of orders at the simultaneous greater frequency of their placement products are manufactured in smaller batches. Such requirements posed by the demand cause increased production costs. Faced with these market conditions enterprises adopt various business models for their production systems in order to facilitate their optimal operation.

The aim of this paper is to present production organisation systems (manufacturing systems) applied in furniture enterprises and to present diagrams characterising their operation. Analyses were conducted on six furniture industry enterprises differing in terms of the number of employees and the type of manufactured products. Enterprises for analyses were selected at random. The dominant production organisation systems were identified based on interviews with sales and planning department staff, thus providing their detailed characteristics.

BASIC CHARACTERISTICS OF MANUFACTURING SYSTEMS

Four basic production organisation systems are distinguished in literature on the subject [Jagdev 2004, Palucha 2012, Matusek 2013, Palucha 2015]: Engineering to Order (ETO), Make to Order (MTO), Assemble to Order (ATO) and Make to Stock (MTS). These systems are used by enterprises most typically in various modifications, adapted to the specific character of manufactured products and the requirements of groups of customers, which have a significant effect on the final form of these systems. The systems also undergo modifications in time. They are successively adapted to changing market conditions and technological capacity to manufacture them. The basic trend for these changes is to shift from the Make to Stock towards Engineering to Order system. This results in an increasing customisation of manufactured products.

The most frequently applied system is Making to Order. This system is sometimes combined with one of the other systems. Combined systems are applied e.g. when the number of orders in some planning periods is insufficient in relation to production capacity or seasonally reduced

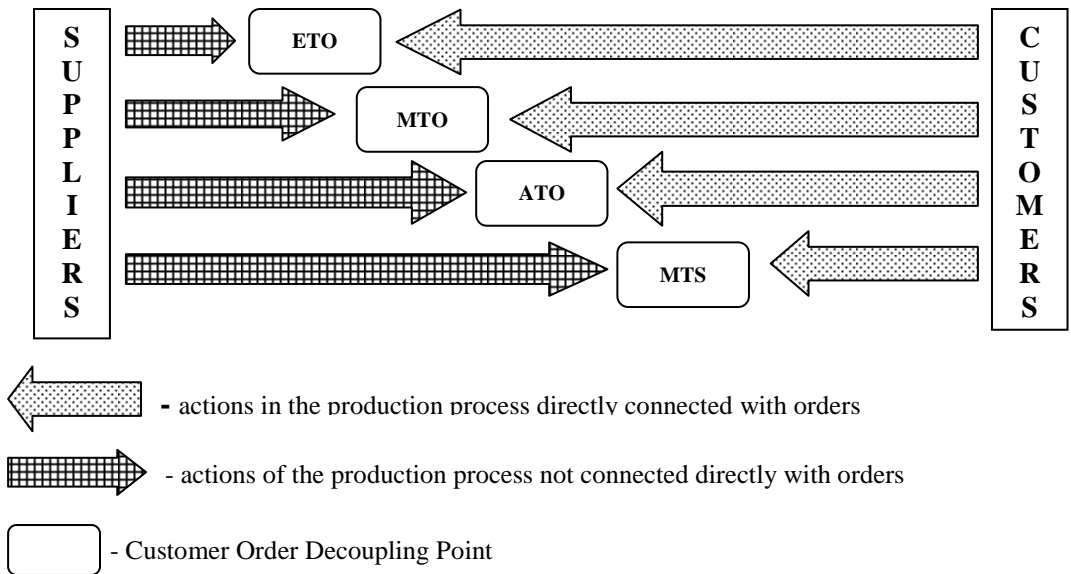
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demand is experienced. Then periodically the Make to Stock system is implemented in relation to all or certain groups of products.

Engineering to Order (ETO) is based on the design of products developed by the manufacturer as ordered by a customer. The customer orders the manufacturer to prepare a design of products in accordance with specified requirements and to manufacture them. In this way the most individualised, customised products are produced, strictly adapted to the needs of a specific customer. Manufacturing is executed in piece or small-scale production systems and it is frequently connected with the service of product assembly in locations indicated by the customers.

Making to Order (MTO) consists in the manufacture of products selected by the ordering party from an offer (catalogue) previously prepared by the enterprise. The products may be offered in various finishing variants. Customers generally are given a choice of products from among the designs presented in the offer. However, in the case of larger orders typically modifications of product finishing following customers' specifications are available.

Assembly to order (ATO) is a combination of two systems: Make to Stock and Engineering to Order. In the first stage of manufacturing elements and potentially also subassemblies and assemblies are produced based on the forecasted demand for finished products and the levels of stocks for parts of finished products in warehouses. In the second stage of manufacturing parts collected from warehouses are assembled and finished to the form of finished products. The manufacturing process in the second stage is initiated based on orders, in which customers specify configurations of finished products, assembled from previously manufactured from previously produced parts and specify the finishing type for ordered products.



ETO – Engineering to Order; **MTO** – Making to Order; **ATO** – Assembly to order; **MTS** – Making to Stock

Fig. 1. Customer Order Decoupling Point

Source: own study.

Making to Stock (MTO) refers to production based on forecasted sales of products in future planning periods. Manufactured products are transferred to the warehouse of finished products and there they wait to be sent to prospective buyers. Customers may choose only from the types of products and the quantities currently found in the warehouse (or the showroom). This manufacturing system is burdened with the greatest risk of inaccurately estimated production, particularly in terms of its volume. The actual demand for specific products may be greater than the manufactured quantity. In such a case the enterprise loses customers and does not make money. In an opposite case, when produced quantities of certain products exceed demand, the enterprise may incur losses. Products manufactured in quantities exceeding the actual demand have to be sold at reduced prices, so that the manufacturing costs are covered at least partially. This manufacturing system was common in the periods when market conditions were dictated by producers. At present this system is most frequently found in enterprises as a supplementation of the other systems, particularly Making to Order, and in the periods of seasonally reduced demand in order to utilise production capacity more efficiently.

In the manufacturing process based on the discussed business models of production organisation we may distinguish the point separating activities, which may be performed before orders for products are placed, from activities performed only after orders are placed by customers. This point is referred to as the Customer Order Decoupling Point (CODP) or order penetration point. Figure 1 presents the position of the Customer Order Decoupling Point in the course of the production process depending on the type of the manufacturing system.

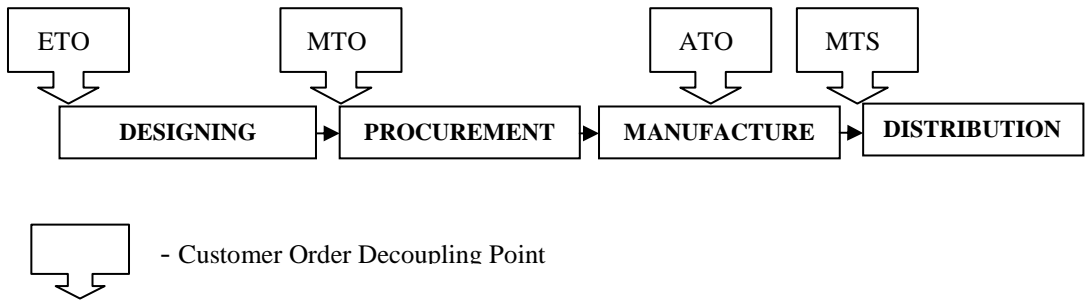
Prior to this point we have actions, which are not directly dependent on orders and customers' requirements specified there (the left-hand side of Figure 1). Actions grouped on the left-hand side of Figure 1 are performed based on the forecasted product sales. This part of the production process is based on the push mechanism – pushing manufactured products onto the market. Earlier performance of actions in this part of the process, i.e. prior to the execution of orders, makes it possible to reduce the lead time. Actions located on the right-hand side of the customer order decoupling point are directly connected with customers' requirements (the right-hand side of Figure 1). They influence the lead time by extending it. This part of the production process operates based on the pull mechanism, affecting manufactured products being pulled by the market.

The smallest number of actions, which may be performed prior to the execution of orders, is found in the case of Engineering to Order. At the same time this system has the greatest number of actions, which may be performed only after the execution of orders is initiated. In turn, the greatest number of actions, which may be made prior to the execution of orders, is found in the Make to Stock system. This system has the smallest number of actions, which may be performed only after the execution of orders has been initiated.

The lowest manufacturing costs and the shortest order lead times are found in the Make to Stock system (MTS). At the same time this production system is characterised by the lowest flexibility when adapting products to customers' requirements. The highest consistency of customers' requirements with the manufactured range of products is observed in the Engineering to Order system (ETO). At the same time, in that case lead times are the longest and manufacturing costs are highest.

Figure 2 presents positions of the Customer Order Decoupling Point depending on the stage (designing, procurement, material production, distribution) for the information production cycle²⁹ and the type of production organisation.

²⁹ We distinguish two types of manufacturing (production) cycles: the information production cycle and the material production cycle. The former comprises the stages of: designing, procurement, manufacturing and distribution. The essence of this cycle is that all actions are connected with processing of information and



ETO – Engineering to Order; **MTO** – Making to Order; **ATO** – Assembly to order; **MTS** – Making to Stock

Fig. 2. The position of the Customer Order Decoupling Point in the information production cycle

Source: own study.

For the Engineering to Order manufacture system the Customer Order Decoupling Point is found at the beginning of the cycle, at the stage of designing. The order penetration point for Making to Order is situated before the stage of procurement. In turn, in the Assembly to Order the Customer Order Decoupling Point is located in the middle of the manufacturing stage – following the manufacture of elements, subassemblies and assemblies, and before their final assembly. The Customer Order Decoupling Point is located the farthest in the information production cycle for the Make to Stock system, i.e. after the stage of manufacture and before the stage of distribution.

CHARACTERISTICS OF PRODUCTION ORGANISATION APLIED IN FURNITURE INDUSTRY ENTERPRISES

Two furniture enterprises applying the ETO manufacturing system were analysed. The scheme for the manufacturing system adopted in both these companies is given in Fig. 3. The first analysed enterprises specialised in manufacturing kitchen furniture for private customers. In view of the number of employees – approx. ten – it was classified to the group of small firms. The enterprise, as arranged with an individual customer, prepared a draft design of kitchen interior fittings including their visualisation, and after the design acceptance by the customer it manufactured all the required elements and assembled them to the final form to be installed. Customers could commission installation of the manufactured products in the indicated room or install them on their own. The firm owners informed that a vast majority of customers ordered the turnkey kitchen furniture installation service.

Both analysed enterprises used specialist software aiding in furniture design and visualisation of interior design, as well as costing and order execution software. Whenever possible, fittings were configured using previously executed designs. Customers were not charged visualisation costs. After order prices were arranged with customers, the order was accepted for execution and entered in the master production schedule. From that moment all changes to the design were charged as additional costs to the customers. Next specific structural and production designs were prepared

materials required for the manufacture of products. The latter cycle is limited only to actions, during which materials for the manufacture of products are processed. Distinguishing both these cycle types refers to a broader definition of the production cycle – the information manufacturing cycle, and a narrower sense – the material manufacturing cycle [por. Durlík 2007, Pająk 2011, Grandys 2013, Tabert 2015].

using CAD (Computer Aided Design) software with explosion procedures for Bill of Materials Or Product Structure (BOM).

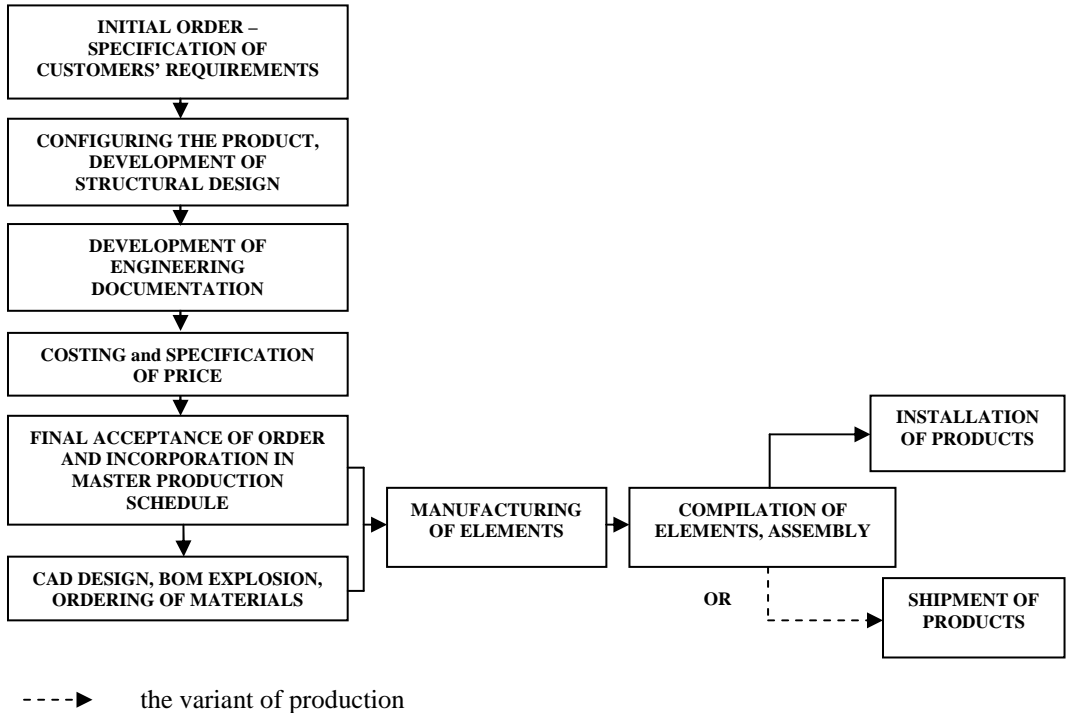


Fig. 3. A scheme of the Engineering to Order production system

Source: own study

The small enterprise was equipped with universal devices with a low degree of specialisation. Production was only executed in the piece or non-direct line mode. A more complex situation was found in the large enterprise, in which next to universal devices automated production lines were also found. This was connected with the fact that this enterprise almost solely accepted orders for large and very large facilities, for which frequently a considerable number of identical products (e.g. chairs) were commissioned. They could be manufactured in the series production system in direct lines. The large enterprise had a well-organised design department and the marketing department.

In the small company a design was prepared by one individual – the co-owner. There was no marketing department. Information on the company and its products could be collected from the website and from a catalogue with photographs of previously executed kitchen fittings designs. Orders for materials required for manufacturing were placed only after the completion of the designing stage. Input warehouses of the large company stored only typical, most commonly used assortments of materials, in relatively small quantities, except for plywood and beech sawn timber. Production-in-progress warehouses for the storage and compilation of parts prior to assembly and finishing were larger.

Production in the Make to Order (MTO) system is executed based on the trade offer prepared by the manufacturer. The trade offer refers to a set of products (assortment), which the company may manufacture based on the previously prepared structural and technical documentation. Moreover, firms typically have mastered the manufacturing process for products on offer. This type of manufacturing was analysed based on two furniture enterprises specialising in the manufacture of cabinet furniture and garden furniture. Both companies were medium-sized enterprises due to the number of their employees and turnover volume. The producer of cabinet furniture employed approx. eighty people, while garden furniture manufacturer – around sixty employees. The scheme of the Make to Order system is given in Figure 4.

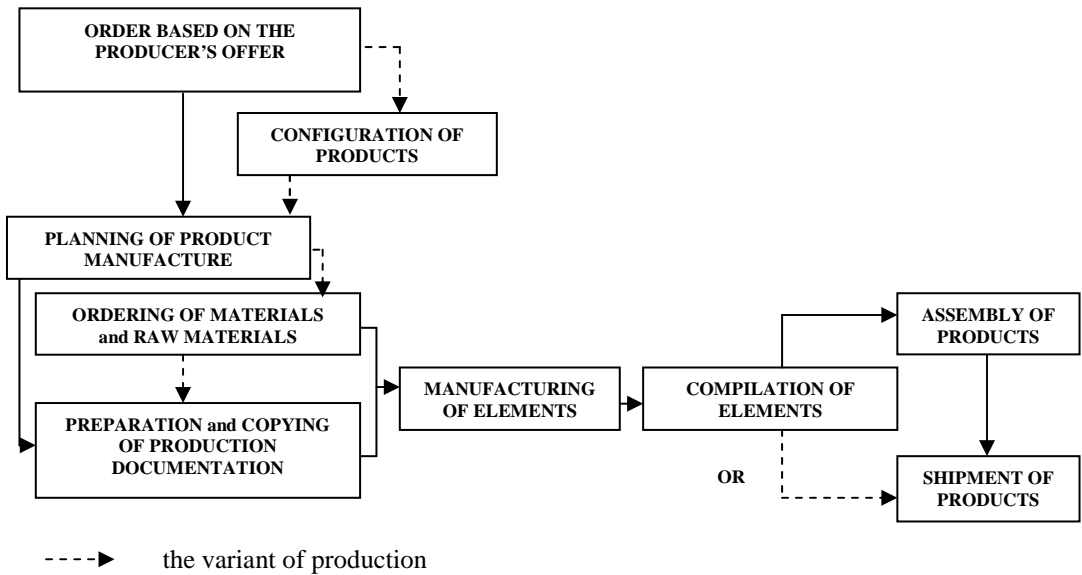


Fig. 4. A scheme of the Make to Order system based on the trade offer

Source: own study.

Both companies had sales departments, which task was to acquire orders. Employees of these departments were highly qualified and strongly motivated by the incentive remuneration system. The firms very actively participated in various exhibitions and fairs, both national and international. They had very well developed websites, containing extensive information on the manufactured range of products. Potential customers were sent catalogues presenting manufactured products and informing on granted certificates and medals won in competitions. Both firms provided considerable potential for the configuration of products based on unified subassemblies and assemblies finished as specified by the customers. Execution of most designs for new products was commissioned to external designers.

Acquisition of orders was most frequently preceded by negotiations with customers. A significant component of negotiated arrangements was connected with the date of order execution, since the current production capacity of the manufacturer had to be taken into consideration. Establishment of the date of order execution was equivalent to its acceptance and incorporation in

the master production plan of the enterprise. The plan was created based on the order of previously placed orders and based on the orders grouped into production series, composed of the same or similar final execution dates. The planning and production organisation departments were supported by specialist software. Input warehouses accumulated only those materials, which were consumed in current manufacture. Due to the short supply cycles and good cooperation with suppliers no stocks for longer time periods were created. Technical equipment was based mainly on typical universal machine tools. Both enterprises also had mechanised production lines. Production was run in the small- and medium-series, non-direct line system in dedicated work centres. Some of the products, particularly garden furniture, were delivered to customers unassembled.

The third production organisation system is referred to as Assembly to Order (ATO). This business model was analysed based on one medium-sized furniture enterprise, which employed approx. one hundred workers. The firm specialised in the manufacture of upholstered furniture, mainly sofa beds, sofas, couches and armchairs. The enterprise had an extensive range of products. The particularly varied and numerous offer concerned dimensional variants and furniture finish variants (colours, fabrics, decorative elements). The sales department employed qualified staff, who had extensive contacts with contractors. Retail stores were primary customers, from which individual customers ordered furniture assembled and finished in accordance with the arranged specifications. The company had their own design department and also used services of external designers.

The production process consisted of two separate technological stages: working of elements and their preliminary assembly, and the final assembly of finished products. These two stages were separated by the warehouse, in which stocks of elements and subassemblies for further assembly were stored. The scheme of the Assembly to Order manufacturing system is presented in Fig. 5. For the processing stage the manufacturing plan was constructed based on the forecasted demand for furniture and the level of stocks of parts in the production-in-progress warehouse.

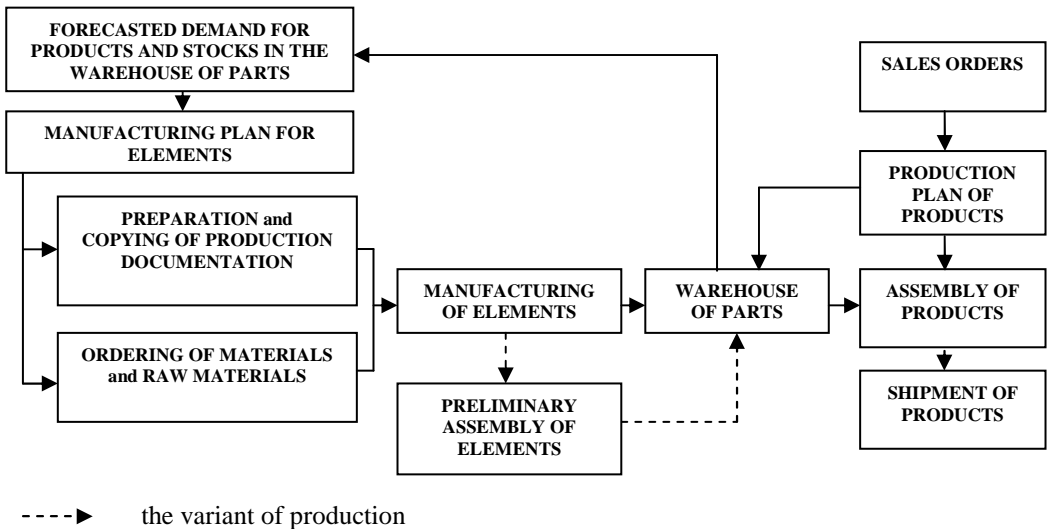


Fig. 5. A scheme of the manufacturing system to warehouse of parts – Assembly to order

Source: own study.

For this part of the production process elements were manufactured in the direct (straight) line mode in large batches. Most of the manufacturing process was executed in production lines. In warehouses of input materials large stocks were accumulated (particularly particleboard and fibreboard) to ensure smooth manufacturing.

For the second stage of the manufacturing process the production plan of finished products was created on the basis of sales orders placed by shops. At this stage production was executed for a specific customer. Dates of order execution were arranged based on the length of the assembly cycle of finished products. Production was non-direct-line, piece or small-batch. Finishing processes were executed on manual and machine work stations. The warehouse of finished products kept limited stocks. Products were supplied mostly in the partly or completely assembled form depending on the type of products and applied structural solutions.

The fourth manufacturing system is the Made to Stock (MTS) system of production to the warehouse of finished products. This business model was observed in an enterprise employing over three hundred workers. A scheme of the Make to Stock manufacturing system is presented in Figure 6. The firm produced on a large scale simple, standard cabinet furniture, with extensive configuration options for sets of products. The manufacturing plan was prepared mainly based on the forecasted demand for products and the level of stocks in the warehouse of finished products and partly based on long-term contracts with domestic and foreign contractors. Fluctuations in demand for furniture was compensated for by an adequate level of stocks in the warehouse of finished products.

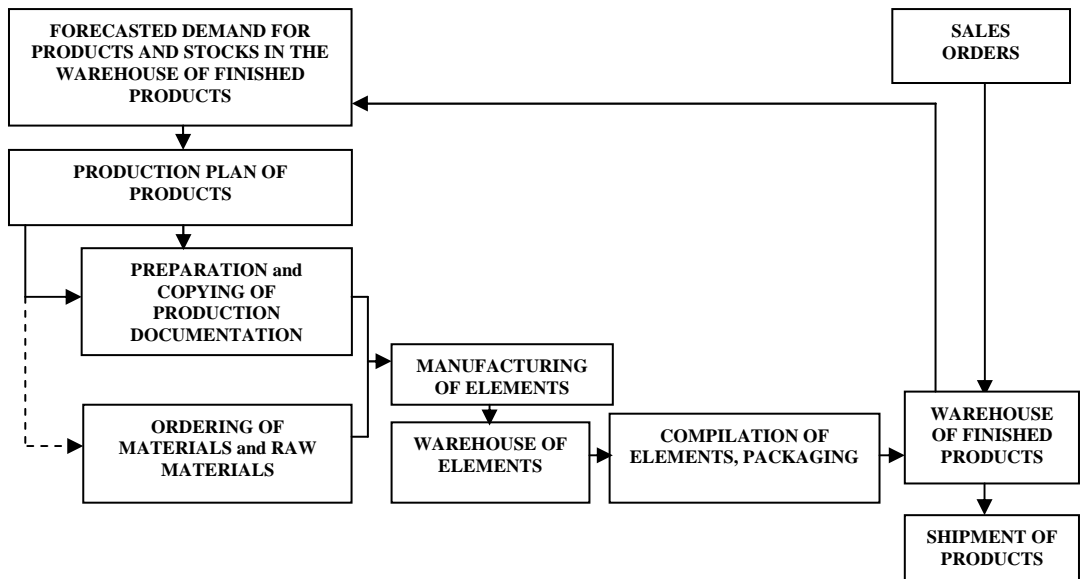


Fig. 6. A scheme of the Make to Stock system manufacturing to the warehouse of finished products (MTS)

Source: own study.

Large-lot production predominated. The entire production process was planned as a direct-line process, in which identical quantities of furniture were manufactured in the same time periods. At this stage of manufacturing products had no specific buyers. Incoming orders were executed on an on-going basis from the warehouses of finished products. Some manufactured products were supplied based on schedules within long-term contracts, arranged in detail for shorter periods in terms of their quantities.

The enterprise had large input warehouses and considerable stocks of materials for production. Technical facilities were predominantly automated production lines. The factory had no separate design department. Design works were performed in a limited scope within the production organisation and control department. The company supplied only unassembled products. The enterprise had a large warehouse of finished products with considerable stocks as well as their own fleet of transport vehicles.

CONCLUSIONS

Conducted analyses indicate that all the four business models (ETO, MTO, ATO, MTS) are applied in furniture industry. It was observed that the type of the business model to a considerable degree was connected with the type of manufactured products.

The Engineering to Order manufacturing system was found in the manufacture of kitchen furniture installed at customers' premises and frame furniture, mainly chairs, which were supplied as a component of larger interior design projects for facilities and buildings housing large events (stadiums, concert halls, conference halls, etc.). A classical solution for the ETO system is piece or small-scale production. Such manufacturing type was found for the firm producing kitchen furniture. In turn, the producer of frame furniture applied a mixed type of production organisation. The series and large-lot manufacturing was combined with piece or small-scale production within one order. Such a solution differs from those described in literature on the subject. The type of manufacturing was determined by the type of customers, in this case large business entities with specific needs.

The Make to Order (MTO) system was applied in producers of conventional cabinet furniture and garden furniture. The applied production organisation system in two analysed enterprises did not differ from the descriptions found in literature on the subject. Selection of the production system for this type of products corresponds to current preferences of buyers of such furniture. Strong competition was observed together with a trend towards reducing order volumes and considerable variability in furniture finish. This may indicate a shift in the production organisation system towards the Finish to Order (FTO) system.

Assembly to order (ATO) was applied in the company manufacturing upholstered furniture. The structure of such furniture is composed of a frame made from particleboard panels and wooden strips. The frame is covered with elastic materials such as bonell or zigzag springs and polyurethane foam. The whole structure is finished with upholstery fabric. Frames in the form of subassemblies and their components may be manufactured in large lots. In contrast, the upholstery, particularly the fabric, may be selected individually depending on customers' orders. For upholstered furniture due to their specific structure the Assemble to Order system is an appropriate solution. If customers' orders are limited only to the selection of upholstery fabric, then the Finish to Order production system is used.

The last analysed business model was the Make to Stock system. This model was observed in a large enterprise producing standard cabinet furniture manufactured for self-assembly. Production was the series and large-batch system. A characteristic feature here was an extensive offer single pieces of furniture, which customers could choose and match creating customised sets adapted in

terms of their functions and dimensions to individual needs. Customers could not choose furniture finish. This business model was well-adapted to the type of manufactured furniture.

REFERENCES

1. Durlik I.: Inżynieria zarządzania cz. I, wyd. 7 uzupełnione. Wyd. Placet, Warszawa 2007.
2. Grandys E.: Podstawy zarządzania produkcją. Wyd. Difin, Warszawa 2013.
3. Jagdev H.S., Brennan A., Browne J.: Strategic Decision Making in Modern Manufacturing. Kluwer Academic Publishers. Boston / Dordrecht / London 2004.
4. Matuszek M.: Rozwój nowego produktu w przedsiębiorstwach środowiska produkcyjnego – konstrukcja na zamówienie (Engineering-to-Order ETO). Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie, z. 63, Wyd. Pol. Śl., Gliwice 2013.
5. Pająk E.: Zarządzanie produkcją. Produkt, technologia, organizacja. Wyd. Naukowe PWN, Warszawa 2011.
6. Palucha K. Zarządzanie systemami produkcyjnymi – nowe wyzwania, [w:] praca zbiorowa pod red. J. Pyki, Nowoczesność przemysłu i usług – nowe wyzwania, TNOiK, Katowice 2012.
7. Palucha K. Organizacyjne problemy środowiska produkcyjnego w łańcuchu dostaw. Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacja i Zarządzanie, z. 83, s.515-527, Wyd. Pol. Śl., Gliwice 2015.
8. Pasternak K.: Zarys zarządzania produkcją. Polskie Wydawnictwo Ekonomiczne, Warszawa 2005.
9. Tabert M.: Manufacturing cycle and its structure in wood industry enterprises. Intercathedra. Scientific Quarterly of the Economics Departments of the European Universities. No 31/2, s. 101-109, Poznań 2015.

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VARIABLE ROOF TRUSS PRODUCTION EFFICIENCY

Abstract: Timber is commonly applied in building constructions due to its properties. It is also used in roof trusses. It is chiefly applied as solid wood in private constructions due to technological limitations in the processing of this material. It is still used in this form as a traditional construction. The economic aspect, wide availability and ease of processing are its advantages over other materials used in roof constructions. The study shows the influence of the quantitative and dimensional structure of roof truss elements on production efficiency.

Key words: wood, roof, efficiency

INTRODUCTION

Wood is an organic renewable material with anisotropic properties. It is a basic building material in many constructions, including roof constructions. As a material which is commonly used in roof truss constructions, it exhibits different properties, depending on forces and the direction of fibres [Wajdzik 2000]. The roof truss is a structure supporting the whole roof. There are two types of timber structures used in construction. Carpentry roof trusses are chiefly used in urban and rural residential buildings and in outbuildings with a maximum span of 12 m. Engineered trusses are used in halls, where the span may reach even 20 m. Due to economic reasons they are superseding metal and reinforced concrete constructions [Wajdzik 2000].

The advantage of engineered trusses over carpentry trusses is the fact that they use limited amounts of timber. However, engineered trusses are not made at the construction site, but they are prefabricated in specialised wood processing plants

There are different materials which can be used for roof constructions. However, due to economic reasons wood is one of the most important materials used in buildings. Scots pine (*Pinus silvestris* L.) and Norway spruce (*Picea abies* L.) are basic wood species used in constructions. However, depending on one's financial capacity, constructions can also be made from oak, larch or poplar wood.

As results from numerous studies on pine and spruce wood, which belong to the group of major materials used in timber constructions, the diameter and length of the knot area determine the usefulness of material for construction. It is also noticeable that density, comprehensive strength and static bending are considerably correlated with the usefulness of material for construction [Mydlarz, Wieruszewski 2012].

Studies have proved that the strength correlation resulting from the wood structure enables control of its properties. It significantly affects the quality of an intermediate product and its strength [Wieruszewski et al. 2012, Kozakiewicz, Krzosek 2013]).

Mańkowski, Krzosek & Mazurek [2000] proved high inhomogeneity in the properties of wood from the same base of raw materials. Simultaneously, the study confirmed that wood from Greater Poland and Pomerania was characterised by the greatest homogeneity of the property under analysis [Mańkowski et al. 2011].

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At present modernised methods are being introduced to accelerate the sorting process. One of them is a machine sorting method, which does not damage timber. PN-EN 14081-1+A1:2016, PN-EN 14081-2:2013, PN-EN 14081-3:2012.

The dimensional structure of timber is an important problem in the acquisition of construction assortments for roof truss elements. It determines the use of material with adequate dimensional and qualitative parameters and directly influences yield indexes and processing efficiency.

AIM AND METHODOLOGY

This study attempts to identify the determinants of processing efficiency based on the parameters of variable qualitative and dimensional structure of solid wood roof truss elements acquired by sawing round wood.

The following tasks were performed to achieve the aim of the study: percentage analysis of the components of a selected roof truss, identifying the influence of the origin of wood material for experimental processing and the influence of its qualitative and dimensional structure by comparing the results with the mean values of the yield of material sawn and production efficiency.

Korczewski, Krzysik & Szmit [1970] described a saw coupling and stated that it was not only a group of saws fixed to the head saw frame but also a log sawing scheme, i.e. a scheme of acquiring sawn material from round wood. The individual method is much different from the group method. Logs are sawn with one saw. During the cutting process, after each kerf the log is moved towards the saw or the saw is moved towards the log. The most important advantage of this method is free selection of timber thickness, depending on the quality of wood uncovered after cutting with a saw. It is particularly useful for valuable wood species, where it is difficult to estimate the log quality by its external traits.

The technological efficiency of wood processing is a basic determinant of economic effects [Hruzik et al. 2005]. The E_p index, expressed with natural units or as percentage, is defined as the ratio between the sum of the commodity value of sawmill products, chips and accompanying products made from a particular material and the purchase cost of the material necessary for their production.

$$E_{(p)} = \frac{\Sigma V_w * C_w + \Sigma V_z * C_z + \Sigma V_o * C_o}{\Sigma V_s * (C_s + T_r)} * 100 \text{ [%]}$$

[source: Hruzik et al. 2005]

where:

V_w – volume of products,

C_w – unit prices of products,

V_z – volume of chips,

C_z – contractual conversion price of chips,

V_o – volume of accompanying products and sawdust,

C_o – conversion price of accompanying products and sawdust,

V_s – volume of raw material,

C_s – contractual price of raw material,

T_r – cost of transport of raw material.

The basic criteria of efficiency are the cost of material to be processed and production assortment. Following the aforementioned calculation assumptions, it is necessary to pay particular attention to the price of raw material, which definitely has the greatest share in the cost of production of sawn materials. Costs of transport increase this value. An increase in the distance of deliveries made to the enterprise increases the overall cost of raw material. It gives reasons to limit the range and flexibility of wood purchase. These factors directly affect production profitability.

We made a qualitative and quantitative analysis of high-volume pinewood to be sawn into roof truss elements. The total volume was about 1,000 m³. There were four quality classes: WA0, WB0, WC0 and WD0 and three thickness classes: 1, 2 and 3. The following percentage of the mass of high-volume timber was observed in individual groups (Fig. 1-2).

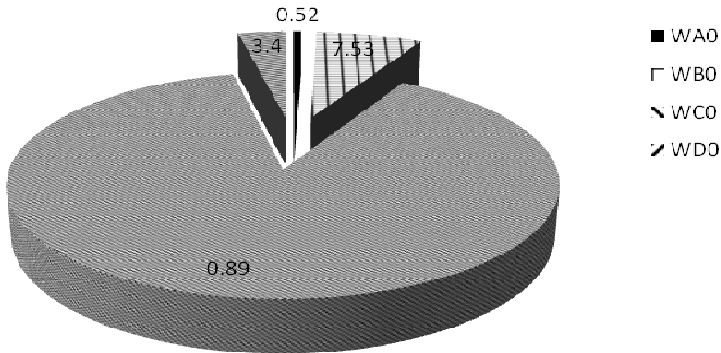


Fig. 1. The percentage of pinewood quality classes

Source: the authors' compilation based on data provided by the enterprise

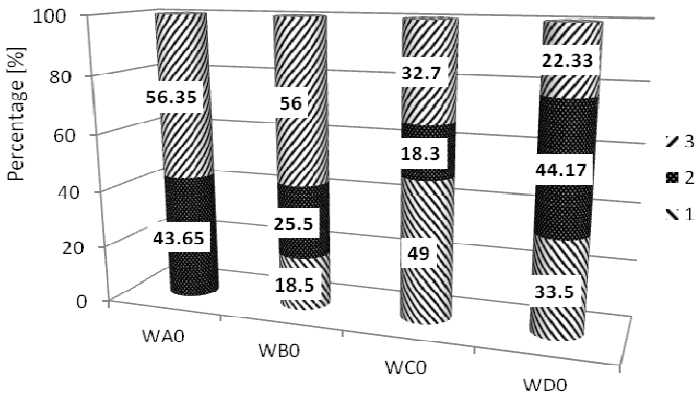


Fig. 2. The percentage of pinewood thickness classes

Source: the authors' compilation based on data provided by the enterprise

As results from the data, class WC0 was the predominant quality group of raw material in thickness classes 1 and 3. However, the wood purchase system is not the same as the order in which wood is delivered to the enterprise. Following the rules of logistics in consecutive orders for roof truss, the enterprise orders wood of adequate quality and thickness so as to obtain logs of required diameters and to saw them so as to achieve the highest output and best quality of main timber.

ANALYSIS OF RESULTS

The aim of the analysis is to show the percentage of individual roof truss components. We used ten randomly selected orders for timber to be used in roof constructions. The total volume was about 126 m³. In order to verify the main constructional elements correctly we did not include the demand for timber for roof boarding or timber for laths and counterlaths. Orders for roof constructions included the following elements: rafters, purlins, collars, wall plates, braces, posts, angle struts, ties, trimmers, ridge purlins, etc.

We verified the results for timber in all orders for ready roof truss sets. Figure 3 shows the percentage of individual roof truss components (rafters, collars, purlins, etc.).

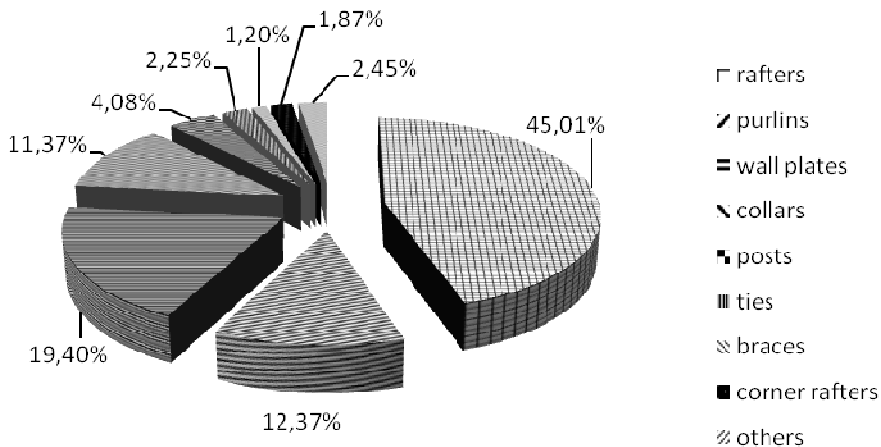


Fig. 3. The percentage of roof components

Source: the authors' compilation based on data provided by the enterprise

As the chart shows, rafters were the main elements of the roof construction volume. They made about 47% of the total volume of timber used. The next most important elements were wall plates (about 19%) and purlins (about 12% of the volume ordered), which support rafters. They were followed by collars (11%) and posts (about 4%), which prevent the deformation of rafters by the load. Ties and braces amounted to about 3% of the timber construction – these elements support purlins. The remaining 2% was covered by the components which depend on the roof design, i.e. ridges, trimmers, eaves planks and ridge purlins.

ANALYSIS OF EFFICIENCY

Constructional timber is a material with high requirements concerning quality and strength. It directly translates to the material quality and dimensions. It is related with variable rates of material use if there is considerable diversity in the assortment of constructional products from solid wood.

The main factor related with the quality of raw material is its price. Figure 4 is an example of variability in the prices of WC0 pinewood, thickness class 1 over nine months in 2015. The net prices ranged from 240-278.5 zlotys per m³ (Fig. 4).

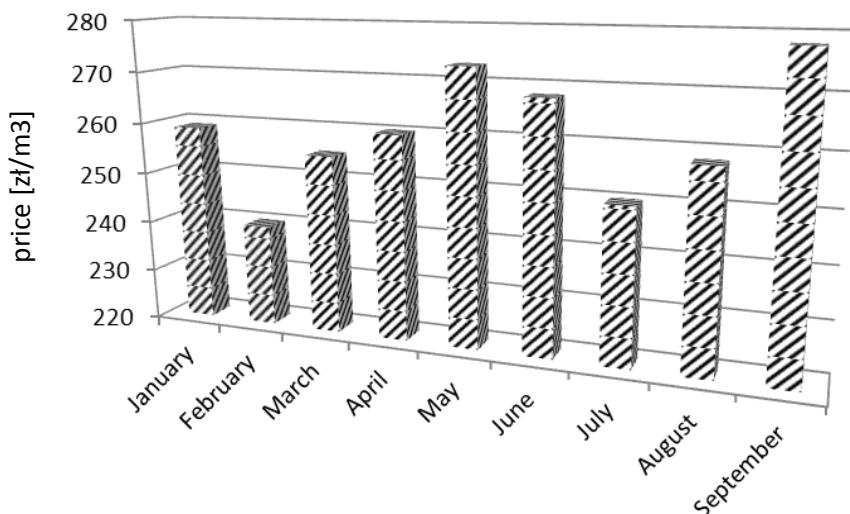


Fig. 4. Prices of WC0 1 pinewood in 2015

Source: the authors' compilation based on data provided by the enterprise

As resulted from the questionnaire survey in the enterprise, in 2015 the average net purchase price of WC0 pinewood timber, thickness class 1 was 254 zlotys per m³ (source: the authors' compilation based on data provided by the enterprise).

Simultaneously, as far as the price of high-volume wood is concerned, the price of ready constructional assortments from pinewood plays a key role. Depending on the diameter and type of assortment, prices create market conditions of the supply of constructional products.

The literature provides information about material efficiency in primary processing. Buchholz (1968) and Hruzik (1995) describe the dependence between the classification of sawmill pinewood and the economic calculation in the sawmill industry.

Due to variability in the indexes of production output and efficiency, it is necessary to analyse this problem systematically.

If we take overall timber, which encompasses individual elements of the roof construction, and the average output, deducting the weight of accompanying materials made in the production process, we can calculate the average production efficiency (Tables 1-2).

Table 1. The average efficiency of pinewood processed into constructional timber of less than 6 m in length

Width [mm]	Rafters	Purlins	Wall plates	Collars, posts, ties
	Ep [%]			
>200	217	235	271	199
<200	204	221	255	187

Source: the authors' compilation based on data provided by the enterprises

If we take the diameter of an element and variable length into consideration, we will see variation in the price of material. The longer the dimension is and the more diversified the diameter is, the higher the thickness of timber is and the higher its price is. These factors directly affect the diversification of efficiency, as can be seen in Tables 1 and 2.

Table 2. The average efficiency of pinewood processed into constructional timber of more than 6 m in length

Width [mm]	Rafters	Purlins	Wall plates	Collars, posts, ties
	Ep [%]			
>200	199	216	250	183
<200	189	204	236	173

Source: the authors' compilation based on data provided by the enterprises

The results show that the increase in the ratio between the dimensions of the cross section of constructional products and material used causes variation in the production efficiency, which tends to decrease. Wall plates are characterised by the highest efficiency – there is considerable processing output. If we take the length of a constructional element as a determinant variable which accounts for a specific change in the price of assortment and increase in the price of material, we can see a decreasing efficiency in the amount of constructional timber acquired, as compared with the length range below 6 m.

SUMMARY

The research resulted in the following general observations and conclusions:

1. Class WC0 was found to be the predominant class of high-volume wood used for the production of roof truss elements.
2. The analysis of the share of individual thickness classes showed that thickness classes 1 and 3 were predominant in most quality classes.
3. The analysis of roof truss orders revealed that rafters were the main constructional elements ordered, followed by wall plates, purlins and collars.
4. The quality of material is the main determinant of its usefulness, whereas the price is the main determinant of its efficiency. The ratio between the product price and the material price has enormous influence on production efficiency. The higher the raw material quality is, the higher the price of top quality ready assortments is.

5. It is noticeable that by purchasing WC0 wood and by adequate selection of final products it is possible to reduce the financial outlay on raw material and thus increase the economic effects of processing.
6. The share of roof truss components ordered has unquestionable influence on production efficiency. The highest rates are generated in the production of purlins and wall plates, while retaining the same quality criteria.

REFERENCES

1. Buchholz J. (1968): Zagadnienie klasyfikacji sosnowego drewna tartacznego na tle rachunku ekonomicznego w przemyśle tartacznym. *Folia Forestalia Polnica Seria B*, 8: 95-127.
2. Dzbeński W., Kozakiewicz P., Krzosek S. (2005): Wytrzymałościowe sortowanie tarcicy budowlano- konstrukcyjnej. Wydawnictwo SGGW. Warszawa 2005.
3. Hruzik J.G., Gotych W., Wieruszewski M. (2005): Efektywność produkcji przykładowych wyrobów tartacznych na rynek krajowy i europejski, w: *Przemysł Drzewny*, Maj 2005, Wydawnictwo Świat. Warszawa, s. 18-21.
4. Korczewski O., Krzysik F., Szmit J. (1970): Tartacznictwo. Państwowe Wydawnictwo Naukowe. Warszawa 1970.
5. Kozakiewicz P., Krzosek S. 2013: Inżynieria materiałów drzewnych. Wydawnictwo SGGW, Warszawa 2011
6. Lenkiewicz W., Zdziarska-Wis I. (1989): Technologia ciesielstwo. Wydawnictwo Szkolne i Pedagogiczne. Warszawa 1989.
7. Mańkowski P., Krzosek S., Mazurek A. (2011): Compression strength of pine Wood (*Pinus Sylvestris L.*) from selected forest regions in Poland. *Annals of Warsaw University of Life Science* 2011, No 75: 81-84..
8. Mydlarz K., Wieruszewski M. (2012): Solid and engineered wood and its significance for innovative solutions in timber building projects. *Intercathedra* 2012, No 28-3: 58-61.
9. PN-EN 14081-1+A1:2016 Konstrukcje drewniane- Drewno konstrukcyjne o przekroju prostokątnym sortowane wytrzymałościowo- Część 1: Wymagania ogólne.
10. PN-EN 14081-2:2013 Konstrukcje drewniane- Drewno konstrukcyjne o przekroju prostokątnym sortowane wytrzymałościowo -- Część 2: Sortowanie maszynowe; wymagania dodatkowe dotyczące wstępnych badań typu
11. PN-EN 14081-3:2012 Konstrukcje drewniane- Drewno konstrukcyjne o przekroju prostokątnym sortowane wytrzymałościowo- Część 3: Sortowanie maszynowe: wymagania dodatkowe dotyczące zakładowej kontroli produkcji
12. Rzadkowski S. (1957): Sprzęgi pił. Państwowe Wydawnictwo Rolnicze i Leśne. Warszawa 1957.
13. Wajdzik Cz. (2000): Więzyby dachowe. Wydawnictwo Akademii Rolniczej. Wrocław 2000.
14. Wieruszewski M., Gotych V., Hruzik J. G., Gołuński G., Marcinkowska A. (2011): Research qualitative of coniferous assortments solid Wood for Wood construction. *Annals of Warsaw University of Life Science* 2011, No 76: 189-193.
15. Wieruszewski M., Gotych V., Hruzik J. G., Mirski R., Lis B. (2012): Impact of raw material quality versus production of construction elements. *Intercathedra* 2012, No 28-3: 94-98.

