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FORUM
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Contents

Recent trends in public and private agricultural research expenditure in Hungary[1]

ANDREW F. FIELDSEND[2]

This paper is based on a case study conducted in the frame of the European Union (EU) Framework 7 project IMPRESA which aimed to evaluate the impact of EU research on agriculture. Official data sets were used to show trends in agricultural research expenditure in Hungary from 2008 onwards, focusing on public and private research efforts, research strategy and priority areas, research staff and evaluation of research, and dissemination of research results. The factors behind these trends were explored through semi-structured, face-to-face interviews with key experts. Total R&D expenditure (not adjusted for inflation) in the field of science 'agricultural sciences' increased from HUF 19.7 billion in 2008 to HUF 22.1 billion in 2016. There was a marked decline in expenditure at public-sector R&D institutes and (until 2015) broadly constant R&D activity at universities, while that of the business sector increased. Public-sector R&D institutes have been reorganised in an attempt to improve their efficiency and effectiveness, but several further actions are needed. These include the development of a national agricultural research strategy, the recruitment of younger, innovative staff coupled with the provision of motivating conditions of work, and a greater emphasis on applied research together with more effective evaluation of research impact.

Keywords: agricultural research, field of science, socio-economic objective, sector of performance, R&D institutes, HE institutes, business enterprises.

JEL code: Q16.

Introduction

Agriculture continues to be an important part of the Hungarian economy. In 2012 it accounted for 5.2 per cent of employment and 3.2 per cent of GDP, while the equivalent figures for the food industry were 3.3 and (in 2011) 2.3 per cent. There were around 5000 food companies in Hungary in 2011, of which 3600 had up to nine employees (Szczepaniak et al. 2014). Agricultural products accounted for 10.1 per cent of exports in 2012 and there was a positive trade balance of HUF 1043.5 billion (approximately EUR 3.4 billion). The largest product groups in terms of export value were cereals, meat and oilseeds/fodder (19, 12 and 10 per

[1] I thank the staff at KSH and AKI for their help in locating and interpreting the relevant data, and the interviewees for their time and patience. This work was partly funded by the EU Seventh Framework Programme grant number 609448. The opinions expressed in this paper are the responsibility of the author and do not necessarily reflect those of the EU.

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cent respectively) and in terms of import value meat, animal fodder and other consumable products (11, 10 and 8 per cent respectively) (VM 2013).

Of the 5 338 000 ha of agricultural area in 2012, 4 324 600 ha was arable land and 758 900 ha was grassland (VM 2013). In 2010, 8800 enterprises and 567 thousand private farms were engaged in agriculture (Andrási–Bóday 2012), accounting for 58.5 and 41.5 per cent of the agricultural area respectively (Tóth 2012). The number of farms has fallen by 41 per cent since 2000. Hungary has a bi-polar farm structure in terms of land area: in 2010, 92.3 per cent of individual farms occupied less than 10 ha of land while corporate farms larger than 300 ha amounted to 85.3 per cent of the whole agricultural area (Tóth 2012). Around 61 per cent of individual farms produced only for their own consumption and 20 per cent produced mainly for the market.

Mindful of the need for food security, growth and job creation in rural territories, and environmental management and climate change mitigation, the European Union (EU) attaches great importance to promoting the sustainable agricultural productivity growth (EC 2016). Investment in agricultural research, both public and private, is one of the factors that influences the level of agricultural total factor productivity (Midmore 2017), and globally the impacts of research on agricultural productivity growth have been studied extensively. Mogues et al. (2012) found that, for the second half of the 20th century, estimates of internal rates of return to investments in agricultural research frequently exceeded 60 per cent. On the other hand, lags between expenditure and their effects on productivity tend to be lengthy, for example estimated by Alston et al. (2010) in the USA to be a minimum of 35 years rising to 50 years. These lags can dampen political enthusiasm for funding agricultural research, notwithstanding the eventual potentially high rates of return.

The European policy context is the 'Innovation Union', one of the EU's seven 'Flagship Initiatives' for implementing its Europe 2020 Strategy of smart, sustainable and inclusive growth. Research and innovation have a critical role to play in the creation of economic prosperity and the resolution of major societal challenges (EC 2010). The aim of the Innovation Union is to enhance the effectiveness of research and development activities by building a solid research and innovation 'system' in Europe to ensure that new knowledge-intensive products and services contribute substantially to growth and jobs. The Innovation Union approach is just as relevant to agriculture as to any other sector of the economy.

There have been few attempts to measure the impact of European agricultural research on productivity and no analysis has yet been undertaken for the EU as a whole (Midmore 2017). To at least partly compensate for this, during the period 2013-2016 the EU Framework 7 research project IMPRESA[3] sought to measure, assess and comprehend the impact of all forms of European agricultural research on key agricultural policy goals, including farm-level productivity but also environmental enhancement and the efficiency of agri-food supply chains (Ruane 2014). Such studies require reliable data series that extend over several decades. Thus, the project began by preparing country-level analyses of the agricultural research expenditures and an assessment of the availabilities of data regarding public and private investments in agricultural research in 20 Member States across Europe, including Hungary (Fieldsend 2014). IMPRESA defined 'agricultural research' as covering all research on the promotion of agriculture, forestry, fisheries and foodstuff production. It includes research on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture; research on the impact of agricultural and forestry activities on the environment; and research in the field of developing food productivity and technology.

This paper presents an assessment of recent agricultural investment trends in Hungary using a mixed-methods approach involving data analysis and semi-structured interviews. The research focuses on public and private research efforts, research strategy and priority areas, research staff and evaluation of research, and dissemination of research results. It identifies positive developments and areas where further actions are needed. The paper presents an abridged set of results (i.e. those that are of general interest beyond the project) from the IMPRESA country case study, but updated to 2016, together with some additional data not considered in the IMPRESA project.

Methodology

A common methodology was used for all IMPRESA country case studies. The first objective of each case study was to investigate the general availability of data related to public and private investments in agricultural research at national level. In Hungary, this was done primarily through consultation with the Hungarian Central Statistical Office (KSH), which has the primary responsibility for data

[3] Impact of Research on EU Agriculture, http://www.impresa-project.eu/.

collection in Hungary in the frame of the National Statistical Data Collection Programme. The KSH has a designated expert for research, development and innovation statistics. For Hungary, it can be concluded that there is no shortage of quantitative data on agricultural R&D and that the KSH undertakes its data collection and distribution tasks in a professional and customer-focused way. The data can be assumed with confidence to be reliable.

The second objective was to review trends in agricultural research expenditure in Hungary in the period 2008-2012, i.e. following the onset of the global financial and economic crises, using KSH data sets. Monetary values are quoted at current prices, i.e. not corrected for inflation. The data are dependent on several definitions, many of which can be found in KSH (2012); some of the most notable ones are described below.

Three 'sectors of performance' are defined in line with the internationally-recognised Frascati Manual (OECD 2015):

- *Government sector*: all organisations performing research and development activities and financed by the government except higher education;
- *Higher education sector*: all universities, colleges and other institutes of post-secondary education which, besides their education tasks, perform research and experimental development activities;
- *Business enterprise sector*: all firms, organisations and institutions whose primary activity is the market production of goods or services for sale to the general public at an economically significant price and which perform research and experimental development activities as well.

Research and development can be classified according to the following criteria:

- *Socio-economic objective*: an R&D programme or project is classified according to its primary objective, i.e. its intended purpose or outcome. In 2007 there were 14 objectives, one of which was 'agriculture' (Eurostat 2008a);
- *Field of science*: nomenclature used to categorise research expenditures of the four 'sectors of performance' according to the research itself, rather than the main activity of the performing unit. One of the six categories is 'agricultural sciences'.

The factors behind these trends were explored through 30-45 minute, semi-structured, face-to-face interviews with experts from national statistical authorities (including the Ministry of Agriculture), agencies in charge of research, public and private research organisations, and farmers' and food industry associations. The interviews were conducted in July and August 2014. The anonymity of all interviewees is respected and no remarks reproduced in this paper should be attributed to any individual or organisation.

For this present paper, the data sets were updated to 2016, which means that the interview results can now be compared to statistical trends occurring both at the time and in the subsequent 18 months.

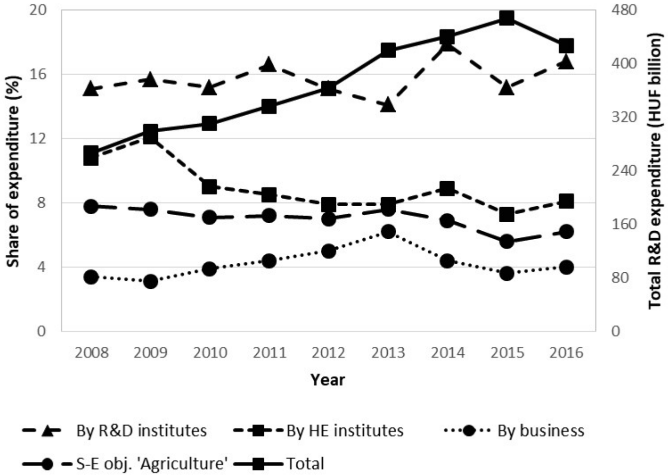
Results

Public-sector research effort

In nominal terms (i.e. not adjusted for inflation), total R&D expenditure in Hungary increased steadily from HUF 266 388 million in 2008 to HUF 468 390 million in 2015, followed by a slight decline in 2016 (Figure 1). The proportion of total R&D expenditure spent on agriculture as a socio-economic objective fell over this period from 7.8 to 7.0 per cent, but still showed a substantial increase. The share of total R&D expenditure allocated to agriculture differed by sector of performance. The share spent by R&D institutes (constant at around 16 per cent) was by far the highest of the three sectors, while that of the HE sector notably declined (from 10.8 to 7.9 per cent). The figure for the business enterprise sector increased slightly, from 3.4 to 4.4 per cent.

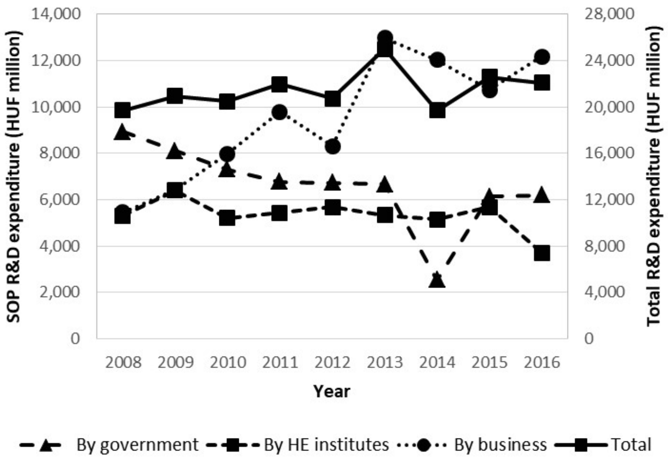
Total R&D expenditure in the field of science 'agricultural sciences' increased during the period 2008-2016, from HUF 19.7 to HUF 22.1 billion (Figure 2). Data disaggregated by sector of performance (SOP) show that, owing to a marked fall in government R&D expenditure, public-sector R&D expenditure declined from HUF 8939 million in 2008 to HUF 6207 million in 2016. It should be recalled that, as a percentage, the real-terms decline (i.e. after inflation is taken into account) would be even higher. This decline was compensated for by an overall increase in business enterprise R&D expenditure in nominal terms, although this remained constant or even declined since a peak in 2013. The figure for HE institutes remained almost constant at around HUF 5500 million in the period 2008-2015, but experienced a notable decline, to HUF 3703 million, in 2016.

The interviewees had conflicting views on the funding situation of public-sector research institutes and, to a lesser degree, universities, and this issue was interlinked with that of organisational restructuring, discussed below.



Sources: KSH (2012) Tables 2 and 20, KSH (2017) Tables 2 and 25, and other KSH annual publications on R&D

Figure 1. R&D expenditure in Hungary, 2008-2016 (in nominal terms)



Sources: KSH (2012) Table 44 and KSH (2017) Table 46

Figure 2. R&D expenditure in the field of science 'agricultural sciences' in Hungary, 2008-2016 (in nominal terms)

Public-sector research institutes are funded by state money, plus private and EU money. An interviewee who should be well placed to give correct information on funding stated that the institutes that are now part of the National Agricultural Research and Innovation Centre (NAIK)[4] depend primarily on government funding with "less than 10 per cent" of funds coming from the private sector. The priority of the current Hungarian government is no longer to save money on research but to spend money on research. The interviewee stated that this does not automatically imply an increase in public-sector funding, but rather to produce institutional changes that will result in real coordination of research. This has previously been lacking; previously individuals have been "trying to do their best", but there has been "no clear strategy and working plan" for individuals and institutions. Agricultural R&D is by nature a long-term activity that requires stability and this was the political rationale for setting up the NAIK.

While it is generally accepted by the interviewees, in line with the published data, that expenditure in public-sector agricultural R&D has declined in recent years, they analysed this trend in different ways. Some stated that, before the establishment of NAIK, most if not all the constituent institutes had financing problems. Insufficient money was available from national funds, but the institutes (and universities) were quite successful at obtaining funds from other sources such as the EU and the private sector. The tax arrangements in force encouraged the private sector to fund research at government institutes, providing "quite a huge" income. Recently the tax system has been restructured, reducing the income of the institutes from that source. Also, with the advent of NAIK, the individual institutes have less opportunity to apply for EU and national funds as they are not so independent and the administrative challenges are much bigger. Others say that private sector and EU funding of government sector institutes is currently increasing.

In terms of political priorities for agricultural R&D, an interviewee suggested that the biggest change in recent years has been "at the political level", with agricultural research now being considered as a "kind of investment". The result of this new approach is a stable political background and, through NAIK, better coordination of research.

[4] On 1 January 2014, many of the research institutes that formerly reported to the (then) Ministry of Rural Development, together with some other state-owned research institutes, were reorganised as thirteen agri-food and farming research institutes under the umbrella of NAIK. This now represents the main public sector funded research activity outside the universities. Four commercial spin-off companies are connected to it.

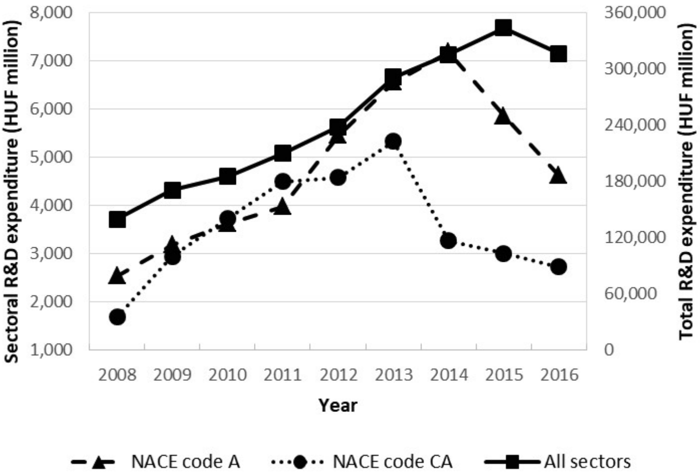
Other interviewees believe that the reason for the setting up of NAIK is centralisation and the elimination of separate 'kingdoms'. It is suggested that as the institutes were receiving relatively little funding from the Ministry of Agriculture they felt little obligation to respond to the needs of the Ministry. NAIK is perceived to be still 'under construction' in the sense that institutes are working together at the technical level, as a support service sector has been created for finance, infrastructure etc., but not scientifically. This is to be expected, of course, and, when the interviews were conducted, was still true for the National Food Chain Safety Office (NÉBIH), a 'background institute' of the Ministry of Agriculture that was formed in 2012 from several institutes, and was not yet operating in a fully integrated way.

The Ministry of Agriculture is liaising closely with the universities, as these are also seen as being "fragmented", with too many such institutions currently involved in agricultural education. The government wants a more concentrated university system that focuses more on education, with a different approach to research, and the intention is to define which tasks should be carried out in universities and which should be undertaken in research institutes. More university research units are likely to be transferred to NAIK (reversing the trend that can be traced back to 2000 when a major restructuring of the university sector took place), but it would still be possible for researchers to present lectures at the universities. This would be the future form of long-term collaboration.

Private-sector research effort

Total R&D expenditure in the Hungarian business enterprise sector increased from around HUF 140 billion in 2008 to around HUF 344 billion in 2015, but declined slightly in 2016 (Figure 3). Between 2008 and 2013, the rate of increase in R&D expenditure for NACE[5] codes A (agriculture, forestry and fishing) and CA (manufacture of food products, beverages and tobacco products) was higher than for total expenditure, and spending levels in the two sectors were similar. However, R&D expenditure for NACE code A fell from HUF 7189 million in 2014 to HUF 4633 million in 2016, while for NACE code CA it declined from HUF 5337 million in 2013 to HUF 2730 million in 2016.

[5] European Classification of Economic Activities (Eurostat 2008b).

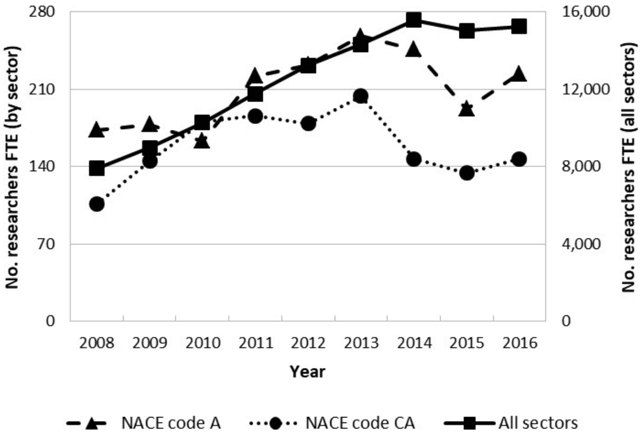


Sources: KSH (2012) Table 50 and KSH (2017) Table 50

Figure 3. R&D expenditure in the business enterprise sector in Hungary by NACE category, 2008-2016 (in nominal terms)

Trends in the numbers of researchers in the business enterprise sector reflected those for R&D expenditure. Total employees increased from 7912 in 2008 to a peak of 15 577 in 2014 (Figure 4). Numbers of researchers in both NACE code A and CA increased until 2013, but at a lower rate, and then declined substantially. In all years except 2010 the number of researchers in the former sector (agriculture) exceeded that in the latter (food manufacturing).

There was a strong conflict in opinions between interviewees on the level of business sector R&D activity in agriculture and the food industry in Hungary. Some interviewees suggest that the level of private-sector agricultural research activity has declined now that the tax system has changed but the KSH believed (as of 2014) that private-sector R&D in Hungary has grown even since the onset of the financial and economic crisis in 2008 and that, in general, private-sector R&D has been increasing while the public-sector R&D has been shrinking. This assessment was echoed by an interviewee from the private sector. It may be a question of how 'R&D' is defined. One view is that business sector 'investment' projects, that at best could be interpreted as 'process innovation', are described as 'research' projects as this allows the company to claim tax breaks. The KSH says that it has cross-checked their general business sector data against tax data and found that, if anything, the business sector claimed less tax against R&D than it was entitled to. On the other hand, the KSH notes that, of around 300 000 businesses in Hungary, fewer than 2000 carry out R&D.



Sources: KSH (2012) Table 49 and KSH (2017) Table 49

Figure 4. Number of researchers (FTE) in the business enterprise sector in Hungary by NACE category, 2008-2016

One interviewee stated that for several reasons Hungary has been a good place to locate commercial agricultural R&D. In the past it was the most easterly country in which that interviewee's company operated. Hungary is in the middle of Europe and as (in the 1980s) a western-focused member of the Eastern bloc it was "part of Europe but not". As Hungary is in the continental climate zone it is possible to select crop varieties that are adapted for the region. It is a 'gateway' for eastern Europe including ex-Soviet Union countries including Russia and to some extent Asia. Furthermore, the country already had the necessary infrastructure: good quality roads, utilities, and good water availability. The standard of agricultural education in Hungary is "unique" and the skills of the educated persons are high. Hungarian people are prepared to work.

Several large international agribusiness companies have well established, if relatively small, R&D operations in Hungary. Furthermore, one interviewee pointed out that, among relatively recent developments, the PannonPharma

Group took over the Research Institute for Medicinal Plants from government ownership in 2008, while the Bunge Europe Research and Development Centre was established in Budapest, working on sunflower and canola oils. There is a suggestion that investment in large R&D projects (e.g. buildings) is low but that the level of actual R&D activity is relatively high. The interviewee observed that the private sector is doing well-targeted research pursuant to their own interests and "doesn't make a lot of noise" about the results.

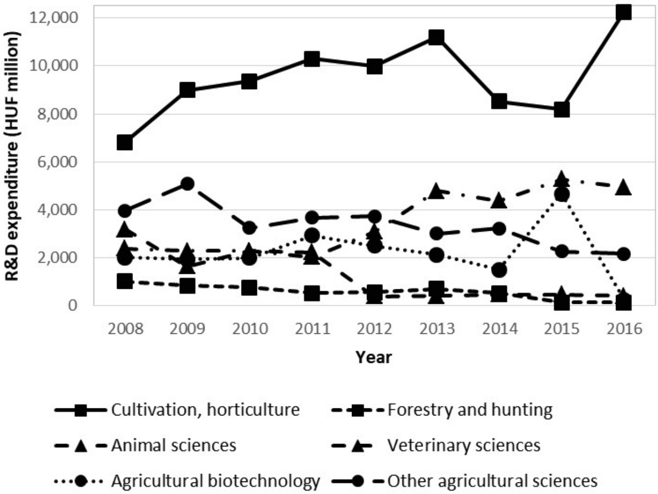
By contrast, another interviewee described Hungarian food industry research as being "fragmented" with a "far from satisfactory" level of private-sector activity. The difference in the level of activities between Hungary and, for example, the UK is "enormous". The latter has used innovation to address the effects of the financial and economic crisis but this has not been the case in Hungary. Research and innovation are seen as areas where money can be saved. Many companies do not have a strategy of continuous innovation.

In fact, the private-sector food industry has its own story. In order to promote practical research and innovation, the Hungarian National Technology Platform of the ETP 'Food for Life' was established in 2006. This was in reaction to the then government's "hostile" policy towards food research: from 2006 to 2010-11 it is said that there was no government funding for food industry research as this was seen as a 'mature' sector that was no longer developing. The Platform produced and circulated the first food innovation strategy in 2006, and this strategy and implementation plan was revised in 2009 in the aftermath of the economic and financial crises. This was submitted to the government at the beginning of 2010 and following the change of government a few months later some ideas started to be included in government documents. So, even if government funding is "still limited" (in terms of funding, most public funds in the Hungarian food industry in fact come from the EU), the food industry is starting to be seen as a government priority.

Further private-sector development could be discouraged by the government's new Land Act which, after the post EU accession transitional sale moratorium that expired on 30 April 2014, introduced strict restrictions on leasehold and ownership title transfer of agricultural land and forestry. This will make it "impossible" for a company to start agricultural R&D in Hungary. It is unlikely to affect existing activities, however, as private companies now have a lot of investments in agricultural R&D fixed assets (offices, greenhouses etc.) in Hungary.

Research strategy and priority areas

In the period 2008-2016, total R&D expenditure in the field of sciences ‘agricultural sciences’ consisted of ca. 90 per cent current costs and 10 per cent capital expenditure. The data can also be disaggregated by sub-category (Figure 5).

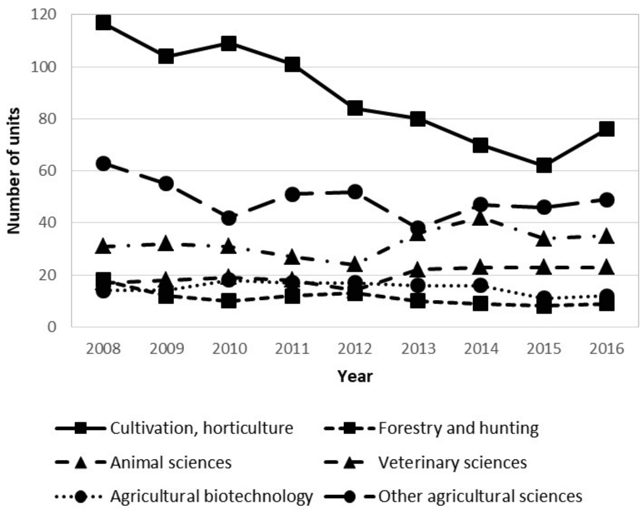


Sources: KSH (2012) Table 56, KSH (2017) Table 55 and other KSH annual publications on R&D

Figure 5. R&D expenditure of R&D units in the field of science ‘agricultural sciences’ in Hungary, 2008-2016 (in nominal terms)

The highest R&D expenditure occurred on cultivation and horticulture, and this accounted for an increasing share of overall expenditure, from 34.6 per cent in 2008 to 55.5 per cent in 2016. Actual expenditure almost doubled from HUF 6819 million to HUF 12 253 million over this period. Animal sciences expenditure more than doubled (from HUF 2382 million to HUF 4957 million) but was offset by a fall in veterinary sciences expenditure from HUF 3196 million to just HUF 421 million. R&D expenditure on agricultural biotechnology remained broadly constant at around HUF 2000 million apart from major fluctuations in 2015 and 2016.

The total number of R&D units in Hungary fluctuated from 2821 in 2008 to 3159 in 2013, but declined to 2727 in 2016. The number in the field of sciences ‘agricultural sciences’ fell from 266 in 2013 to around 220 in 2012, since when it has remained fairly constant. The decline can be almost entirely accounted for by the reduction in the number of units in cultivation and horticulture (Figure 6), although this group remains the biggest. The numbers of animal and veterinary units fell slightly and that of biotechnology units increased. Within the 'other agricultural sciences' category, the number of food product sciences institutes fluctuated around 20 in this period.



Sources: KSH (2012) Table 54, KSH (2017) Table 53 and other KSH annual publications on R&D

Figure 6. **Number of R&D units in the field of science 'agricultural sciences' in Hungary, 2008-2016**

Historically, government sector research institutions were very fragmented and there was no clear strategy on how agricultural research should be organised. Around 2006/7 it was proposed within the (then) Ministry of Agriculture and Rural Development that a national institute like INRA in France should be created, but there was a very strong resistance as the institutes wanted to keep their autonomy. Later, as the Ministry did not have enough money, universities absorbed (and therefore also part-finance from Ministry of Education funds) the agricultural research institutes nearest to them. For example, the Agricultural College in Gyöngyös (near Budapest) absorbed the wine institute in Eger and the University of Pécs took over the nearby grape research institute.

This ‘dance’, as one interviewee described it, was not part of a wider political research strategy, and was seen as a big loss for Hungarian agriculture. The institutes wanted to remain independent but did not have enough funding to do so and felt that it would be better to merge with the nearest educational institute. The problem was that the people in the university framework had no research strategy. There was still a strict separation between the research institutes and the teaching activities. There were also plans at that time to merge some institutes, such as the small animal institute in Gödöllő with the large animal institute in Herceghalom. This happened, but the constituent parts were later separated, and recently again merged, but in a different way.

The government currently does not yet have an agricultural research strategy as it is concentrating on the restructuring described above. Several interviewees felt that having a strategy is an important priority, as are identifying who is responsible for what in Hungary, linking up with the strategies of other EU Member States and at EU level, and stability. It is suggested that the research priorities of some other EU Member States (e.g. biomass use in cities) are not priorities in Hungary. Hungary is described as being an outsider in development of international strategies as it is focusing on reorganisation. However, the Ministry of Agriculture states that it would like to see more international research collaboration as it perceives agricultural research as an international activity, the results of which tend to have public rather than commercial benefits.

One interviewee suggested that future research strategy should be much more selective and much more focused on the needs of the country. At present, less than 10 per cent of maize seed sold in Hungary is of cultivars bred by the Hungarian Academy of Sciences’ Agricultural Institute at Martonvásár while 90 per cent come from various international companies. Martonvásár commands a 70-80 per cent share of the Hungarian wheat market but there is increasing competition from German and Austrian cultivars.

Among interviewees, climate change was mentioned as one area that could be a priority for agricultural R&D, as could plant genetics and production of local varieties adapted to local conditions (and climate change). In line with the total ban on growing GM crops in Hungary, it seems that researchers are not proposing new GM-related research projects. For food, resource efficiency along the food chain, and transdisciplinary research that combines manufacturing, ICT and energy management solutions in the food chain were mentioned as possible priorities. At a practical level the main challenges for the future include closer cooperation between institutions (such as through NAIK) and improved English language skills to enhance participation in EU and other international research activities.

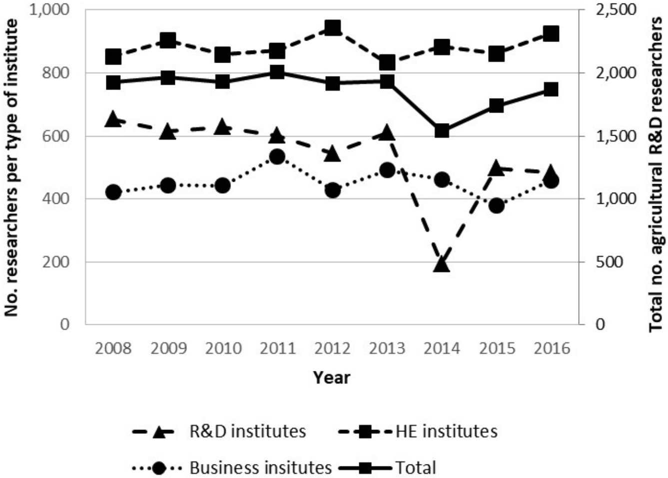
A future strength of NAIK should be the ability to conduct multidisciplinary research. Some interviewees felt that public- and private-sector agricultural research could also be better aligned, with the latter focusing on market-driven research. There are said to be very few examples in Hungary of strong research cooperation between private companies and research institutes. One approach recently promoted by the government is the establishment of 'clusters' centred on universities. The latter tend to provide services rather than real innovation but the companies are starting to develop new products and technologies. A feeling in the private sector, by contrast, is that government research policy is "not relevant" as the private sector is focused on the demands of the market.

Duplication of research efforts by the Ministry of Agriculture and the research units of the Hungarian Academy of Sciences is also recognised but it is not so clear how this can be solved because the latter organisation is an independent (and powerful) entity similar to a Ministry. Such Academies of Sciences seem to be a legacy of former Soviet influence with no clear equivalent in western Europe.

Similarly, an interviewee felt that there could be more research collaboration between Hungarian food industry companies at the pre-competitive phase, possibly through the National Technology Platform. The view of this interviewee is that the public sector carries out little if any research on food-related issues.

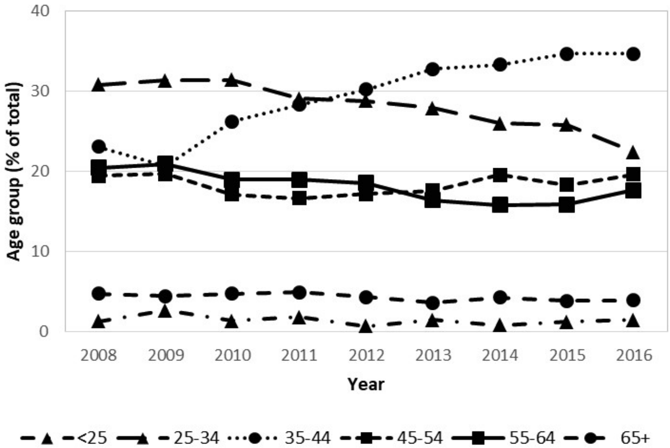
Research staff and evaluation of research

The total number of agricultural researchers remained fairly constant at around 1900 in the period 2008-2014, although lower figures were recorded for 2014 and 2015 (Figure 7). The dominant group, which increased from 853 persons in 2008 to 926 persons in 2016, has been researchers in HE institutes, even although the HE sector accounts for the smallest share of recorded agricultural R&D expenditure. By contrast, the number of researchers in R&D institutes declined from 653 to 484 over the same period, while the number employed in business enterprise institutes fluctuated around 450. Gender-disaggregated KSH data show that, in 2016, 41.1 per cent of all agricultural sciences researchers were women.



Sources: KSH (2012) Tables 38-40, KSH (2017) Tables 40-42 and other KSH annual publications on R&D

Figure 7. Number of researchers in the field of science 'agricultural sciences' in Hungary, 2008-2016



Sources: KSH (2012) Tables 38-40, KSH (2017) Tables 40-42 and other KSH annual publications on R&D

Figure 8. Age profile of researchers in the field of science 'agricultural sciences' in Hungary, 2008-2016

There is evidence that the average age of agricultural R&D staff is increasing: the percentage of researchers aged 25-34 declined from around 31 per cent in 2008 to 22.5 per cent in 2016, while those aged 35-44 increased from a little over 20 per cent to 34.7 per cent (Figure 8). The data do, however, suggest declines in the percentages of older age groups: from 20.5 to 17.7 for those aged 55-64 and 4.8 to 4.0 for those aged 65+.

In the minds of interviewees, perceptions of trends in human resources, particularly in the government sector research institutes, are linked to their interpretation of the way in which the institutes are funded. In the understandings of some interviewees, since most of these institutes “did not receive any” government funding they were not so exposed to staff cutbacks arising from reductions in government budgets. They say that since the formation of NAIK there have been cutbacks in administrative staff (but not (yet) in R&D staff) resulting in around HUF 1 billion of savings annually.

Another view is that staff numbers in the government sector research institutes have continuously declined in recent years as funding has been cut and leavers have not been replaced, and at the same time the average age of the staff has increased. There has been no real human resource development strategy. Young people do not want to go into research because there is no clear future for them and government sector research staff are not well paid and not well motivated. The Ministry of Agriculture recognises that there is need to renew the research staff in research institutes and universities as there are a large number of staff over 60 or even 70 years of age.

Most interviewees had strong views about the evaluation of agricultural R&D activities, at the level of both institutes and individuals. There is a need to measure the quality of research personnel, in terms of their ability and motivation to do R&D. Personal motivation is “not always money”. Money clearly has a positive influence, and one interviewee noted that in at least one public-sector research institute in Poland staff who publish high impact-factor research papers receive a financial bonus. Furthermore, some researchers are not involved in international research because it involves extra work but in parallel they conduct private research to earn more money.

It is widely accepted that the evaluation of the work of government sector agricultural research institutes has been inadequate in the past. It is suggested that over many years much research has simply been repeated in a different way.

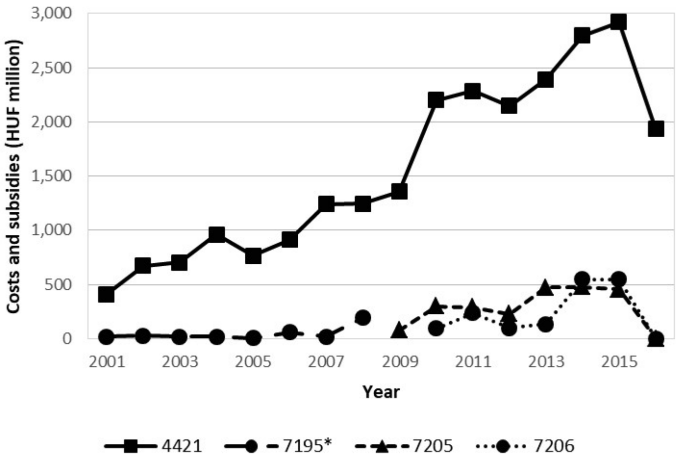
In 2004-2005, evaluation consisted of an institute making an annual report and someone in the Ministry of Agriculture and Rural Development (as it was then) providing an opinion on it. This was obligatory to get the budget for the next year. There was a proposal within the Ministry for an annual performance contract to be signed between the government and each research institute but this was not accepted because the research institutes did not want such a transparent procedure. After six months there would have been an interim report and a final report coupled with an independent evaluation process. However, demand for better performance should be linked with the provision of acceptable working conditions.

There is still no proper evaluation plan or indicator plan for evaluation of public-sector agricultural R&D, although a strategy for evaluation of food chain safety research is under development. Evaluation procedures in NAIK have apparently been strengthened but are still quite basic and do not distinguish between outputs, outcomes and impacts: the focus at present is on financial issues.

Dissemination of research results

The classical channel for the flow of academic knowledge from academics to farmers is via advisors and advisory services. This is the clearest route by which the results of research can be translated into increased agricultural productivity. Hungary does not have a state-run service of specialist farm advisors, but rather the national Chamber of Agriculture manages the provision of advice to farmers through a very strongly regulated system that involves around 1100 contracted but self-employed advisors. The service is dominated by the provision of subsidised advice within the frame of the EU's Farm Advisory System (EC 2013).

Farmers' expenditure on training and consultancy, and the amount of state subsidies for these activities, can be estimated from Hungarian Farm Accountancy Data Network (FADN) data. The FADN consists of 1599 individual and 388 corporate sample farms as representatives of ca. 106 000 commercial farms. The variables of the Hungarian FADN are described and coded in the Farm Return document. Costs of education (including vocational training and farm advice) incurred by farmers (variable 4421) increased steadily from around HUF 409 million in 2001 to around HUF 2923 million in 2013 (Figure 9). Subsidies for extension services (variable 7205) increased from HUF 75 million in 2009 to around HUF 475 million in 2013 and for vocational training (variable 7206) reached almost 550 million in 2014. Non-payment of subsidies in 2016 can be attributed to administrative delays in the implementation of the 2014-2020 Rural Development Programme and is reflected in a substantial decline (to around HUF 1936 million) in farmers' expenditure on vocational training and farm advice in 2016.

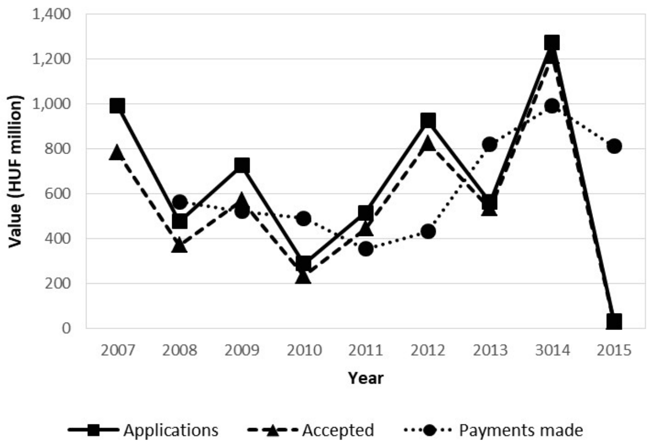


*Until 2008, all consulting services related grants (i.e. 7205 and 7206) were reported together as 7195

Source: Hungarian FADN database via AKI

Figure 9. Costs of training and further training, consultancy (4421), and state subsidies paid to farmers for agricultural extension (consultancy) services (7205) and vocational training (7206,) in Hungary, 2001-2016 (in nominal terms)

The Agricultural and Rural Development Agency, the Hungarian 'paying agency' and another 'background institute' of (at that time) the Ministry of Agriculture, publishes annual data on numbers of persons and financial value of payment applications; accepted payments; and payments actually made via the Rural Development Programme of the Common Agricultural Policy for Measure 114: Farm advisory system, (FADN variable 7205). Initial enthusiasm (around HUF 1 billion of payment applications) was followed by a slump (to less than HUF 300 000 in 2010) caused, to a great extent, by lengthy delays in making payments to the farmers to subsidise the cost of paying an advisor (Székely–Halász 2010), and a subsequent recovery to a peak of HUF 1.275 billion at the end of the funding period in 2014 (Figure 10).



Source: MVH (2018)

Figure 10. **Value of payment applications, accepted applications and payments made for farm advisory services paid out via the Rural Development Programme in Hungary, 2007-2015 (in nominal terms)**

The Hungarian government is trying to put more emphasis on applied research with clear end uses. Despite the setting up of NAIK, adjusting the mentality of its research staff from one that is science-driven to being practice-driven is accepted by the interviewees as being a much slower process than building new buildings and buying new equipment. Renewal of the personnel via the appointment of younger researchers is needed. Some interviewees believe that state research institutes sometimes do not know who is going to use their results; they are doing the research for its own sake.

The Hungarian government has not yet been able to create a situation where all of the actors in the agricultural knowledge chain communicate with each other. The advisory services are not well developed for disseminating the results of the research and there is said to be no vision on whether the research should be targeted at large or small farmers.

The Ministry of Agriculture recognises that it is not sufficient to rely on websites and publications, and is trying to strengthen communication by encouraging personal contacts between researchers and farmers. To raise awareness of good practices in agriculture it has set up experimental farms where people can see technologies in operation through demonstration activities. It sees the need to strengthen the farm advisory system by finding young advisors and helping them with their technical progress via training, conferences, and involving them in scientific programmes e.g. via on-farm experiments. However, the most difficult challenge is to make farmers believe that it is a good decision to adopt new solutions. Very few small farmers will change their practices even with great effort. It is very difficult even to engage with mid-size farmers; it is necessary to do so through the education of their children and grandchildren.

Discussion

In the frame of the IMPRESA project, Chartier et al. (2014) surveyed the availability of official data sets on investment in agricultural research and, from these, the structure of, recent levels of, and trends in agricultural research expenditures in 19 EU Member States plus Switzerland which between them account for just over 95 per cent of European agricultural research. A small number of countries (Germany, Spain, the United Kingdom, Italy and France) accounted for over 70 per cent of public agricultural science budget allocations, and a substantial minority accounted for less than 5 per cent. The survey included seven Eastern EU Member States, namely Bulgaria, the Czech Republic, Hungary, Latvia, Poland, Romania and Slovenia. According to 2018 United Nations data, these seven countries account for around 16 per cent of the population of the EU-28 (and 86 per cent of the population of the 11 post-socialist Member States), so clearly their per capita expenditure on agricultural research is very low by European standards.

While it is the case that the Gross Domestic Product per capita of the EU-11 is also lower than that of the EU-28, agriculture plays a relatively more important role in the economies of these countries. Midmore (2017) argued that it is in the EU-11 that the impact of agricultural research is most needed, owing to difficult climatic conditions for agriculture, the rapid transition to family farming and the legacy of central planning. He notes with concern, however, that here as elsewhere in the EU, trends in expenditure are declining. In Hungary, total R&D expenditure in the field of agricultural sciences increased during the period 2008-2016, from HUF 19.7 to HUF 22.1 billion (Figure 2), but these figures are not adjusted for inflation. Public-sector R&D expenditure declined markedly over this period, and the proportion of total R&D expenditure spent on agriculture as a socio-economic objective also fell over this period (Figure 1). These trends are supported by the views of most of the interviewees. The stated intention of the Hungarian Ministry of Agriculture is to maintain the levels of public-sector expenditure on agricultural R&D but, notwithstanding the points that follow, this approach is insufficient: the level of expenditure should be increased.

It is evident from the results of this study that an increase in public-sector spending will, in isolation, have only a limited effect on agricultural productivity growth, even in the long term. The Hungarian Government's focus on what it sees as much-needed organisational reforms can be taken as a genuine attempt to improve the efficiency and effectiveness of public-sector agricultural research by developing the 'critical mass' of research institutes through greater cooperation. This in turn could lead to more interdisciplinary research and participation in EU-level research activities. Its desire to enhance the career prospects of younger researchers is another positive message. Prerequisites for this include improved salaries, more pleasant working environments and adequate resourcing of research activities (FAO 2014). Any action must be supported by well-designed personal development programmes including learning and using English, and the results cannot be measured by quantitative data alone. Several interviewees noted that more qualitative data are required to measure 'human' aspects such as the level of motivation of agricultural researchers. It is not entirely clear how to collect such data although the suggestion of using interviews (for example of researchers or of users of the farm advisory services) surely has a place. The Hungarian Ministry of Agriculture stated that it "would be ready to use any feasible and reliable method".

The absence of an official research strategy for agriculture is another serious concern and the identification of priority research topics, and aligning these where possible with the EU and other EU Member States, must begin very soon. There are two associated issues. Firstly, the potential for alignment of public- and private-sector research. This is easier said than done because private-sector agricultural research priorities are market-driven and broadly independent of government policy. Secondly, the need for a greater emphasis on applied research. It would be unreasonable in the extreme to suggest that the disconnect between research and practice is exclusive to Hungary. SCAR (2012) discussed this issue at length and advocated the distinction between science-driven research and innovation-driven research. There is a conflict between the publication of research papers and papers for implementation: the former tend to be included (and viewed favourably) in staff evaluation systems while the latter are considered to be of lesser value.

Chartier et al. (2015) reported that coverage of agricultural research expenditure data by fields of science varies across countries from full availability to complete absence, and that coverage of expenditure data by socio-economic objectives is even poorer. In this respect, the excellent performance of the KSH sets the standard to which data agencies in other countries should aspire. It is essential that complete data sets be collected and Hungary shows that it is feasible to do so. Even so, there were some questions that could not be adequately answered. One was whether the KSH data relating to business enterprise agricultural R&D activity were truly accurate. Some interviewees expressed doubts, and the dramatic reversals in trends shown in Figures 3 and 4 are difficult to explain. The KSH was specifically asked for their interpretation of these reversals. Their opinion was that a high proportion of projects are financed from government funds and that the timing of the payments influences the levels of expenditure. Also, it was not at all clear, either from the data or the interviews, which sector (if any) has driven the increase in business sector agricultural R&D. Some KSH data indicate that between 2007 and 2011 manufacture of food products as a percentage of total business enterprise expenditure on R&D has increased, while agriculture and fishing has declined, but the two years use different NACE code sets.

Even with complete data sets, measuring the impact of agricultural research on productivity in the post-socialist EU Member States is difficult because, as Midmore (2017) observed, of the structural break involved in the transition from centrally-planned to market economies that began early in the 1990s. Midmore (2017) believes that the report of Ratinger and Kristkova (2015), which estimates national internal rates of return in the Czech Republic to be between 14 and 32 per cent, is the sole national study from the Eastern EU.

The interviewees in this study noted the distinction between data that measure *outputs* and those that measure (shorter-term) *impacts*, with the availability of the latter being inadequate. This matches the findings of Fieldsend and Székely (2013) who reported that, for farm advisory services, there are no data on the level of use of private-sector advisory services, on the quality of advice provided by public sector advisors or on the impact of this advice on the performance of the farming sector. These weaknesses in contemporary practices related to the ex-post evaluation of Hungarian agricultural research are widely recognised and were stressed by several of the interviewees. They are deep-seated problems that can be traced back over many years and there is broad agreement that "something must be done". Again, though, Hungary is not unique and the author is not aware of any good practice elsewhere in Europe. The most effective approach may be to focus on improving the quality and relevance of the research *output*, in the expectation that this will enhance its *uptake*. The political will to address the issue does seem to exist and it remains to be seen whether this will actually happen after the present round of 'top level' reorganisations has been completed.

References

Alston, J. M.–Andersen, M. A.–James, J. S.–Pardey, P. G. 2010. *Persistence pays: U.S. agricultural productivity growth and the benefits from public R&D spending*. New York: Springer.

Andrási, Z.–Bóday, P. 2012. Characteristics of Private Farms and Family Farm Labour in Hungary by Settlement Size. *Hungarian Statistical Review* Special Number 15, 34–47.

Chartier, O.–Doghmi, M.–Fourcin, C.–van den Broek, M.–Midmore, P. 2014. *Investment in agricultural research in Europe: synthesis report. Deliverable 2.2 of the EU FP7 project IMPRESA.* http://www.impresa-project.eu/, downloaded: 22.02.2018.

EC 2010. *A Rationale for Action. Accompanying document to the communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Europe 2020 Flagship Initiative: Innovation Union. COM(2010) 546*. Brussels: European Commission.

EC 2013. *Farm Advisory System*. https://ec.europa.eu/agriculture/direct-support/cross-compliance/farm-advisory-system_en, downloaded: 22.02.2018.

EC 2016. *A strategic approach to EU agricultural research & innovation: final paper*. Brussels: European Commission.

Eurostat 2008a. *Comparison between NABS 2007 and NABS 1992*. http://www.oecd.org/science/inno/43299905.pdf, downloaded: 22.02.2018.

Eurostat 2008b. *NACE Rev. 2 – Statistical classification of economic activities in the European Community*. http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF, downloaded: 22.02.2018.

FAO 2014. *The State of Food and Agriculture: Innovation in family farming*. Roma: FAO.

Fieldsend, A. F. 2014. *Study on Investment in Agricultural Research: Review for Hungary. Country report for the EU FP7 project IMPRESA*. http://www.impresa-project.eu/fileadmin/user_upload/IMPRESA/Filesharing/IMPRESA_country_report_Hungary.pdf, downloaded: 22.02.2018.

Fieldsend, A. F.–Székely, E. 2013. An assessment of the Agricultural Knowledge and Innovation System in Hungary. *Rural Areas and Development Series* 10, 27–44.

KSH 2012. *Research and development, 2011. Microsoft Excel spreadsheet.* Budapest: KSH.

KSH 2017. *Research and development, 2016. Microsoft Excel spreadsheet.* Budapest: KSH.

Midmore, P. 2017. Agricultural science research impact in the Eastern European Union Member States. *Studies in Agricultural Economics* 119(1), 1–10.

Mogues, T.–Yu, B.–Fan, S.–McBride, L. 2012. *The Impacts of Public Investment in and for Agriculture: Synthesis of the Existing Evidence. International Food Policy Research Institute Discussion Paper 01217*. Washington DC: IFPRI.

MVH 2018. *Data from the Hungarian Agricultural and Rural Development Agency website*. http://www.mvh.gov.hu, downloaded: 22.02.2018.

OECD 2007. *Revised field of science and technology (FOS) classification in the Frascati Manual*. Paris: OECD Publishing.

OECD 2015. *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. The Measurement of Scientific, Technological and Innovation Activities*. Paris: OECD Publishing.

Ratinger, T.–Kristkova, Z. 2015. R&D Investments, technology spillovers and agricultural productivity, case of the Czech Republic. *Agricultural Economics-Zemedelska Ekonomika* 61, 297–313.

Ruane, J. 2014. *Background document to the FAO e-mail conference on 'Approaches and methodologies in ex post impact assessment of agricultural research: Experiences, lessons learned and perspectives'*. http://www.impresa-project.eu/fileadmin/user_upload/IMPRESA/Filesharing/IMPRESA_FAO_e-conference_background_doc.pdf, downloaded: 22.02.2018.

SCAR 2012. *Agricultural Knowledge and Innovation Systems in Transition – a reflection paper*. Brussels: European Commission.

Szczepaniak, I.–Mroczek, R.–Lámfalusi, I.–Felkai, B. O.–Vágó, Sz. 2014. Development of the Polish and Hungarian food industry from 2000 to 2011. In: Potori, N.–Chmieliński, P.–Fieldsend, A. F. (eds.) *Structural changes in Polish and Hungarian agriculture since EU accession: lessons learned and implications for the design of future agricultural policies*. Budapest: AKI, 265–292.

Székely, E.–Halász, P. 2010. *A mezőgazdasági tanácsadás intézményi feltételei és működési tapasztalatai*. Budapest: AKI.

Tóth, O. 2012. *Farm structure and competitiveness in agriculture*. Paper prepared for oral presentation at the 132nd Seminar of the EAAE "Is transition in European agriculture really over?" Skopje, 25-27 October 2012.

VM 2013. *The Hungarian Agriculture and Food Industry in Figures, 2012*. Budapest: Ministry of Rural Development.

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

SZILVIA ERDEINÉ KÉSMÁRKI-GALLY[1]

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.

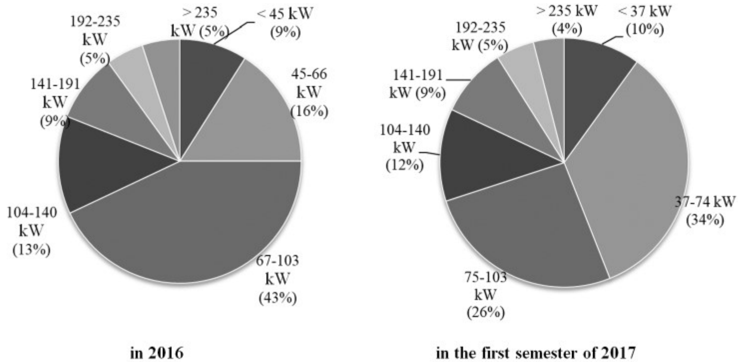
[2] 1 horsepower (1 HP) = 0.745699872 kW (kilowatt)

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).

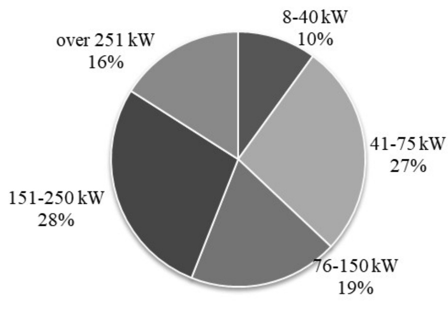
The NARIC MGI annually monitors operating costs based on Hungarian farm data. As Table 5 shows, these data are similar to previous ones, although the average machine age is lower (12.3 years) than the national average. Examining machine capacities, it can be seen that the proportion of 151-250 kW engine 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.

References

AKI 2017. Mezőgazdasági gépek forgalma. *Statisztikai jelentések* 27(3), 1–15.

AKI 2018. Mezőgazdasági gépek forgalma. *Statisztikai jelentések* 28(1), 1–17.

Bíró, Sz. (ed.)–Rácz, K. (ed.)–Csörnyei, Z.–Hamza, E.–Varga, E.–Bene, E.–Miskó, K. 2015. *Agrár- és vidékfejlesztési együttműködések Magyarországon.* Budapest: Agrárgazdasági Kutató Intézet.

CEMA 2015. *Tractor Market Report. Calendar year 2014.* http://cema-agri.org/sites/default/files/publications/2015-02%20Agrievolution%20Tractor%20Market%20Report.pdf, downloaded: 19.06.2017.

Draperi, J.-F. 2015. Cooperatives in France: Issues and challenges at the start of the 21st century. *Revue international de l'économie sociale,* http://recma.org/article/cooperatives-france-issues-and-challenges-start-21st-century, downloaded: 19.06.2017.

Erdeiné Késmárki-Gally, Sz.–Karakasné Preil, É.–Rák, R. 2017. *Mezőgazdasági gépi munkák költsége 2017-ben.* Dabas: NAIK MGI.

GÉPKÖR 2017. *Mi tehát a gépkör?* http://gepkorszov.hu/mi-tehat-a-gepkor/, downloaded: 11.07.2017.

KSH 2014. *Magyarország mezőgazdasága. Gazdaságszerkezeti Összeírás 2013.* Budapest: KSH.

Government of Hungary 2011. *Act CLXXV of 2011 on the right of association, public utility status, and the operation and funding of civil society organisations.* https://net.jogtar.hu/jogszabaly?docid=A1100175.TV, downloaded: 19.06.2017.

Lips, M.–Burose, F. 2012. Repair and maintenance costs for agricultural machines. *International Journal of Agricultural Management* 1(3), 40–46.

Morris, J. 1988. Estimation of tractor repair and maintenance costs. *Journal of Agricultural Engineering Research* 41(3), 191–200.

NARIC MGI 2017. Database of the National Agricultural Research and Innovation Centre's Institute of Agricultural Engineering.

Némediné Kollár, K.–Neszmélyi, Gy. 2015. Aspects of Spatial Economic Processes of Disadvantaged Areas in Hungarian and International Perspective. *Romanian Review of Regional Studies* 11(2), 3–18.

Sirinathsinghji, E. 2013. *US Staple Crop System Failing from GM and Monoculture*. http://www.i-sis.org.uk/US_Staple_Crop_System_Failing_from_GM_and_Monoculture.php, downloaded: 19.06.2017.

Takács, I.–Hajdú, J.–Nagy, I.–Kárpáti, A. 1996. *Gépkör. Egy jó alternatíva.* Gödöllő: FM Műszaki Intézet.

Takács, I.–Baranyai, Zs. 2013. A géphasználati együttműködések, avagy a virtuális üzemek elmélete és gyakorlata a magyar mezőgazdaságban. *Gazdálkodás* 57(3), 270–281.

Takácsné György, K.–Takács, I. 2016. A magyar mezőgazdaság versenyképessége a hatékonyságváltozások tükrében. *Gazdálkodás* 60(1), 31–50.

Tóthné Heim, L. 2011. A kölcsönösségen alapuló géphasználati formák megvalósíthatóságának kérdései a Dél-Dunántúl régióban. *Acta Scientiarum Socialium* 34(1), 45–55.

World Bank 2017. *Agricultural machinery, tractors.* http://data.worldbank.org/indicator/AG.AGR.TRAC.NO, downloaded: 19.06.2017.

Examining management tools that characterise the corporate internal information system and their impact on corporate performance[1]

GERGELY GÖRCSI[2] – ZSUZSANNA SZÉLES[3]

Corporate management tasks cannot successfully be executed without decision-support functions of appropriate quality. The importance of producing and achieving relevant, accurate and up-to-date information is unquestionable as such information provides stand-alone value. According to current trends, the need for reporting systems based on specific expectations, which can be used to provide decision-makers with a long-term competitive advantage, has increased. In our research, we set out to investigate how different management techniques (e.g. performance tracking) can support decision-making. Our findings are based on the data from the World Management Survey carried out in 2004, involving more than 700 companies from 34 countries (Bloom–Van Reenen 2007). The impacts of each management method on company performance are also examined. It is hypothesised that using information support management methods for decision-making can influence the overall success of a company. We also look for relations between the company's ownership status (i.e. family, founder, institution manager, private, or other ownership) and the corporate internal information system.

Keywords: decision support, management tools, information system, reporting system, business intelligence.

JEL codes: M29, M49.

Introduction

The competitive environment of companies is in a state of constant change due to the following factors: disappearance of market boundaries, increasing competition, appreciation of information and knowledge, changing consumer habits, rapid change of companies, and expanding product and service portfolio.

The need to respond to changes increases the role of decision support, and executives ought to rely on the available information throughout their decision-making process.

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We have endeavoured to study the quality of corporate internal information systems because we perceive the management expectations associated with data delivery. We look at the information system not as an IT solution, but as a complex toolkit for leadership, regardless of how it is implemented.

Literature review

A number of microeconomic models are based on the assumption that both sellers and buyers possess complete information on the quality of goods available on the market. However, in practice, most frequently market players do not possess complete information (in other words, they lack some necessary information about the goods in question). Consequently, a common problem in decision-making situations derives from the fact that information is not necessarily available for free.

As Stigler's (1961) model of optimal economic research suggests, market players have incomplete information, while corporate management does not possess all the necessary information to make decisions in the vast majority of cases. Akerlof's (1970) "Market for Lemons" explains the phenomenon of asymmetric information as observed during day-to-day operations. Spence's (1973) signalling model focuses on investment decisions in uncertain circumstances. These approaches highlight the nature of information in companies.

Resources are essential to business operation (Barancsi et al. 2001). These essential resources can be categorised as human resources, raw materials, energy, capital, and information.

Information can also be defined as goods because it can be referred to as public goods (exclusion is not possible), and as a luxury property as the value of information decreases in accordance with the reproduction by its owner (Kiss et al. 2000). The use of market information contributes to the development of products by companies (Moenaert–Souder 1990; Moorman 1995).

Information supports decision-making as a factor in reducing uncertainty. Information can be regarded as a resource when corporate interests can be established. Its use has three closely related elements: decision-making, communication, and the operation of processes. Decisions, according to the conceptual definition, turn information into actions (Forrester 1961). According to another approach, decisions are meant to turn information into information (Nemény 1973). Therefore, from a corporate perspective, decisions stand for the use of the available information and the creation of new information. Communication, on the other hand, is information flowing into the use of information. The final element of information use is the execution of processes (Chikán 2006).

The corporate internal information system serves information purposes. The task of the corporate internal information system is to provide target-oriented information systematisation and processing. Its function is to satisfy stakeholders' information needs. The information needs of the companies can be divided into external and internal categories: internal information is generated within the organisation, so it can only be accessed through its own information system, while external information may be embedded into the corporate information system, if needed.

The corporate internal information system consists of several closely related elements (Szalay 2009):

- People: leaders, analysts, IT professionals.
- Databases: structured data storage.
- Hardware: physical IT tools which are necessary for the operation of the system.
- Software: programmes that are responsible for controlling hardware.
- Data processing methods and reporting tools.

It should be assumed that all leadership levels focus on the information relevant to them, which is detailed according to their individual needs (Anthony–Vijay 2013). It is vital for reports produced in a meaningful and consumable fashion to be timely available, with specific content available to the selected user circle (Szalay 2009). The individual integration of functional points (such as purchasing, controlling, accounting, sales, marketing) and establishing a relationship between reports should become standard practice. The lack or inadequate functioning of the above creates the need to improve the performance of the information system.

Development plans should be implemented so that users enjoy optimal freedom when using the information available to them (Phillips-Wren–Carlsson 2014). To achieve this, business intelligence systems offer a variety of solutions designed to improve the decision-making process (Cser et al. 2010). Business intelligence stands for the necessary processes, technologies and tools designed to turn data into information, transform information into knowledge, and translate knowledge into plans for driving a profitable business. Business intelligence includes data warehouses, business analytics tools, and knowledge management (Loshin 2012).

In addition to development purposes, the major intent behind improving information management is: “the efficient management of information resources and the ability of the organisation to provide everything needed for the use of information systems, access to information and the proper assistance of end users” (Wormell 1991. 208). The need to exploit the opportunities offered by the information environment and the need to develop the information acquisition process aim to improve the performance of management tasks.

Considering the literature analysed above, it can be argued that information as a resource is of the utmost importance and significantly contributes to the success of the company. The main task of the corporate information system is to support managerial work by transforming the information generated during operation into consumable information. In our paper, we wish to further investigate how different management techniques, such as performance tracking, can support decision-making.

Research hypothesis

Our research focuses on mapping the corporate internal information system. This paper examines the relationship between the management techniques describing the company’s internal information system and the ownership of the company. The initial assumption is that family-owned companies pay less attention to the corporate internal information system than manager-owned companies.

Based on this, we formulated our first hypothesis:

H1: There is a relationship between the quality features of the corporate internal information system and the ownership status of the companies.

We also analyse the relationship between the company’s internal information system and revenue changes. Our hypothesis is that the nature of the corporate internal information system influences the revenue change. Considering that a higher level information system leads to more grounded managerial decision-making and increases revenue, this could be seen as a logical statement. Thus, our second hypothesis is as follows:

H2: There is a relationship between the quality features of the corporate internal information system and revenue changes.

Research methodology

Data

Our hypotheses were tested by using the data of the World Management Survey from 2004 (WMS 2004). This research involved more than 700 companies from 34 countries and the number of employees ranged from 50 to 10 000, with a median of 675 (Bloom–Van Reenen 2007). In the survey, respondents assessed the levels of management tools applied at their companies, on a scale of 1 to 5.

In our paper, we only analysed responses where all the necessary information was available.

A total of 20 variables are included in the WMS database as follows:

1. Introduction of modern lean manufacturing techniques
2. Rationale for lean manufacturing introduction
3. Success of modern manufacturing techniques
4. Process documentation
5. Performance tracking
6. Review of performance
7. Performance dialogue
8. Consequence management
9. Type of targets
10. Interconnection of goals
11. Time horizon
12. Goals are stretching
13. Clarity of goals and measurement
14. Instilling a talent mindset
15. Recruiting talent
16. Building a high-performing culture
17. Making room for talent
18. Developing talent
19. Creating a distinctive employee value proposition
20.Retaining talent

In addition, the most relevant corporate data are also included in the database. We will use only the variables that need to be defined in order to interpret the results.

The database contains information about the changes in company revenue.

Regarding the company's ownership structure, the founder had ownership rights at 114 of the companies observed. There were 336 companies owned by another company (including banks, insurance companies, etc.). A distinct category was made up of 21 companies where managers had acquired the property rights and another category was that of 59 individual entrepreneurs who ran their own businesses without central management. Other types of non-profit organisations, such as charity foundations and associations (41 observed), were included. The country in which the company operated was also defined.

Defining variables related to the internal information system

As a tool for compiling information, we will use the factor analysis method. For an efficient analysis, it is necessary to reduce the number of variables (originally 20), while maintaining as much of the data-based information content as possible. In order to achieve this, we will perform the Principal Component Analysis, which allows a number of variables (criteria) to be considered together. The main components will be represented by the common meanings of the variables, which will be used for further analysis.

As a solution, we employ a correlation matrix that contains the pairwise correlation coefficients between the variables. The conformity of the model was verified by the KMO and the Bartlett test (Munro 2004). The model assumes a value of 0.954 for the KMO, which means that it has a strong factorisation potential. The Bartlett test has a significance value below 0.05. Communality shows how some variables explain the extent of factors. The desired value limit has an explanatory power above 0.5. From the 14 remaining variables, the first two factors explain more than 60% of the model, resulting in a 2-factor model for the variables.

The rotated component matrix can be used to determine which variables are found in the first and second components (Table 1).

Table 1. Rotated component matrix[a]

Variables	Component	
	1	2
Introduction of modern lean manufacturing techniques	.806	
Success of modern manufacturing techniques	.789	
Performance tracking	.774	
Rationale for lean manufacturing introduction	.758	
Review of performance	.749	
Process documentation	.729	
Performance dialogue	.711	
Consequence management	.652	
Interconnection of goals	.602	
Goals are stretching	.593	
Recruiting talent		.759
Creating a distinctive employee value proposition		.751
Instilling a talent mindset		.688
Developing talent		.650

a. Rotation converged in 3 iterations.

Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalisation.

Source: authors' own calculation based on the WMS (2004) database

The first component has 10 variables which define the level of the corporate internal information system. The other component has four variables that show the level of corporate knowledge management. Our aim is to research the level of the corporate internal information system, so we continue with the first factor defined in the Principal Component Analysis.

Analysis and findings

Relationship between the corporate internal information system and the company's ownership type

We established a hypothesis on whether there is a relationship between the corporate internal information system and the type of company ownership. Variance analysis was used to compare variable averages in order to find out whether there was a definite difference between certain corporate characteristics (company ownership types) and the corporate internal information system. According to the null hypothesis that there is no correlation between the two criteria, the expected value of each type is the same.

$H0 = \mu 1 = \mu 2 = \mu 3 = \mu 4 = \mu 5 = \mu 6 = 0$, where μ is the expected value of the analysed report (the value of a corporate internal information system based on each type of ownership).

Table 2. Level of the corporate internal information system by ownership type

Company ownership	N (items)	Mean	Standard deviation	Standard error	95% confidence interval for the mean		Minimum	Maximum
					Lower bound	Upper bound		
family	1182	-.1864860	1.07945390	.03139752	-.2480871	-.1248849	-2.95755	2.25443
founder	879	-.1459121	1.16214953	.03919833	-.2228455	-.0689788	-3.10769	2.06446
institution	2697	.0940627	.88018722	.01694863	.0608291	.1272963	-2.73711	2.18682
manager	171	.3907152	.76671900	.05863247	.2749737	.5064566	-.87077	1.94571
other	276	.0176897	1.07877174	.06493443	-.1101420	.1455214	-1.97213	2.08228
private	440	.0529578	1.02620485	.04892240	-.0431934	.1491091	-2.14279	1.81900
Total	5645	.0000000	1.00000000	.01330969	-.0260921	.0260921	-3.10769	2.25443

Source: authors' own calculation based on the WMS (2004) database

Table 2 presents the descriptive statistics for the variables. If we look at the column of the average values, we can see that family businesses have the lowest-level enterprise information systems. On average, the best results for the company's internal information system were achieved by manager-owned companies.

Table 3. Test of homogeneity of variances

Levene statistic	df1	df2	Sig.
45.733	5	5639	.000

Source: authors' own calculation based on the WMS (2004) database

Levene's (Levin) test shows that the value of the significance level is low (≤0.05), thus the null hypothesis is rejected (Table 3). However, these findings do not provide a sufficient basis to draw conclusions from without further investigation, therefore we will perform an analysis of variance (ANOVA).

Table 4. Difference between the companies' information levels (ANOVA)

	Sum of squares	df	Mean square	F	Significance
Between groups	111.108	5	22.222	22.648	.000
Within groups	5532.892	5639	.981		
Total	5644.000	5644			

Source: authors' own calculation based on the WMS (2004) database

Table 4 shows the calculated value of F and the level at which it is significant. This level approaches zero, below the 5% limit. If the null hypothesis were true, then the value would approach 1. The likeliness of reaching such an F ratio is approximately 0%, which is very rare. As a result, we must reject the null hypothesis and conclude that the levels of companies' internal information systems differ significantly.

The result of the Post Hoc Test is shown in Table 5, where the mean of each group is compared to the average of all other groups. Where the significance level is below 0.05, the null hypothesis is rejected. This applies to almost all groups except family – founder, founder – other, institution – other and private – other ownership, where the differences between the averages are not significant.

Table 5. Post Hoc Test of the companies' information levels by ownership type

(I) Predominant ownership type	(J) Predominant ownership type	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
					Lower bound	Upper bound
family	founder	-.04057386	.04411750	1.000	-.1701227	.0889750
	institution	-.28054870*	.03455300	.000	-.3820119	-.1790855
	manager	-.57720118*	.08104331	.000	-.8151809	-.3392215
	other	-.20417568*	.06622021	.031	-.3986281	-.0097233
	private	-.23944384*	.05531786	.000	-.4018820	-.0770056
founder	family	.04057386	.04411750	1.000	-.0889750	.1701227
	institution	-.23997484*	.03847148	.000	-.3529445	-.1270052
	manager	-.53662731*	.08278987	.000	-.7797357	-.2935189
	other	-.16360181	.06834662	.251	-.3642983	.0370947
	private	-.19886998*	.05784644	.009	-.3687332	-.0290067
institution	family	.28054870*	.03455300	.000	.1790855	.3820119
	founder	.23997484*	.03847148	.000	.1270052	.3529445
	manager	-.29665247*	.07811350	.002	-.5260290	-.0672760
	other	.07637303	.06260045	1.000	-.1074502	.2601962
	private	.04110486	.05092904	1.000	-.1084458	.1906555
manager	family	.57720118*	.08104331	.000	.3392215	.8151809
	founder	.53662731*	.08278987	.000	.2935189	.7797357
	institution	.29665247*	.07811350	.002	.0672760	.5260290
	other	.37302550*	.09639982	.002	.0899521	.6560989
	private	.33775734*	.08926295	.002	.0756410	.5998736
other	family	.20417568*	.06622021	.031	.0097233	.3986281
	founder	.16360181	.06834662	.251	-.0370947	.3642983
	institution	-.07637303	.06260045	1.000	-.2601962	.1074502
	manager	-.37302550*	.09639982	.002	-.6560989	-.0899521
	private	-.03526816	.07605901	1.000	-.2586117	.1880754
private	family	.23944384*	.05531786	.000	.0770056	.4018820
	founder	.19886998*	.05784644	.009	.0290067	.3687332
	institution	-.04110486	.05092904	1.000	-.1906555	.1084458
	manager	-.33775734*	.08926295	.002	-.5998736	-.0756410
	other	.03526816	.07605901	1.000	-.1880754	.2586117

*. The mean difference is significant at the 0.05 level.

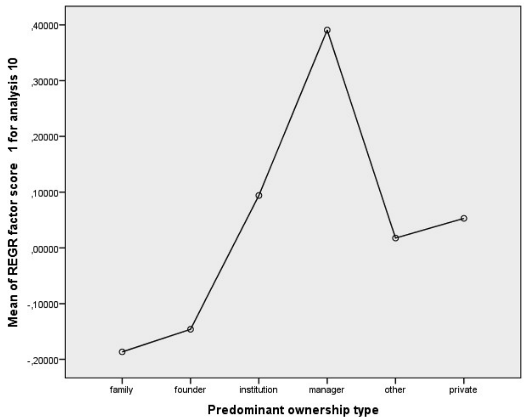
Source: authors' own calculation based on the WMS (2004) database

Let us look at the cases where the difference between the averages is positive. Table 5 shows that the information levels of institution – family, institution –

founder, institution – other, and institution – private ownership pairs are higher than those of other types of enterprises (family, founder, other, and private ownership). Those companies where the owners were managers had a higher average value than any other type.

Thus, it can be argued that management-controlled companies reach the best information provision levels. In the case of individual entrepreneurs, we see positive averages for private – family, private – founder and private – other pairs, which means that the level of information is better for private entrepreneurs than for family, founder and other owner types. The information level of the "other owner type" company group is higher than in family-owned companies, so family-owned companies are the least likely to report on the company's situation, which is not a surprising outcome.

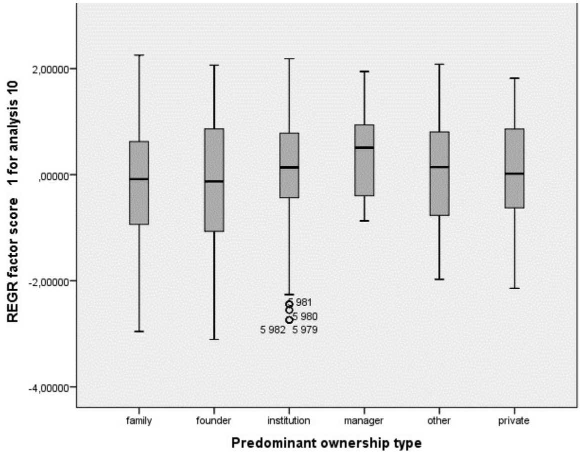
The above result is illustrated by the Means Plots chart (Figure 1). The information supply value of companies with a manager-based ownership is high. In the case of family businesses, variables are low, meaning that they use minimal information management tools.



Source: authors' own design based on the WMS (2004) database

Figure 1. Means plots of the information supply value

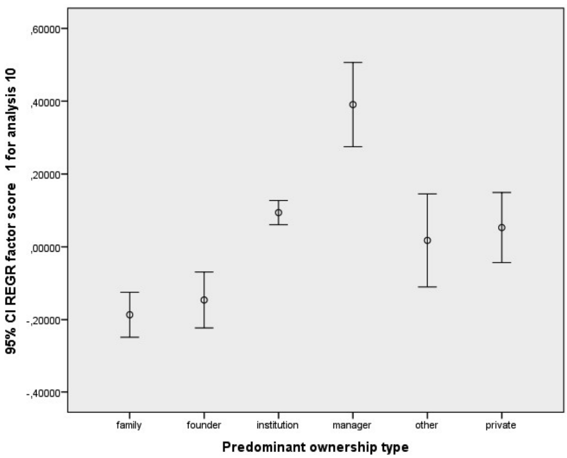
In Figure 2, the highest and lowest values of each group show the maximum or minimum scores of information level by ownership type (excluding the outlier values). The median information level is the highest in managerial companies and the lowest in founder-owned companies, which means the difference between average information levels is the highest for these two types.



Source: authors' own design based on the WMS (2004) database

Figure 2. Minimum and maximum scores of information level by ownership type

Figure 3 shows the results, taking into account the averages and standard errors. We can see that the average of manager-owned companies is the highest, whereas that of family businesses is the lowest. The standard error is high for manager-based and other ownership and it reaches the lowest value for institutional ownership.



Source: Authors' own calculation based on the WMS (2004) database

Figure 3. Error bar of information level by ownership type

In the light of these findings, we will accept the H1 hypothesis: there is a measurable relationship between the quality features of the company's internal information system and its ownership type.

Relationship between the company's internal information system and its revenue

In relation to our second hypothesis, we will look at the relationship between the company's internal information system and the changes in its revenue. As we use several variables in this section, we will employ a multivariate regression analysis.

We included as independent variables the following: the corporate internal information system factor, the knowledge management factor, the ratio of graduate employees, the number of weekly average manager hours, and the value of corporate capital (property, machines, equipment, total assets).

The correlation table resulted is shown in Table 6. For the multivariate regression calculation, we consider the correlations between dependent and independent variables. Additionally, we also test for the correlation between independent variables (multicollinearity).

The company's internal information system has a correlation of 0.036 with sales growth rate, which indicates a weak link. The highest correlation value is for the ratio of graduates among employees, but with 0.068 this also indicates a very low correlation.

Based on the findings above, the H2 hypothesis can be verified: there is a measurable relationship between the quality features of the company's internal information system and the changes in its revenue. While this relationship is weak, it is statistically verifiable.

With regard to multicollinearity, the highest correlation value is between the number of graduates among employees and the level of knowledge management (value of 0.216). This sounds logical since both are human resource management KPIs (Key Performance Indicators).

Table 7 shows the explained amount of the dependent variable (sales growth rate). This is statistically low; however, since we are talking about changes in sales revenue, this may be noteworthy. In addition, it is important to note that the standard error rate is 0.22182.

Table 6. Correlations between variables

Variables		Sales growth rate	Corporate internal information system	Knowledge management	% of all employees with a degree	Hours per week, managerial	Log capital (ppent)
Pearson Correlation	Sales growth rate	1.000	.036	.034	.068	.053	.001
	Corporate internal information system	.036	1.000	-.057	.098	.099	-.007
	Knowledge management	.034	-.057	1.000	.216	.103	.200
	% of all employees with a degree	.068	.098	.216	1.000	.199	-.022
	Hours per week, managerial	.053	.099	.103	.199	1.000	.207
	Log capital (ppent)	.001	-.007	.200	-.022	.207	1.000
Sig. (1-tailed)	Sales growth rate	.	.016	.020	.000	.001	.477
	Corporate internal information system	.016	.	.000	.000	.000	.337
	Knowledge management	.020	.000	.	.000	.000	.000
	% of all employees with a degree	.000	.000	.000	.	.000	.090
	Hours per week, managerial	.001	.000	.000	.000	.	.000
	Log capital (ppent)	.477	.337	.000	.090	.000	.
N	Sales growth rate	3666	3666	3666	3666	3666	3666
	Corporate internal information system	3666	3666	3666	3666	3666	3666
	Knowledge management	3666	3666	3666	3666	3666	3666
	% of all employees with a degree	3666	3666	3666	3666	3666	3666
	Hours per week, managerial	3666	3666	3666	3666	3666	3666
	Log capital (ppent)	3666	3666	3666	3666	3666	3666

Source: authors' own calculation based on the WMS (2004) database

Table 7. Model summary

Model	R	R square	Adjusted R square	Standard error of the estimate
1	.086[a]	.007	.006	.22182

Dependent variable: Sales growth rate

Predictors: (Constant); Log capital (ppent); Corporate internal information system; % of all employees with a degree; Hours per week, managerial; Knowledge management

Source: authors' own calculation based on the WMS database

Table 8. Analysis of variance (ANOVA)[a]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	1.343	5	.269	5.461	.000[b]
	Residual	180.083	3660	.049		
	Total	181.426	3665			

a. Dependent variable: Sales growth rate

b. Predictors: (Constant); Log capital (ppent); Corporate internal information system; % of all employees with a degree; Hours per week, managerial; Knowledge management

Source: authors' own calculation based on the WMS database

The ANOVA test (Table 8) is also within the limit of 0.05 in this case, so the null hypothesis is rejected; therefore, there is a link between the dependent and the independent variables. Again, the relationship is very weak as many other factors can have an influence beyond the variables included in the model.

Table 9. Coefficients diagram of the sales growth rate dependent variable

Model		Unstandardised coefficients		Standardised coefficients	t	Sig.	95% confidence interval for B	
		B	Standard error	Beta			Lower bound	Upper bound
1	(Constant)	.011	.031		.344	.731	-.050	.072
	Corporate internal information system	.006	.004	.028	1.661	.097	-.001	.014
	Knowledge management	.005	.004	.022	1.276	.202	-.003	.013
	% of all employees with a degree	.001	.000	.053	3.041	.002	.000	.001
	Hours per week, managerial	.001	.001	.039	2.282	.023	.000	.002
	Log capital (ppent)	-.001	.002	-.010	-.597	.551	-.006	.003

Source: authors' own calculation based on the WMS (2004) database

However, the Coefficients diagram (Table 9) shows that the t-tests of corporate internal information system and knowledge management do not yield significant results because their value is greater than the expected 0.05 value. The Beta coefficient in the standardised coefficients column shows the importance of independent variables to each other in the linear context. The highest value (Beta = 0.053) is for the proportion of graduates among employees, which is not surprising as it was high compared to the other variables in Table 6. Based on these findings, the most important variable in the weak relationship is the proportion of graduates among employees.

Thus, among the variables examined, it is not the quality of the company's internal information system that affects revenue changes to the greatest extent; regardless, there is a verified correlation.

Conclusions

The relationship between the corporate internal information system and the company's ownership model suggests that decision support is an important element of corporate governance.

Based on our research, the corporate internal information system arguably has a noticeable impact on the sales revenue. This effect is, however, low as sales growth is influenced by a number of other factors and the respondents' underestimation or overestimation of certain variables should also be considered in such research studies. Yet, we think that the result is not negligible and that it is worth investing in the development of company information systems.

Our study highlights the importance of internal information systems in supporting decision-making. An important research limitation is that all data refer to medium-sized companies from the manufacturing sector, where productivity is easier to measure.

We suggest two basic directions for future research: measuring the decision support capacity of corporate internal information systems by using key indicators and a methodology to assist in the design of corporate information system development directions.

References

Akerlof, G. 1970. The Market for Lemons: Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics* 84(3), 488–500.

Anthony, R. N.–Vijay, G. 2013. *Menedzsmentkontroll-rendszerek*. Budapest: Paé Könyvkiadó.

Barancsi, É.–Horváth, J.–Szennyessy, J. 2001. *Vállalkozásgazdaságtan.* Tatabánya: Tri-Mester.

Bloom, N.–Van Reenen, J. 2007. Measuring and explaining management practices across firms and countries. *The Quarterly Journal of Economics* 122(4), 1351–1408.

Chikán, A. 2006. *Bevezetés a vállalatgazdaságtanba.* Budapest: Aula Kiadó.

Cser, L.–Fajszi, B.–Fehér, T. 2010. *Üzleti haszon az adatok mélyén. Az adatbányászat mindennapjai.* Budapest: Alinea Kiadó.

Forrester, J. W. 1961. *Industrial Dynamics.* Cambridge, MA: MIT Press.

Kiss, F.–Major, I.–Valentiny, P. 2000. *Információgazdaság és piacszabályozás*. Budapest: Akadémiai Kiadó.

Loshin, D. 2012. *Business Intelligence: The Savvy Manager's Guide.* Waltham, MA: Morgan Kaufmann.

Moenaert, R. K.–Souder, W. E. 1990. An Analysis of the Use of Extrafunctional Information by R&D and Marketing Personnel: Review and Model. *Journal of Product Innovation Management* 7(3), 213–229.

Moorman, C. 1995. Organisational Market-Information Processes – Cultural Antecedents and New Product Outcomes. *Journal of Marketing Research* 32(3), 318–335.

Munro, B. H. 2004. *Statistical Methods for Health Care Research (5th ed.).* Philadelphia: Lippincott Williams and Wilkins.

Nemény, V. 1973. *Gazdasági rendszerek irányítása.* Budapest: Közgazdasági Kiadó.

Phillips-Wren, G.–Carlsson, S. 2014. *DSS 2.0 – Supporting Decision Making with New Technologies. Frontiers in Artificial Intelligence and Applications.* Amsterdam: IOS Press.

Spence, M. 1973. Job Market Signaling. *The Quarterly Journal of Economics* 87(3), 355–374.

Stigler, G. J. 1961. The Economics of Information. *The Journal of Political Economy* 69(3), 213–225.

Szalay, Zs. G. 2009. *Menedzsment információs rendszerek gazdasági elemzése. PhD Thesis*. Gödöllő: Szent István Egyetem.

WMS 2004. *Manufacturing: 2004 Survey Data.* https://worldmanagementsurvey.org/wp-content/uploads/2010/08/BloomVanReenen_QJE1.zip, downloaded: 03.05.2017.

Wormell, I. 1991. Az információs menedzserek szerepe a gazdasági szervezetekben: oktatási és képzési szempontok. *Tudományos és Műszaki Tájékoztatás* 38(5–6), 209–215.

Forecasting the regional unemployment rate based on the Box-Jenkins methodology vs. the Artificial Neural Network approach. Case study of Brașov and Harghita counties

SZILÁRD MADARAS[1]

This paper presents different methods for the forecasting of unemployment rates in two Romanian counties. The stationarity of the monthly unemployment rate time series between January 2000 and November 2016 was examined using the ADF and KPSS tests. Based on time series, a forecast was estimated using two approaches: the Box-Jenkins methodology and the Artificial Neural Network-based NAR model. Results showed a decreasing trend by the end of the forecasted period in all cases, except for the NAR model of Harghita County. Comparing the forecasted values with the officially registered unemployment rates from the same period, we observed that, by the end of the period, the differences between the real and predicted values became higher in the NAR model than in the ARMA model-based forecasting. These results indicate that, in these particular cases, NAR neuron network model-based forecasts fit well if values are estimated for a short-term period, while for medium-term forecasts the ARMA model-based forecasting is more precise.

Keywords: regional unemployment, time-series models, forecasting and prediction methods, Box-Jenkins methodology, Artificial Neural Network.

JEL codes: C32, C53, R15.

Introduction

Time series analysis is an actual topic in regional studies. Approaches differ in the assumptions and models used for testing, i.e. the regions are studied as unique cases using the Box-Jenkins methodology or the group of regions or counties form a panel data base structure. Both of these are generally used in regional time series forecasting, while Artificial Neural Networks (ANN) currently represent a new approach in economic research.

The present study examines the unemployment rate monthly time series in Brașov and Harghita counties (NUTS3 level territorial units for statistics) from Romania. The differences between the two case studies were verified using the main regional indicators, while the employment and unemployment analysis

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proved the special situation of unemployment in those counties. In Brașov, a typical urban development-related employment was observed in the services and industry sectors, while Harghita, as a mainly rural county, was characterised by high agricultural employment.

The time series analysis and the forecasting are focusing on these two case studies. The ADF (Augmented Dickey-Fuller) and the KPSS Lagrange Multiplier tests were used to analyse the stationarity of the unemployment rate time series. The unemployment rate was forecasted using the Box-Jenkins methodology and, secondly, an Artificial Neural Network-based NAR model was set up and used for this purpose.

Literature review

Spatial differences, as evidenced by the spatial modelling of unemployment, are one of the actual topics tackled by regional unemployment research. Schanne et al. (2008) forecasted regional unemployment using a spatial GVAR model in the case of the German regions. Madaras (2009) modelled the unemployment rate in the Central Region (NUTS2 level territorial units for statistics) of Romania using the random effect panel regression model. Kryńska (2014) discussed regional employment forecasting methods and presented different forecasting case studies from the regions of Poland, while Mayor et al. (2007) set up shift-share and ARIMA models for forecasting employment in the Spanish regions.

Using the Box-Jenkins methodology as an ARIMA (1, 1, 4) process, Madaras (2014) modelled the number of the unemployed in Romania for the period January 2005–June 2013 and, based on that, performed a medium-term forecasting. The Box-Jenkins methodology was also used for the time-series forecasting of macroeconomic indicators in Romania (Morariu et al. 2009), to forecast regional tourism demand in Spain (Fernandes et al. 2008), and to forecast regional employment in Germany (Longhi et al. 2005).

The Artificial Neural Network (ANN)-based forecasting of the regional tourism demand time series was used by Fernandes et. al. (2008) compared with an ARIMA model estimation. Longhi et al. 2005 used ANN models for regional employment forecasting in Germany and proved that those were useful forecasting tools compared with the maximum likelihood random effect estimator [ML]-based panel model forecasting.

Research methodology

Stationarity analysis is one of the primary subjects of time series analysis, while time dataset-based model identification, which represents a forecasting instrument, is another important research topic.

In this paper, we used two of the most commonly known unit root tests, the ADF (Augmented Dickey-Fuller) and the KPSS Lagrange Multiplier test. Those tests present significant differences regarding the null hypothesis: the first one has the null of non-stationarity, while the second one has the null of stationarity (Kirchgässner–Wolters 2007).

The Box-Jenkins methodology has a long and prestigious past in the field of time series research. The p-order auto-regressive model (AR_p) is based on the assumption of a given time *t*, the endogenous y_t variable depends on its time delayed values of the previous 1, 2, ... p periods (Kirchgässner–Wolters 2007; Pecican 2006):

$$y_t = a_0 + a_1 y_{t-1} + ... + a_p y_{t-p} + u_t ,$$

with u_t being the error term.

The q-order moving average process (MA_q) describes the y_t, as

$$y_t = \mu + b_1 u_{t-1} + ... + b_p u_{t-q} ,$$

where μ is the mean and $u_{t-1},...u_{t-q}$ are pure random processes, for the previous 1, 2, … q periods (Kirchgässner–Wolters 2007; Pecican 2006).

The autoregressive moving average process (ARMA) with AR order p and MA order q are:

$$y_t = a_0 + a_1 y_{t-1} + ... + a_p y_{t-p} + \mu + b_1 u_{t-1} + ... + b_p u_{t-q} + u_t$$

and the ARIMA (p,d,q) autoregressive integrated moving average process refers to an I (integrated) process.

This model, initially developed by Box and Jenkins in the 1970s, is constructed with the following steps: model identification, i.e. the determination of p, q values, using the autocorrelation function (ACF) and the partial autocorrelation function (PACF), and the d of the I(1) process are specified testing the stationarity of the time series. These tests are followed by the estimation of the model coefficients and model validation (Kirchgässner–Wolters 2007; Pecican 2006).

The selection of the best fitting model is usually based on the Akaike Information Criterion (AIC) values (Pecican 2006). And, in the last step, the thus constructed model is used for the short- or medium-term forecasting of the time series.

The ANN has a wide application in research and the statistical perspective of its implementation was discussed, among others, by Cheng and Titterington (1994) and by Warner and Misra (1996).

In financial and economic time series analyses, the ANN is present as a useful nonlinear, semiparametric model.

The *feed-forward* Artificial Neural Networks are those where the inputs have forward connections to the neurons in the (one or more) hidden layers, reaching the output layer at the end. The information from one layer to other is transmitted by the activation function f_j, generally a logistic function:

$f_j(Z) = \frac{e^z}{1 + e^z}$, where j represents the *j*th node in the hidden layer,

and the feed-forward network is defined as:

$h_j = f_j(\alpha_{0j} + \Sigma_{i \to j} w_{ij} x_i)$, where w_{ij} represents the weights and the $i \to j$ summation, which include all input nodes feeding into j, and α_{oj} is the bias (Tsay 2005).

The first phase of the ANN construction is network building, i.e. determining the number of hidden layers and nodes. The second phase is the training process and, as a result, we have the estimated best fitting biases and weights of the nodes, according to the selected criterion.

In time series estimation, the ANN approach of nonlinear autoregressive models (NAR) has the *d*-period delayed values of y(t) as input:

$$y(t) = f(y(t-1), ..., y(t-d))$$

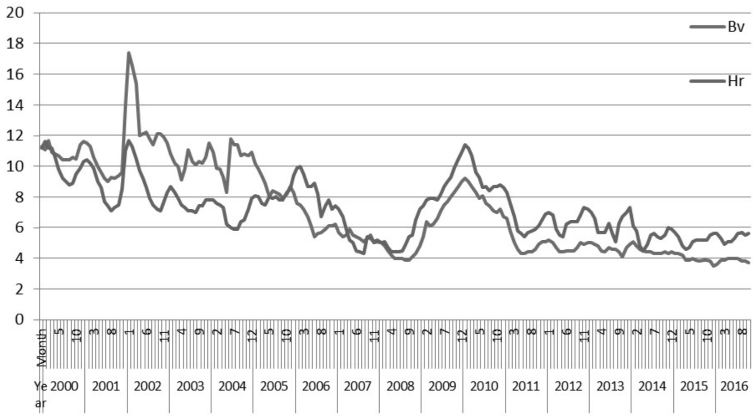
The time series analysis of the unemployment rate was performed in two counties (Brașov and Harghita) from the Central Region of Romania. These two counties were selected because, according to many regional socio-economic indicators, they were rather different: in Brașov, the share of the inhabitants living in the urban area, the regional gross domestic product, and the number of enterprises per 1,000 inhabitants are all higher than in Harghita County. Major differences could be observed among them in the activity rate, the employment rate and the unemployment rate.

In Brașov County, the high unemployment rate (7.2%) recorded in 2010 was presumably due to the local consequences of the 2008 world financial crisis, but it decreased to 3.6% in 2016. In Harghita County, the unemployment rate was higher (8.8% in 2010 and 5.8% in 2016), due to the greater vulnerability of the local labour market to the same economic impact. Although activity rates and employment rates in Brașov and Harghita counties reached relatively similar levels in 2016, there were major differences in the structure of the employed population: a high share of agricultural employment in Harghita (23.67%), as opposed to a high share of employment in services in Brașov (51.54%).

The time series of monthly unemployment rates in Brașov and Harghita counties for the period January 2000 – November 2016, used for the calculations below, were obtained from the Tempo Online database of the Romanian National Institute of Statistics (INSSE 2018).

Results

The time series analysis contains the stationarity tests, the Box-Jenkins method and the Artificial Neural Network analysis, as described below. The evolution of unemployment rates in the two counties followed similar trends in the studied period (Figure 1).



Source: author's own design based on INSSE (2018) data

Figure 1. Evolution of unemployment rates in Brașov and Harghita counties (January 2000 – November 2016)

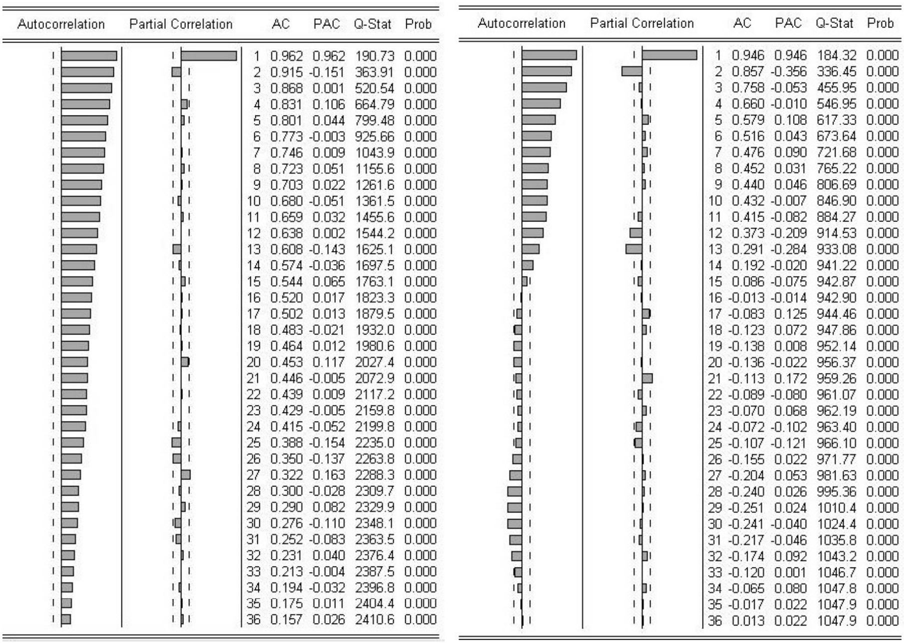
The stationarity of the series was examined using the ADF and KPSS tests (Table 1). Both of the univariate unit root tests suggest that the unemployment rate monthly time series in Brașov is a non-stationary, eventually I(1) series, while in Harghita the results of the ADF test suggest an AR(p) process. The results of the KPSS test are similar.

Table 1. Univariate unit root tests of unemployment rate time series in Brașov and Harghita counties (January 2000 – November 2016)

County	Level		First Difference	
	ADF	KPSS	ADF	KPSS
Brașov	-2.008759(1)	1.435880(11)***	-11.09876(0)***	0.045059(13)
Harghita	-3.724851(1)***	0.081944(10)	-8.765453(0)***	0.035965(1)

Source: author's own calculations based on INSSE (2018) data

In the next step, the autocorrelation function (ACF) and the partial autocorrelation function (PACF) values were calculated for model identification. For the unemployment rate time series from Brașov County, results indicated an AR(2) process (Figure 2a), while for Harghita County the partial autocorrelation test indicated an AR(2) process (Figure 2b). ARMA or ARIMA models were also considered and more tests had to be computed for the identification of the most appropriate model.



Source: author's own calculations based on INSSE (2018) data

Figure 2. Correlogram of unemployment rate time series in Brașov (a) and Harghita (b) counties

The best fitting ARMA model was chosen based on the AIC values: ARMA(1,1) for both counties (Table 2).

Table 2. Akaike information criterion (AIC) values for the estimated models of the unemployment rate time series in Brașov and Harghita counties

Brașov County		Harghita County	
ARIMA	**AIC**	**ARMA**	**AIC**
(2,0,0)	2.891793	(2,0)	2.499080
(1,0,1)	1.899506	(1,1)	1.214645
(1,1,1)	1.920951	(1,2)	1.382784
(2,1,1)	1.966818	(1,3)	1.420065
(2,0,1)	1.961739	(2,1)	1.394078
(2,0,2)	2.900252	(2,2)	2.314901
(2,0,3)	2.862625	(2,3)	2.435688

Source: author's own calculations based on INSSE (2018) data

The ARMA(1,1) model statistics of the unemployment rate time series from Brașov and Harghita counties are presented in Table 3 and we can see that, in the first case, the R-squared is equal to 0.96, while in the second case the R-squared is 0.94, which means that both estimated models explain the time series well. In the next step, the models are used for a medium-term forecast of the time series.

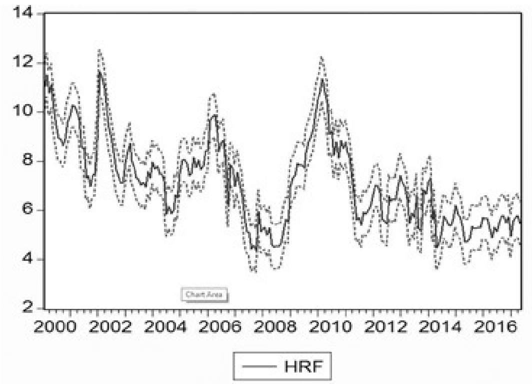
Table 3. ARMA models of monthly unemployment rate time series in Brașov and Harghita counties (January 2000 – November 2016)

Dependent variable	**Unemployment rate in Brașov County**			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.140487	1.643046	3.737259	0.0002
AR(1)	0.964376	0.018738	51.46694	0.0000
MA(1)	0.260068	0.069814	3.725161	0.0003
R-squared	0.956994			
Adj. R-squared	0.956562			
AIC	1.899506			

Dependent variable	**Unemployment rate in Harghita County**			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.844177	0.661996	10.33869	0.0000
AR(1)	0.931595	0.024561	37.93010	0.0000
MA(1)	0.428266	0.065383	6.550110	0.0000
R-squared	0.941462			
Adj. R-squared	0.940874			
AIC	1.214645			

Source: author's own calculations based on INSSE (2018) data

The ARIMA-based forecasting of the unemployment rates was carried out for the period December 2016 – May 2017. The same trends resulted as observed in the previous years: high values in first months of the year and decreasing values by the end of the period (Figure 3).



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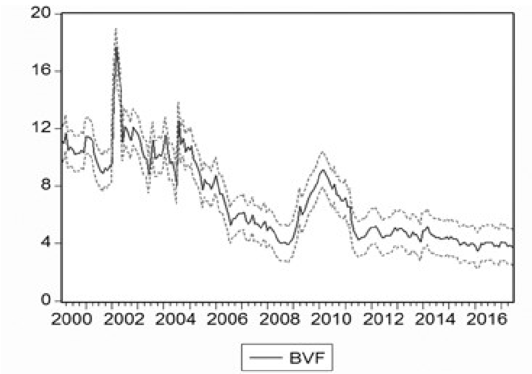
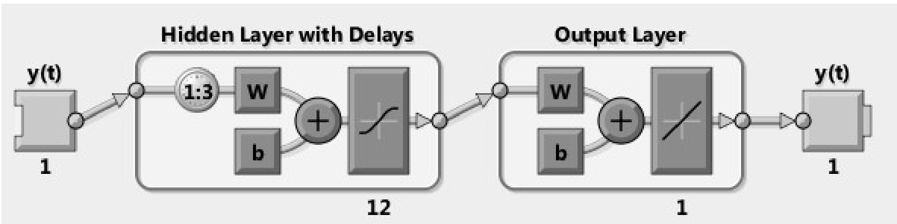


b.

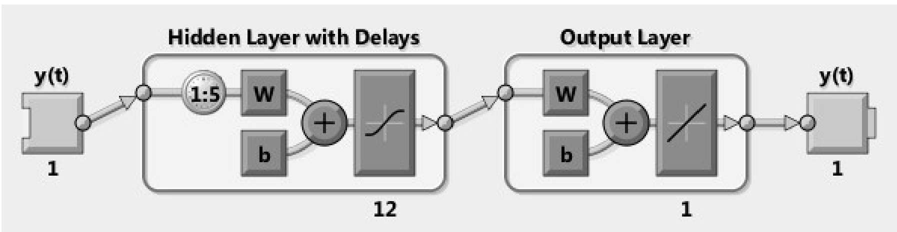
Source: author's own calculations based on INSSE (2018) data

Figure 3. ARIMA-based forecasting of monthly unemployment rates in Brașov (a) and Harghita (b) counties

For the prediction of the natural logarithmed values of unemployment rate time series in Brașov and Harghita counties, I built up the ANN-based NAR model. The time series was divided into three groups: the training group with 173 observations, the validation group with 10 observations, and the testing group with 20 observation values. In the case of the logarithmed unemployment rate in Brașov County, the network architecture was set to 1 input, 12 hidden neurons and d = 3 number of delay, while in the case of the logarithmed unemployment rate in Harghita County it was set to 1 input, 12 hidden neurons and d = 5 number of delay (Figure 4). With this neuron network architecture and lag values, the errors are autocorrelated.



a.



b.

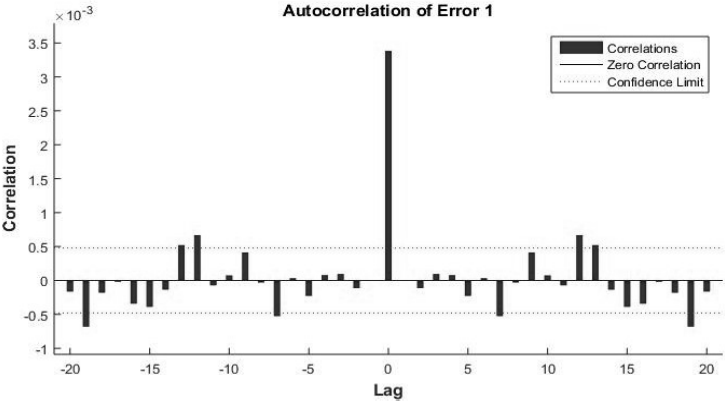
Source: author's own design

Figure 4. NAR neuron network construction of monthly unemployment rates in Brașov (a) and Harghita (b) counties

The time steps were divided into three groups: the training group (85%), the validation group (5%), and the testing group (10%). In both Artificial Neural Networks, the Levenberg-Marquardt training algorithm was used. The prediction errors became uncorrelated, after a retraining process (Figure 5), and this way the final form of the ANN models was validated for the second forecasting.

The two neuron network models presented above were used for a medium-term forecasting of unemployment rates in Brașov and Harghita counties.

Both the ARIMA model and the NAR model forecasted higher unemployment rates for Harghita than for Brașov County (Table 4), as that was the most common characteristic between January 2000 and November 2016 (Figure 1). In all cases, with the exception of the NAR model for Harghita County, results show a decreasing trend by the end of the forecasting period, which is similar to the previous years' periodicity: higher unemployment rates in the winter and lower in the summer.



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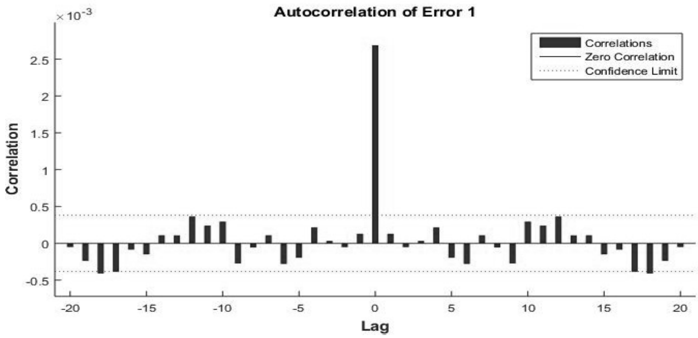

b.

Source: author's own calculations based on INSSE (2018) data

Figure 5. Autocorrelation errors of logarithmed unemployment rate time series in Brașov (a) and Harghita (b) counties

Table 4. Results of the Box-Jenkins and the Artificial Neural Network forecasting of monthly unemployment rates in Brașov and Harghita counties

Month	ARMA models		NAR models	
	Brașov	Harghita	Brașov	Harghita
	%	%	%	%
2016M12	3.740316	5.736696	3.8851	5.4722
2017M01	4.143789	4.946636	3.7602	5.7280
2017M02	4.038858	5.556964	4.0287	5.3310
2017M03	4.066147	5.703539	3.8241	5.8240
2017M04	3.814162	5.776752	4.1868	5.0325
2017M05	3.879695	5.473426	3.8578	6.0922

Source: author's own calculations based on INSSE (2018) data

In the end, I compared the forecasted values to the officially registered unemployment rates from the same period (Table 5).

Table 5. Comparison of forecasted values with the officially registered unemployment rates

Month	Registered value of the unemployment rate		Difference to ARMA model forecasting		Difference to NAR model forecasting	
	Brașov	Harghita	Brașov	Harghita	Brașov	Harghita
	%	%	%	%	%	%
2016M12	3.60	5.80	-0.14	0.06	-0.29	0.33
2017M01	3.60	5.80	-0.54	0.85	-0.16	0.07
2017M02	3.60	5.90	-0.44	0.34	-0.43	0.57
2017M03	3.50	5.20	-0.57	-0.50	-0.32	-0.62
2017M04	3.20	4.90	-0.61	-0.88	-0.99	-0.13
2017M05	3.20	4.80	-0.68	-0.67	-0.66	-1.29

Source: author's own calculations based on INSSE (2018) data

We can observe that the officially registered unemployment rates follow the same trend as in the two estimated models. By the end of the forecasting period, the differences between the real and predicted values were higher for the NAR model-based forecasting than for the ARMA model-based forecasting, while at the beginning they were almost the same.

Conclusions

In this paper, two forecasting models were developed for predicting monthly unemployment rates in Brașov and Harghita counties, using the time series for the period January 2000 – November 2016. Based on the Box-Jenkins methodology, ARMA(1,1) type models resulted for both counties. Secondly, NAR neuron network models were constructed by 1 input and 12 hidden neurons for both counties, but with different numbers of delay. The error autocorrelation test results indicated that these types of NAR models were most appropriate for the time series.

Results showed a decreasing trend by the end of the forecasted period in all cases, except for the NAR model of Harghita County.

Comparing the forecasted values with the officially registered unemployment rates from the same period, we can observe that, by the end of the forecasting period, the differences between the real and predicted values became higher for the NAR model than for the ARMA model-based forecasting. These results indicate that neuron network model-based forecasts fit well if values are estimated for a short-term period, while for medium-term forecasts the ARMA model-based forecasting is more precise.

My results confirm the findings of Fernandes et al. (2008) that the NAR or other neuron network-based models are useful alternatives to the Box-Jenkins methodology for regional economic data time series forecasting.

In future studies, the different types of neuron network models are recommended to be analysed in comparison to the commonly used Box-Jenkins methodology to identify their usefulness and limitations in regional economic research.

References

Cheng, B.–Titterington, D. M. 1994. Artificial Neural Networks: A review from a statistical perspective. *Statistical Science* 9, 2–54.

Fernandes, P.–Teixeira, J.–Ferreira, J. M.–Azevedo, S. G. 2008. Modelling tourism demand: A comparative study between Artificial Neural Networks and the Box-Jenkins methodology. *Romanian Journal of Economic Forecasting* 2008(3), 30–50.

Goschin, Z.–Constantin, D.–Roman, M.–Ileanu, B. 2008. The current state and dynamics of regional disparities in Romania. *Romanian Journal of Regional Science* 2(2), 80–105.

INSSE 2018. http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, downloaded: 18.02.2018.

Kirchgässner, G.–Wolters, J. 2007. *Introduction to Modern Time Series Analysis*. Berlin, Heidelberg: Springer–Verlag.

Kryńska, E. 2014. *Employment Forecasting. Social Policy Thematic Issue No 2.* Warsaw: Institute of Labour and Social Studies.

Longhi, S.–Nijkamp, P.–Reggianni, A.–Maierhofer, E. 2005. Neural Network Modeling as a Tool for Forecasting Regional Employment Patterns. *International Regional Science Review* 28(3), 330–346.

Madaras, Sz. 2009. A munkanélküliségi helyzet elemzése a Központi Régió megyéiben. *Közgazdász Fórum* 12(5), 45–58.

Madaras, Sz. 2014. A gazdasági válság hatása a munkanélküliség alakulására országos és megyei szinten Romániában. *Közgazdász Fórum* 17(1–2), 136–149.

Mayor, M.–López, A. J.–Pérez, R. 2007. Forecasting Regional Employment with Shift–Share and ARIMA Modelling. *Regional Studies* 41(4), 543–551.

Morariu, N.–Iancu, E.–Vlad, S. 2009. A Neural Network Model for Time-Series Forecasting. *Romanian Journal of Economic Forecasting* 2009(4), 213–223.

Pecican, Ș. E. 2006. *Econometrie*. București: Editura Beck.

Schanne, N.–Wapler, R.–Weyh, A. 2008. Regional unemployment forecasts with spatial interdependencies. *IAB-Discussion Paper* 28/2008, http://nbn-resolving.de/urn:nbn:de:0168-ssoar-307640, downloaded: 18.02.2018.

Tsay, R. S. 2015. *Analysis of Financial Time Series*. Hoboken, NJ: John Wiley & Sons.

Warner, B.–Misra, M. 1996. Understanding Artificial Neural Networks as Statistical Tools. *The American Statistician* 50(4), 284–293.

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