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Situation of power machines and operating cost changes in Hungarian agriculture based on farm data

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Operating cost control is essential to making the right decision for farmers, managers, etc. in the agriculture. Machinery operating costs form a significant proportion of the expenses involved in agricultural production and, thus, the appropriate or inappropriate use of machinery can significantly influence the efficiency of farming. The primary goal of this study is to examine operating costs and analyse the causes of changes in the Hungarian machinery market during the past few years. Expenses can be reduced in every farm and, thus, my aim is to summarise cost reduction possibilities. My research shows that the EU co-financed support for machinery and equipment investment has a great impact on the replacement and average annual usage of power machines because, after the end of EU subsidies, the number of agricultural machines sold has decreased.

Keywords: direct and indirect costs, cooperation, market, performance, production.
JEL codes: O13, Q11, Q13.

Introduction

At the end of the 20th century, significant changes occurred in the Hungarian agricultural sector (e.g. ownership, structure, laws, etc.), changes that affected integration and cooperation. Also, Hungary's economic processes are still undergoing change (Némediné Kollár–Neszmélyi 2015). Especially since the advent of mechanised agriculture, agricultural machinery plays an indispensable role in feeding the world. Today, most farmers use tractors and other motorised equipment to help with field work and agricultural production is very machine-intensive. It means that it is difficult to produce without machines and equipment, which are dependent on farmer's knowledge, machine parameters, and environmental conditions. One of the most important factors of competitive production is mechanisation, which allows tasks to be done in a timely and high-quality manner. Good utilisation, modernisation and timely replacement of the machines are key ingredients to efficient agricultural production.

Agricultural technology is changing rapidly. Nowadays, in Hungary, about one thousand distributors are trading agricultural machines and spare parts, thus the machine portfolio is very diverse and broad, but only 10% of distributors have a significant turnover. All major machine manufacturers and dealers can be found

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on the Hungarian machinery market. The latest, most modern models of agricultural equipment are available to farmers.

During the summer of 2013, the Hungarian Central Statistical Office (KSH) carried out a detailed survey on the number of farm machines in the Hungarian agricultural sector. In December 2013, the KSH also recorded the average age of power machines. The Research Institute of Agricultural Economics (AKI) compiles an annual statistical report on Hungarian agricultural markets, which also includes economic data related to agricultural machinery and spare parts investments. Operating costs can account to 20-30% of annual production costs (Lips–Burose 2012). The Institute of Agricultural Engineering (NARIC MGI), working under the National Agricultural Research and Innovation Centre (NARIC), annually monitors the operating costs. In other words, the Institute carries out an observation of the machines found on the so-called "base farms". Why is this important? The prices and costs of agricultural machinery, including machine operating costs, are changing every year. Total machine operating costs depend on several factors. At the end of service life, all equipment becomes uneconomical and should be replaced. If farmers choose the most suitable machine, that could also have a positive impact on profit. If farmers do not reduce their operating expenses, they will not be able to compete effectively.

Research methodology

Agricultural machinery includes many types of equipment. My research focuses on the following power machines: tractors, (wheat, maize) combines, self-propelled harvesters, self-propelled loaders, other self-propelled machines, and agricultural trucks.

The costs of operating machinery can be divided into two categories:

- Direct costs: fuel and lubricants; operator labour (with social contribution taxes); repair and maintenance costs; machinery depreciation; and other (insurance rates, equipment storage);
- Indirect costs: fixed and current assets, capital gains, other terms of income needs, and general costs associated with the machines.

Total operating costs are calculated as the sum of the seven costs listed above.

My work refers only to diesel-powered machines. The price of diesel is ca. HUF 325/kg or HUF 273/l (tank car) and the price of lubricants is ca. HUF 850/kg (EUR 1 = HUF 315). It is important to note that the prices and costs do not include VAT. I emphasise that these data show averages and differences may occur. Total operating costs for a particular type of machines vary widely from one geographic region to another because of soil type, rocks, terrain, climate, and other conditions.

Research findings

Agricultural equipment in Hungary

In 2013, a detailed survey on the number and average age of power machines available in the Hungarian agricultural sector was carried out by the Hungarian Central Statistical Office (KSH 2014). Table 1 shows the average age of power machines at the end of 2013. According to KSH data, the average age was 18.3 years. The economic life of a machine is the number of years over which costs are to be estimated. It is often less than the machine's service life. This means that the total amortisation time is ca. 35-37 years and that machines that are older than 50 years can still be found in the Hungarian farming sector.

Table 1. The age of agricultural power machines (in December, 2013)

Agricultural equipment	Average age (years)	Rate (%)			
		< 10 years	11–20 y.	21–30 y.	> 30 years
Corporation					
Tractors	13.7	47.4	28.9	23.7	4.3
<8 kW	11.7	52.4	33.6	14.0	0.7
8-20 kW	14.8	44.0	27.1	28.8	4.9
21-40 kW	19.9	24.0	29.4	46.6	13.6
41-60 kW	18.5	23.5	35.4	41.1	6.4
61-100 kW	10.4	61.6	28.3	10.0	1.6
>100 kW	10.9	62.8	22.4	14.8	3.0
Combines	10.8	57.6	31.4	11.0	1.2
Other self-propelled machines	11.5	59.9	24.0	16.1	4.0
Total of power machines	13.1	50.0	28.6	21.4	3.8
Sole proprietorship					
Tractors	20.5	24.2	33.4	42.4	18.4
<8 kW	19.9	27.5	34.5	38.0	20.7
8-20 kW	22.4	15.6	34.6	49.8	17.4
21-40 kW	27.3	10.4	23.9	65.8	38.6
41-60 kW	21.5	14.6	40.1	45.3	16.6
61-100 kW	15.0	41.9	34.8	23.3	7.5
>100 kW	13.6	50.5	27.1	22.4	7.0
Combines	17.4	33.6	34.2	32.2	10.5
Other self-propelled machines	18.4	31.9	27.6	40.5	12.3
Total of power machines	19.7	25.7	34.7	39.6	16.5
Average machine age (years)					
Tractors	19.3				
Combines	15.4				
Other self-propelled machines	15.1				
Total of power machines	18.3				

Source: KSH 2014

Table 2. Agricultural equipment in Hungary (in December, 2013)

	Unit	Corporation	Sole proprietorship
Agricultural area	1000 hectares	2 155	2 435
Number of farms	piece	8 442	484 723
Agricultural area per farm	hectare	255	5
Number			
Tractors	piece	21 927	98 960
Combines	piece	3 365	7 405
Other self-propelled harvesters	piece	6 409	5 937
Agricultural trucks	piece	4 983	10 624
Power machines	piece	35 956	122 926
Engine power			
Tractors	1000 kW	1 891.2	5 544.3
Combines	1000 kW	677.4	1 033.0
Other self-propelled harvesters	1000 kW	133.0	64.2
Self-propelled loaders	1000 kW	165.0	92.0
Other self-propelled power machines	1000 kW	201.5	141.1
Agricultural trucks	1000 kW	360.6	703.1
Power machines	1000 kW	3 428.7	7 577.7
Engine power per piece			
Tractors	kW/piece	89.2	56.0
Combines	kW/piece	201.3	139.5
Other self-propelled harvesters	kW/piece	155.5	77.3
Self-propelled loaders	kW/piece	55.0	46.0
Other self-propelled power machines	kW/piece	78.9	45.4
Agricultural trucks	kW/piece	72.4	66.2
Power machines	kW/piece	95.4	61.6
Number of machines per agricultural area			
Tractors	pieces/1000 ha	9.84	40.64
Combines	pieces/1000 ha	1.56	3.04
Other self-propelled harvesters	pieces/1000 ha	0.40	0.34
Self-propelled loaders	pieces/1000 ha	1.39	0.82
Other self-propelled power machines	pieces/1000 ha	1.19	1.28
Agricultural trucks	pieces/1000 ha	2.31	4.36
Power machines	pieces/1000 ha	16.68	50.48
Engine power per agricultural area			
Tractors	kW/1000 ha	877.5	2 267.7
Combines	kW/1000 ha	314.3	424.2
Other self-propelled harvesters	kW/1000 ha	61.7	26.3
Self-propelled loaders	kW/1000 ha	76.6	37.8
Other self-propelled power machines	kW/1000 ha	93.5	57.9
Agricultural trucks	kW/1000 ha	167.3	288.7
Power machines	kW/1000 ha	1 590.9	3 111.7

Source: KSH 2014

As seen in Table 1, most of the machines are younger than 10 years and of a larger kilowatt size in corporations, whereas their age is between 21 and 30 years in the case of sole proprietorship. The capacity of engine power per agricultural area is significant, however the number of machines per farm is very low (0.253 pieces/farm). In order to increase the number of the machines and address this situation, farms outsource agricultural works.

In Hungary, the number of tractors exceeded 100 000 in the early 2000s (World Bank 2017). In 2013, the average kilowatt size of power machines was 95.4 kW/piece for corporations and 61.6 kW/piece for sole proprietorship (see Table 2). It can be seen that, in the case of corporations, this number is higher because their land area is bigger than for sole proprietorship, thus they can work at lower costs.

According to the data of the Research Institute of Agricultural Economics, the agricultural machinery market in Hungary is characterised by fluctuation, because one of the most important factors when it comes to numbers is the availability of EU funding (AKI 2017). The machinery market responded intensively to machinery purchase funding opportunities, with machine sales falling after the end of subsidies. This is proved by the fact that the number of high engine power tractors (over 81 engine HP[2]) per farm increased by 450% between 2000 and 2013, while the number of tractors with low engine capacity (less than 26 engine HP) dropped by half (see Table 3).

Table 3. Farm mechanisation changes in the period 2000–2013

	Number of machines (thousand pieces)			Rate (2000=100%)	Number of machines per farm (pieces)			Rate (2000=100%)
	2000	2005	2013		2000	2005	2013	
Tractors	123.5	128.3	120.2	97.3	0.13	0.05	0.09	73.8
< 26 HP	28.2	24.0	14.1	50.0	0.03	0.03	0.03	97.9
27-80 HP	75.9	67.0	59.5	78.4	0.08	0.09	0.12	153.5
> 81 HP	19.5	37.3	46.6	239.2	0.02	0.05	0.09	468.2
Combines	12.1	12.1	10.8	88.9	0.01	0.02	0.02	174.1

Source: Bíró et al. 2015

Total equipment increased in the world and on the European market by 2013, but it decreased between 2014 and 2015 (CEMA 2015). However, the expansion of the Hungarian machinery market continued until 2014 and sales declined only in 2015 as funding closed.

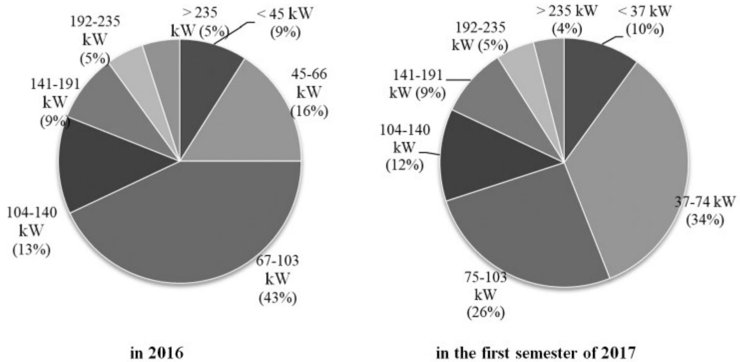
[2] 1 horsepower (1 HP) = 0.745699872 kW (kilowatt)

Table 4. Number of machines sold in Hungary between 2013 and 2016 (pieces)

Agricultural machine and engine size	2013	2014	2015	2016
Tractors	1 967	3 737	2 777	2 279
≤44 kW	170	216	280	200
45-66 kW	575	936	581	355
67-103 kW	709	1 651	1 252	972
104-140 kW	245	517	313	305
141-191 kW	124	265	189	218
192-235 kW	51	74	80	113
≥236 kW	93	78	82	116
Combines	272	264	371	314
≤198 kW	62	60	99	55
199-220 kW	40	34	32	23
≥221 kW	170	170	240	236
Self-propelled loaders	315	630	375	338

Source: AKI 2017

The values in Table 4 show that the number of tractors sold in 2014 was about 50% higher than in the previous year. 371 pieces of combines were sold in 2015, 40 percent more than a year earlier. It was an intensive year for EU agricultural subsidies available to farmers. The demand for the largest engine power machines (over 221 kW and 300 engine HP) increased by 41 percent and 240 pieces of such combines were sold. 2 777 pieces of tractors were sold in 2015, that is 26 percent less than a year earlier. Except for the lowest and highest engine power tractors, sales dropped significantly for all capacity categories. 45 percent of sold tractors (1 252 pieces) had an engine power of 67-103 kW. In addition to the sales of new equipment, the market of spare parts doubled in ten years, which may indicate an increase in the lifetime of the machines, despite of funding and sales (AKI 2017). In 2016, 61 percent of total agricultural machinery investments were related to power machines and 39 percent to other implements. The investment amount decreased by 39% in 2016 compared with 2014, while demand for more powerful machines witnessed a rapid growth on the market. As Figure 1 shows, tractors with engine power of 67-103 kW were the best-selling machines in 2016, although the sales of over 235 kW tractors have also increased in recent years. The average engine size of combines also increased from 2009 to 2016 (by 30% in the case of over 220 kW capacities), thus engine power per machine also grew.



Source: AKI 2017

Figure 1. Engine power of tractors in Hungary

As seen in Table 4, the Hungarian machinery market is characterised by quantity changes and the demand for new machines depends on the availability of EU and/or national funding. Many new machines have been introduced in the crop production sector and, due to the funding available, they could also be purchased in the livestock and horticultural sectors. In recent years, the average productivity of Hungarian agriculture has improved, which is due not only to the increase in technical equipment but also to the improvement of asset efficiency. At the same time, arable crop-producing farms have been characterised by growth. The increase in the technical equipment supply was not accompanied by improvements in capital productivity. Investment subsidies may have played an important role in this process (Takácsné–Takács 2016).

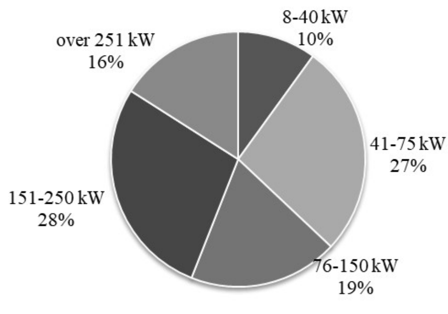
The NARIC MGI annually monitors operating costs based on Hungarian farm data. As Table 5 shows, these data are similar to previous ones, although the average machine age is lower (12.3 years) than the national average. Examining machine capacities, it can be seen that the proportion of 151-250 kW engine power machines grew most notably in 2015 (37.6% of the machines). Farm data have changed only slightly in recent years (e.g. average farm size, number of agricultural machines, average machine age, etc.). Unfortunately, the machine procurement funding has not achieved the desired results. Investments in machinery are slow and non-intensive, therefore the average machine age has not decreased in recent years. Repair and maintenance, operator labour and overhead costs per repair hour have increased steadily.

In agriculture, buying new equipment is important and requires significant financial sources. The Hungarian Tax Code allows farmers to depreciate farming equipment over seven years, but the owners are ready to replace equipment only after ca. 12 years of use.

Table 5. Agricultural machinery in the period 2013–2016

	Unit	2013	2014	2015	2016
Capacity					
Tractors	kW/piece	93.6	100.3	96.5	89.2
Combines	kW/piece	288.1	304.3	293.5	231.8
Self-propelled loaders	kW/piece	65.7	65.4	67.4	65.1
Other self-propelled harvesters	kW/piece	375.0	375.0	375.0	375.0
Other self-propelled machines	kW/piece	147.3	149.3	153.0	93.0
Average of power machines	kW/piece	103.9	110.9	109.2	96.9
Average age					
Tractors	year	13.2	11.6	12.4	13.4
Combines	year	3.1	2.3	3.0	3.0
Self-propelled loaders	year	15.1	16.4	16.0	17.0
Other self-propelled harvesters	year	1.0	2.0	3.0	0.0
Other self-propelled machines	year	4.4	5.4	6.5	4.3
Average of power machines	year	13.2	11.8	12.3	12.0
Proportion of tractor engine power					
21-40 kW	%	4.2	3.1	4.2	4.8
41-75 kW	%	36.2	32.4	32.1	27.3
76-150 kW	%	21.0	23.0	21.6	19.4
151-250 kW	%	33.2	35.5	37.1	27.5
over 251 kW	%	5.4	6.0	6.0	16.4
Number of tractors per farm	pieces/farm	13.0	13.8	14.5	13.4
Number of power machines per farm	pieces/farm	23.0	23.0	23.5	22.7

Source: author's own calculations based on NARIC MGI (2017) data



Source: author's own calculations based on NARIC MGI (2017) data

Figure 2. Engine power of tractors

As Figure 2 shows, tractors with engine power of 41-75 kW and 151-250 kW were the favourite type of machines in 2016 on Hungarian "base farms".

Operating costs of agricultural machinery in previous years

Why is it important to monitor the operating costs? Machinery and equipment are major cost items in farm businesses. Larger machines, new technology, higher prices for parts and new machinery have all caused machinery and power costs to rise in recent years. However, farmers and good machinery managers can control machinery and power costs per hectare. Making smart decisions about how to acquire machinery and in how much capacity to invest can reduce machinery costs. All these decisions require accurate estimates of the costs of owning and operating farm machinery.

Total operating costs of machines depend on several factors. It is important to keep in mind the optimum farm and land size, to choose the most suitable equipment and the most appropriate engine power. If farmers choose the most suitable machines, that could have a positive impact on profit. The profit of farms can increase if farmers choose the most suitable machines economically speaking. At the end of service life, all equipment becomes uneconomical and should be replaced. Typically, new equipment operates at low repair and maintenance costs. The skill of the operator, working conditions, and maintenance standards are recognised as important determinants of machinery repair costs, many aspects of which lie within the farmer's control (Morris 1988). If farmers do not reduce their operating expenses, they will not be able to compete in the agricultural sector effectively.

Nowadays, agricultural machinery distributors offer more machine types than in previous years. Farms operate with several machines, thus the analysis of operating costs is more complicated and detailed machine operating costs are generally not available. Table 6 shows the most important "base farm" data.

In my calculation, the total operating cost is the sum of the following costs: direct costs (fuel and lubricants, operator labour, repair and maintenance, machinery depreciation, other expenses) and indirect costs (fixed and current assets, general costs).

The total operating cost of agricultural machines per hectare is very hectic and the repair and maintenance cost increased in 2016. The price of electricity diminished as determined by the Hungarian government, therefore the total energy cost per hectare also decreased significantly.

Table 6. Machinery costs of "base farms"

	Unit	2013	2014	2015	2016	2016/2015 (%)
Area cultivated by machines	hectare	3 558	3 571	3 517	2 927	83.2
Engine power per piece	kW/piece	103.6	110.9	109.2	96.9	88.7
Annual usage of tractors	hour/piece	1 276	1 243	1 255	967	77.0
Annual usage of power machines	hour/piece	1 195	1 210	999	968	96.9
Repair and maintenance costs of tractors	HUF/nha	1 312	1 376	1 323	1 420	107.3
Repair and maintenance costs of power machines	HUF/nha	1 554	1 677	1 845	1 881	101.9
Repair and maintenance costs of self-propelled power machines	HUF/ha	20 564	21 055	18 298	19 913	108.8
Repair and maintenance costs of self-propelled and non-self-propelled power machines	HUF/ha	33 492	36 635	30 004	34 829	116.0
Total repair hours of power machines	hour/piece	184.0	202.3	194.4	121.9	62.7
Share of repair and maintenance costs of power machines in total operating costs	%	27.3	29.5	29.6	30.4	102.7
Share in total operating costs of						
fuel and lubricants	%	42.7	41.0	38.5	34.1	88.6
operator labour	%	18.2	17.7	19.3	21.2	109.8
repair and maintenance costs	%	20.6	21.8	22.8	23.2	101.8
machinery depreciation	%	18.5	19.5	19.5	20.0	102.6
Annual usage cost of tractors	HUF/hour	6 850	7 618	7 191	6 596	91.7
Annual usage cost of combines	HUF/hour	24 461	24 939	21 407	19 241	89.9
Annual usage cost of power machines	HUF/hour	7 502	8 342	8 167	6 947	85.0
Operating cost of tractors	HUF/nha	6 695	6 688	6 631	6 944	104.7
Operating cost of power machines	HUF/nha	7 445	7 587	7 923	8 333	105.2
Operating cost of tractors	HUF/ha	61 371	57 474	58 383	61 178	104.8
Operating cost of power machines	HUF/ha	93 821	91 998	96 033	93 516	97.4

Note: 1 nha = 26.315 kWh

Source: author's own calculations based on NARIC MGI (2017) data

Operating costs of agricultural machinery in 2017

The forecast calculation for 2017 was determined by farm data, the experiences of machinery and parts distributors, the data of the Hungarian Central

Statistical Office and the Research Institute of Agricultural Economics, as well as by the provisions of different applicable acts. Technical information, such as life expectancies, fuel consumptions, repair and maintenance costs, and insurance rates, is adjusted from time to time, based on the information received from researchers, manufacturers and users of equipment.

My aim is to assist farmers, extension personnel, and others involved in costing farm operations and machinery decision-making. Prices of similar agricultural machinery vary between firms and regions. The performance of machines also varies under different working conditions. The performance of a machine is also dependent upon the type of work it is doing. The performance will also depend upon the age and condition of the machine. The operating costs of machines with engine power of 20 kW and under are too high and they are used in agriculture only in special cases. I emphasise that these data are averages. Total operating costs for a particular type of machines vary widely from one geographic region to another because of soil type, climate, and other conditions. Table 7 presents the performance and estimated prices of some agricultural equipment.

Table 8 shows the estimated operating costs of some agricultural equipment. In the case of agricultural works, the total operating cost is determined by soil condition. There are four categories of soil conditions (I, II, III, IV). Category I means flat (0-5.0%) and medium-heavy soils. This research includes calculations related only to category I, without getting into more detail. The calculated operating costs of agricultural machine works are shown in Table 9. The actual costs of "base farms" for 2017 are still under analysis.

Cost reduction possibilities

Effective cost management is very important to farmers. Thus, they have to pay attention to the possibilities of making farming more efficient and less expensive. To improve the current situation, all farmers and managers should be aware of the prices, production costs, profitability, as well as of the factors influencing them. The prerequisite for good management and development decisions is to know the performance, costs, and fuel consumption of the machines.

Based on the various domestic studies, it can be stated that some factors of operating costs are constantly changing in practice and therefore, to ensure a profitable management, steps have to be taken to economise costs. Machine operating costs can be reduced.

Table 7. Equipment prices and performance

Engine power [kW]	Engine power average [kW]	Machine price			Machine performance			
		[thousand HUF/kW]	[1000HUF/ piece]	Depreciation [HUF/piece]	[usage hour/ year]	Capacity utilisation [%]	[nha/usage hour]	[nha/year]
Tractors								
21-40	30	209.3	6 280	4 710	1 500	24	0.274	410
41-75	58	166.7	9 667	7 250	1 600	27	0.595	952
76-100	88	213.5	18 790	14 092	1 700	31	1.037	1 762
101-150	125	250.9	31 360	23 520	1 800	35	1.663	2 993
151-200	175	250.6	43 854	32 891	1 900	38	2.527	4 801
201-250	225	244.3	54 965	41 224	2 000	40	3.420	6 840
Combines								
76-100	88	283.7	24 969	18 727	550	30	1.003	552
101-150	125	283.7	35 468	26 601	575	31	1.473	847
151-200	175	283.7	49 655	37 241	600	32	2.128	1 277
201-250	225	283.7	63 842	47 882	625	33	2.822	1 763
Self-propelled loaders								
21-40	30	503.4	15 101	11 326	1 600	25	0.285	456
41-75	58	482.1	27 959	20 969	1 700	26	0.573	974
76-100	88	460.7	40 546	30 409	1 800	27	0.903	1 625
101-150	125	439.4	54 930	41 198	1 900	28	1.330	2 527
151-200	175	418.1	73 174	54 881	2 000	29	1.929	3 857
Self-propelled harvesters								
Mowers								
201-250	225	312.1	70 215	52 661	600	30	2.565	1 539
251-300	275	312.1	85 833	64 375	600	32	3.344	2 006
Forage harvesters								
251-300	275	219.4	60 346	45 260	600	31	3.240	1 944
301-350	325	211.9	68 872	51 654	625	32	3.952	2 470
Other self-propelled harvesters								
21-40	30	312.1	9 362	7 021	400	24	0.274	109
41-75	58	312.1	18 100	13 575	450	25	0.551	248
76-100	88	312.1	27 462	20 596	500	26	0.869	435
101-150	125	312.1	39 008	29 256	525	27	1.283	673
151-200	175	312.1	54 612	40 959	550	28	1.862	1 024
201-250	225	312.1	70 215	52 661	575	29	2.480	1 426

Note: 1 nha = 26.315 kWh

Source: Erdeiné Késmárki-Gally et al. 2017

Table 8. Total operating costs of machines (without tax)

Engine power [kW]	Engine power average [kW]	Costs							Total operating cost
		Fuel and lubricant	Labour	Repair and maintenance	Depreci-ation	Other costs	Fixed and current assets	General costs	
		[HUF/nha]							
Tractors									
21-40	30	3 420	4 877	2 391	1 148	534	304	618	13 292
41-75	58	3 197	2 376	1 885	761	363	204	429	9 215
76-100	88	3 008	1 445	1 513	800	264	201	352	7 584
101-150	125	2 853	956	1 279	786	223	193	305	6 595
151-200	175	2 736	666	1 106	685	196	168	269	5 827
201-250	225	2 621	522	984	603	178	149	245	5 301
Combines									
76-100	88	3 102	1 678	3 810	3 394	586	740	628	13 938
101-150	125	2 944	1 212	3 357	3 142	474	681	556	12 366
151-200	175	2 839	889	2 916	2 917	388	630	497	11 077
201-250	225	2 770	711	2 531	2 715	335	585	453	10 101
Self-propelled loaders									
21-40	30	3 537	5 257	4 333	2 484	627	588	812	17 638
41-75	58	3 309	2 772	3 989	2 152	467	501	635	13 826
76-100	88	3 146	1 865	3 852	1 871	400	436	557	12 125
101-150	125	3 051	1 342	3 783	1 630	366	383	509	11 064
151-200	175	2 955	981	3 714	1 423	333	338	470	10 214
Self-propelled harvesters									
Mowers									
201-250	225	2 680	783	2 784	3 422	314	728	499	11 210
251-300	275	2 570	663	1 841	3 208	255	677	427	9 641
Forage harvesters									
251-300	275	2 674	657	6 205	2 328	432	532	615	13 444
301-350	325	2 626	571	5 640	2 091	396	480	566	12 369
Other self-propelled harvesters									
21-40	30	3 249	5 476	5 190	6 416	1 053	1 383	1 069	23 836
41-75	58	3 087	2 883	4 691	5 475	670	1 170	840	18 817
76-100	88	2 944	1 936	4 192	4 738	516	1 011	716	16 053
101-150	125	2 818	1 392	3 692	4 345	424	924	634	14 228
151-200	175	2 741	1 016	3 208	3 999	363	849	566	12 743
201-250	225	2 700	809	2 784	3 694	317	783	515	11 602

Note: 1 nha = 26.315 kWh

Source: Erdeiné Késmárki-Gally et al. 2017

Table 9. Total operating costs of the major types of works on category I soil[3] and in the case of smaller capacity size, 2017 (without TAX)

Activity	Engine power [kW]	Total operating cost (HUF/ha)
Ploughing under 20 cm	21-40	14 414
Ploughing under 20 cm	41-75	10 337
Ploughing between 21-26 cm	21-40	20 901
Ploughing between 21-26 cm	41-75	14 989
Ploughing between 27-32 cm	21-40	25 225
Ploughing between 27-32 cm	41-75	18 090
Smoothing	21-40	5 042
Smoothing	41-75	3 615
Rolling	21-40	5 035
Rolling	41-75	3 608
Cultivation (loosening and tilling)	21-40	6 610
Cultivation (loosening and tilling)	41-75	4 980
Sowing (cereals)	21-40	7 508
Sowing (cereals)	41-75	6 163
Sowing (corn)	21-40	8 823
Sowing (corn)	41-75	7 274
Sowing (sugar beet)	21-40	11 287
Sowing (sugar beet)	41-75	9 697
Sowing (vegetable)	21-40	13 336
Sowing (vegetable)	41-75	11 501
Spraying	21-40	5 427
Spraying	41-75	4 204
Fertilising	21-40	3 927
Fertilising	41-75	2 907
Manuring (organic fertilisers)	21-40	23 519
Manuring (organic fertilisers)	41-75	19 442
Slurry injection	21-40	64 389
Slurry injection	41-75	48 081
Mowing	21-40	9 248
Mowing	41-75	7 209

[3] Category I: flat, medium-heavy soils; category II: flat, bound soils, multiplier 1.16; category III: flat, loose sand, heavy soils, slightly sloping and medium-heavy soils, multiplier 1.38 (in case of soil works) and 1.24 (in soil surface works); category IV: slightly sloping, loose sand and heavy soils, sloping and heavy soils, multiplier 1.72 (in case of soil works) and 1.44 (in soil surface works). Flat: 0-5.0%; slight slope: 5.1-12.0%; strongly sloping: 12.1-17.0%

Activity	Engine power [kW]	Total operating cost (HUF/ha)
Baling with small baler (2 t/ha)	21-40	7 892
Baling with small baler (2 t/ha)	41-75	6 262
Baling with small baler (4 t/ha)	21-40	15 785
Baling with small baler (4 t/ha)	41-75	12 523
Baling with big baler (2 t/ha)	41-75	9 392
Baling with big baler (4 t/ha)	41-75	18 785
Bale packaging (2 t/ha)	21-40	3 925
Bale packaging (2 t/ha)	41-75	3 110
Bale packaging (4 t/ha)	21-40	7 851
Bale packaging (4 t/ha)	41-75	6 220
Harvesting (cereals) (4 t/ha)	76-100	22 301
Harvesting (cereals) (4 t/ha)	101-150	19 786
Harvesting (cereals) (7 t/ha)	76-100	39 028
Harvesting (cereals) (7 t/ha)	101-150	34 626
Harvesting (corn) (5 t/ha)	76-100	27 877
Harvesting (corn) (5 t/ha)	101-150	24 733
Harvesting (corn) (8 t/ha)	76-100	44 603
Harvesting (corn) (8 t/ha)	101-150	39 572
Harvesting (sunflower)	76-100	18 120
Harvesting (sunflower)	101-150	16 076
Harvesting (oilseed rape)	76-100	21 744
Harvesting (oilseed rape)	101-150	19 292
Harvesting (sugar beet)	101-150	54 067
Harvesting (potato)	41-75	60 375
Harvesting (tobacco)	41-75	47 042
Harvesting (berry fruit)	41-75	37 634

Source: Erdeiné Késmárki-Gally et al. 2017

To reduce costs, it is important to improve the way in which machines are used and increase their annual performance. It is possible to improve the annual usage of machines in hours by getting agricultural work better organised. Another important thing is fuel consumption. The cost of propellant per performance unit can be reduced by higher technical standards, optimal machine-equipment combination, proper engine maintenance, as well as optimal machine capacity. According to my research, the operating costs of more powerful engines are more favourable under normal use conditions. Insurance costs are determined by the various insurance companies and significant cost savings can be achieved with the right insurance agreement.

Total operating costs are difficult to estimate as they vary greatly depending on operating conditions, management, soil condition, maintenance programmes, local costs, etc. In recent years, the productivity of Hungarian agriculture has improved due to technical equipment supply growth and equipment efficiency improvements.

As previously seen, in order to improve effectiveness, producers need to increase work efficiency, quality and discipline, as well as to reduce costs. It is important to improve machine utilisation and increase annual performance and usage hours as, thus, operating costs may decrease.

Agricultural machinery cooperation

During the agricultural production process, farmers cooperate with different groups and organisations. In Hungary, a diverse system of farmers' organisations was developed (e.g. agricultural cooperatives, equipment rental services, professional organisations, etc.). The goals of these cooperation efforts are to achieve a better market position and to access financing sources.

The extent of cooperative forms per country or region is fundamentally influenced by ownership and farm size. Thus, the machine work service spread large-scale monoculture farms in the United States (Sirinathsinghji 2013), whereas in France the cooperative form is more typical (Draperi 2015). In other Western European countries, where family farms dominate, other professional organisations can be found. Of course, in most European countries, there are other machinery cooperation forms.

Similar to the other European examples, the cooperation of farmers is also important in Hungary. The following agricultural machinery cooperation forms can be found in Hungary: agricultural cooperatives, equipment rental services, machinery service providers, and machinery rings (Takács et al. 1996; Takács–Baranyai 2013).

But what characterises these forms? The first agricultural cooperatives were created in Europe in the seventeenth century. An agricultural cooperative is a cooperative where farmers pool their resources in certain areas of activity. A broad typology of agricultural cooperatives distinguishes between agricultural service cooperatives, which provide various services to their individually farming members, and agricultural production cooperatives, where production resources (land, machinery) are pooled and members farm jointly. In agriculture, there are broadly three types of cooperatives: machinery pool, manufacturing/ marketing cooperative, and credit union. Machinery pool: a family farm may be too small to justify the purchase of expensive farm machinery, which may only be used irregularly. Local farmers may get together to form a machinery pool that purchases the necessary equipment for all the members to use. The agricultural equipment is owned by the members and they sell free machine capacity to non-members. This form is mainly spread among specialised farmers with clear tasks and appropriately distributed capacities. In this case, farmers manage the machines. It has several advantages and disadvantages. The advantage of agricultural cooperatives is that farmers divide machine investment costs and reduce operating costs, thereby reducing production costs. The disadvantage of this form is that the cooperative goes together with greater administration requirements and higher costs. An accurate allocation of capacities is also more difficult to achieve. Waiting times may also be longer and more consultation is needed for planning and organising machine works.

Equipment rental refers to a service providing machinery, equipment and tools of all kinds and sizes for a limited period of time to final users. In the case of an agricultural machinery rental service, it provides machines and only minimal technical assistance on machine use. Farmers have to know how to operate the machines. This relationship is business-based, while other forms of machine utilisation are mostly characterised by professional knowledge transfer. The advantage of rental services is that they have professional knowledge about machine use and they often offer farmers the best solution (e.g. a quick solution in case of a non-functioning machine). Another advantage is that investment and maintenance costs may be reduced. In addition, the farmer is independent from others (e.g. in time). The disadvantage of this form is that the technical condition of the rented machine is completely unknown. The risk of failure is greater. It takes a lot of time to receive compensation for damages which, in many cases, is not even possible to get.

In countries with an advanced agriculture, machinery service providers play an important role in carrying out production tasks in a timely and adequate manner. In the United States, relatively large organisations have been established. In Western Europe, the owners of harvesting machines have set up such enterprises. Most of them own a farm and they deliver machine services as a secondary activity. The intensity of the two activities may be different. There are farmers who do not have land and they only service machine works. The advantage of an agricultural machinery service is the high professionalism. Generally, they work with the most innovative and high-performance machines and they have the best production technology knowledge. Farmers can save on investment costs. However, there is also a disadvantage: the vulnerability that may arise both from service prices and when the services are performed.

A cost-efficient and common machine use form is the machinery ring which can be found in Western Europe (e.g. in Austria and in Germany). Machinery rings are aggregations organised by the farmers themselves. With joint investments and mutual aid, the managing process of the individual farm should become more efficient. Most of machinery rings are managed by professional employees. They support their members by providing them with a structure for common projects and canvassing projects with new business for extra income. Its fundamental feature is that farmers integrate their own machines into the organisation and keep the ownership of the machines. Machine purchases are coordinated, so specialisation is developed individually, while complex machining solutions and machine systems are created within the machine range, according to production needs. Members usually have fewer machines than their required activities, but with the help of services, they can perform all the technological operations in a proper and timely manner. They can provide an adequate tool for all technological tasks. Currently, nearly 300 machinery rings operate in Germany, with 200 000 members. 35% of the farms are members of these organisations and they cultivate about 45% of the agricultural land. In Austria, there are around 170 machinery rings and the government supports these organisations, although funding may be different in the provinces. This cooperation form is also important in Central and Eastern European countries (GÉPKÖR 2017). The advantage of this form is that the costs of services remain with the farmers. It can cover almost all the activities involving farmers. Another advantage is that, by increasing the viability of farming, members largely create the necessary conditions for business operations, thus ensuring the sustainability of agricultural production. According to Tóthné Heim (2011), the strengths of machinery rings are that a member is also owner of the machine and sells its unnecessary capacity in the market. It reduces the major costs of machine ownership (interest and depreciation). A more efficient use of machinery enables farmers to earn extra income from using their farm machinery. Its disadvantage is that cooperation requires significant organisational work.

In Hungary, its operation is based on *Act CLXXV of 2011 on the right of association, public utility status, and the operation and funding of civil society organisations* (Government of Hungary 2011). In recent years, machinery rings have been characterised by stagnation and sometimes recession. Unfortunately, their activity has also decreased and, in many cases, their real work is not very perceptible in Hungary.

The benefits of the above-mentioned professional organisation are the following (GÉPKÖR 2017):

- Contribution to a more rational use of technical resources, reduction of disadvantages resulting from overcapacity;
- Saving of machinery costs per farm (30-80%);
- Saving of operating costs due to optimal machine utilisation (20-35%).

All of the above-mentioned forms of machine utilisation are already found in practice in Hungary. However, operation within an organised framework has not yet been developed or it has only partially been developed. As far as the organised cooperation form is concerned, agricultural machinery services are the most well-known in Hungary. Equipment rental services are also often found in practice, but this form only means farmers lending machines to other farmers.

Machinery cooperatives are not well-known in Hungary (Tóthné Heim 2011).

In my view, cooperation forms can only be effective if they are built on one another or are complementary to one another.

Discussion and conclusions

Based on the data of the Hungarian Central Statistical Office, the proportion of tractors older than 20 years was not that high at the end of 2013, therefore higher capacity tractors were newer. Nowadays, the average farm size of individual farmers is still small. Most of them do not own machinery and, therefore, they depend on agricultural machinery service providers. As a solution to this unfavourable situation, they would like to increase the number of equipment items, but mostly with old machines, which causes a further increase of the average machine age. Farmers purchased more agricultural equipment in 2014 than in previous years. In recent years, machine purchase subsidies have had a good impact on the number of agricultural power machines and their average age.

According to the data taken from NARIC database, the average machine age is 12.0 years, which is better than national numbers. To rejuvenate the Hungarian agricultural power machine stock, producers should buy approximately ten to twenty thousand new power machines per year. In the agricultural sector, after the end of EU subsidies, machinery purchases have not been significant, which means that the number of older machines has started to grow. Unfortunately, in many cases, machinery purchases have not been based on the right decision. According to my analysis, the capacity of machines newer than 10 years is double compared to older ones.

Analysing data and trends, it can be stated that there is a lack of some types of machines (e.g. advanced plant protection machines), while the quantity and capacity of other machines is too high, which causes excess capacity and poor asset utilisation (e.g. tractors, tillage equipment) in Hungary.

It is important for farmers and managers to monitor and reduce their operating costs. In case of long-term use, the operating cost of power machines increases significantly, thus it is essential to replace old equipment. In order to improve the efficiency of farming, the efficiency of machines should be increased, their quality improved and costs reduced. The ways to reduce costs are the following:

- Improve machine utilisation;
- Increase annual performance;
- Ensure better organisation and management of machine works;
- Choose agricultural machines and engine capacity according to farm and land size;
- Be careful with maintenance and repair works;
- Replace machines in time;
- Depreciate the machine according to its price;
- Cooperate with others.

To reduce operating costs, agricultural cooperation forms may also prove advantageous in Hungary. Such cooperation forms exist in Hungary, but their work is not very intensive. Their system, strategy and structure must be defined. Unfortunately, it can often be seen that certain concepts are unclear and mixed in Hungary and, therefore, misunderstandings and cooperation problems may arise. It is important to develop solutions, methods, and models that, on the one hand, help to compile machinery based on the existing toolbox, but with higher efficiency, greater safety and lower costs, and, on the other hand, help to plan and implement mechanisation development processes both technically and economically.

Total operating costs are difficult to estimate as they vary greatly depending on operating conditions, management, maintenance programmes, local costs, etc. It is important for everybody to keep in mind that favourable production costs may only be achieved through appropriate expertise and concentration of production, appropriately sized machine fleet and the well-managed use of machinery.

In this paper, I have examined operating costs and analysed the causes of changes in the Hungarian machinery market. But these conclusions should be carried forward into models and calculations. Above all, my future task is to develop such models and measure cost reduction.

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