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Challenges of Industry 4.0 in Hungarian agriculture

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Although the technological revolutions in agricultural production are already at stage 5.0, the majority of Hungarian farmers are familiar with the achievements of 4.0 in theory, but most of them still use only elements of stage 2.0. The range of BigData applications goes far beyond production itself and even covers the entire supply chain. It plays a role in global issues such as food safety and sustainable management, and the results of the data from the system are used to improve efficiency. The development of the Internet of Things (IoT), which wirelessly connects agricultural production and supply chain members, will result in a lot of new, real-time data. An important challenge for these changes is to create new business models for farmers, but it also brings with it a number of open regulatory issues, such as data security and data ownership issues. Decision-making issues do not necessarily remain in the hands of farmers, but the data owner can have a major influence on the design and selection of alternatives. Sustainable integration of Big Data resources is a challenge, as it is crucial for the enterprise model. In order to introduce and apply new technologies, it is absolutely necessary to rethink and transform the existing processes. Developments should not be done in isolation, but together with innovative companies and farmers. It is important to keep in mind that in the future, the collection and sharing of data and the different work tools will be compatible with each other, and data transfer will be as simple as possible, keeping security in mind. The present study examines the theoretical effects of BigData applications in comparison to business models used in conventional technology along the business model research issue based on Lindgradt et al. (2009).

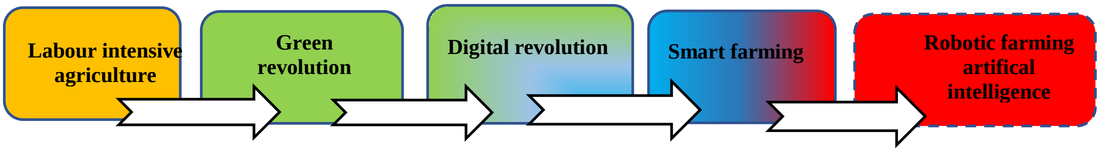
Keywords: Big Data, IoT, business model, agricultural innovation

1. Introduction

Numerous global trends are influencing agribusiness. Agricultural production needs to face the following main challenges: a growing population, increasing urbanization, climate change, and technology change. We are in the middle of new agriculture revolution. The stages of the agriculture are the following (Kovács–Husti 2018, Lejon–Frankelion, 2015, Popp et al. 2018, Rose–Chilvers 2018, Varga 2018, Lencsés–Mészáros 2021), (Figure 1):

1. Labour-intensive agriculture: low productivity, enough food for population, and 1/3 of the population needed to work in the agriculture.
2. Green revolution: the adoption of new technologies such as yield variety, chemical fertilizers, agro-chemicals, irrigation, and new methods of cultivation, including mechanization. The key leader was Norman Borlaug.
3. Digital revolution / Precision farming: variable rate technology, site specific decision, GIS, GPS
4. Smart farming: big data, cloud based, on-line sensors, UAV.
5. Robotic farming: robots used in agriculture production, e.g. spraying drones, and weed-management robots. These technologies are still under development.

Figure 1 Technology revolutions in agriculture production



Source: Own construction based on: Kovács–Husti (2018); Lejon–Frenkelius (2015); Popp et al. (2018); Rose–Chilvers (2018); Varga (2018), Lencsés–Mészáros (2021).

Agriculture in 4.0 is still at an early stage of development, mostly used in Western Europe and North America for the time being. Within Agriculture 4.0 technology, BigData applications can be used on issues such as food safety and sustainable farming, and the results of the data from the system play a role in improving efficiency. The development of the Internet of Things (IoT), which wirelessly connects agricultural production and members of the supply chain, is creating much new, real-time data and making it available (Wolfert et al. 2017).

However, the new technology presents a number of challenges, to which Szőke and Kovács (2020) drew attention. Efficient processing of large amounts of data still involves problems. Broadband internet is not yet available everywhere. Data from different manufacturers are not compatible with each other, so data transfer between systems is not guaranteed. The quality of the data collected also varies, which poses a different kind of compatibility issue. The application of new technology requires the acquisition of new skills, which is time-consuming and requires the organization of trainings and courses. There is a need to create and apply new business models. Analyses of unprecedented size and speed change the opportunities for participants in the production process and create new business models. Management of the economy, access to data, real-time forecasting and monitoring, combined with developments in the IoT, will manifest themselves in further automation and autonomous operation of the economy. It can already be seen that Big Data will cause a significant rearrangement in the balance of power between the actors involved in production. When using Big Data, a lot of heterogeneous data is also a big challenge to apply to intelligent processing and analytics. Sustainable integration of Big Data sources, data sources are a challenge as this is crucial for the corporate model (Wolfert et al. 2017).

There may be other barriers to the diffusion of technology. Fodor et al. (2020) approached the issue from a legal perspective. One of the biggest barriers to innovation in Hungary is the unfavorable legal regulatory environment, which includes bureaucratic and thus cumbersome administration, lack of financial resources and skilled labor, is less open to innovation management, and has the problem of knowledge transfer. The unfavorable legacy of previous periods has resulted in a still tangible, disorganized environment, such as an increasingly aging farming community, large-scale tenure, undivided common property, a lack of agricultural co-operation, and incomplete regulation. The process of transformation at the time of the regime change was followed only by a significant delay in the emergence of innovation, which was created through the EU support system.

Assessing the Hungarian situation, László Farkas (who is a pioneer farmer of precision farming) also highlighted the regulatory environment as a factor hindering new technologies and making it difficult to catch up with developed countries. The other hindrance is that it is difficult to implement development without external help. Using expert advice, it is necessary to optimize it for the processes of the given economy, for which one of the best solutions is precision or smart technology. In addition to using expert advice, Szilárd Szabó emphasized his commitment. Appropriate calculations for investment costs are now available, the return can be limited, but in a large company, a lot can depend on the attitude of the employees. The application of new technologies is a step-by-step process in which planning, construction and education also have a place (Agronapló 2018).

NAK (2019) conducted research among precision farmers, which we believe also suggests the spread and use of smart technology. The concept of precision farming is well-known among Hungarian farmers engaged in crop production: 79% have heard of it and know what it means, and 61% are open to the use of precision technology tools. Other studies show that only half of crop growers have heard of it, but this percentage also depends on the size of the farm. Users of precision farming are mainly under 40 years of age, have a tertiary education, and cultivate more than 300 hectares of land, which is in line with international experience (Lencsés et al. 2014). 23% of farmers actually use some element of precision farming. Of those who do, 79% are satisfied with it. The most common precision devices are GPS 58%, guide 47%, and automatic steering 24% (NAK 2019). However, according to a survey by Pólya and Varanka (2015), 44% of all farmers use GPS, while 48% of the farmers under 40 years of age do so.

Of the control systems, 30% of weeds follow a robotic pilot, followed by VRT sowing and fertilizer application (25%). The use of anti-pest sensors, drones, and precision irrigation sensors is still in its infancy: their application rate is only around 5% (Kemény et al. 2017). Regarding future plans, most farmers would introduce drones (13%), RTK (real-time kinematic systems, 13%) and automatic steering (12%).

The survey by Berta (2018) contradicts all this, where 63% of agricultural entrepreneurs do not use GPS, 16.3% use it only on a power machine, and 20.7% on a power and work machine. And there are problems for entrepreneurs in accessing precision data. In the survey, 39 farmers used the data analysis option, so the numbers are extremely low. Of this, 51.2% retrieve the data themselves, 14% access it with assistance, and 34.8% have it sent to them. All this points to the fact that only a small proportion of farmers are able to use digital technology related to precision farming. Thus, it is thought-provoking that the application of smart systems is less successful than it would be based on data extraction and analysis.

However, the results of the survey are nuanced by the fact that two-thirds of farmers stated that they use at least one of the technologies described. Based on this, the question arises as to whether some farmers are either unaware of precision technology or their actual use is not considered precision farming (NAK, 2019). Takácsné (2015) segmented farmers in terms of the application of technological innovation. They can be basically divided into two major groups: innovators and early adapters actively involved in innovative developments, and those who use mature technology, that is, pragmatic early adopters, late conservatives, and late sceptics.

Lencsés et al. (2014) pointed out that the biggest problem of the interviewed farmers depends on the professional knowledge and attitude of the manager and staff to a great extent. Because of this, farmers sometimes think that investing in precision technology will not bring the expected positive results, so they do not buy other accessories or start using their precision tools in the traditional way. Takács-György and Takács (2011) highlighted high investment costs as a limiting factor. As a result, farmers do not dare to embark on a change in technology. According to their studies, the risk is in the different prices of input and output materials, in the production structure, in the yields of precision farming in different areas, and in the size of the plant. In another study, Takácsné (2011) points out that in areas with homogeneous conditions, the return on investment takes more time, as no significant material cost savings can be achieved. Takácsné (2015) also drew attention to the fact that different technological elements belonging to precision technology run different life paths. This is due to differences in technological developments and differences in their "palpability" in their application. Significant improvements in pest control are still expected in the identification of pests or the refinement of remote sensing.

Several studies highlight the importance of expertise (Gaál–Illés 2020; Takács-György–Takács 2011). Farmers using new technology need to have a complex body of knowledge that is less popular due to its novelty, with the older generation refraining from using it. Computer skills are required to manage smart machines and systems, and to extract the data from them. This can be helped by the organization of various trainings, the involvement of agro-informatics in the extraction and proper management of data, and the operation of the expert advisory system in this direction.

2. Model and method

Osterwalder et al. (2005) describes value configuration as the arrangement of activities and resources. Core competency includes the competencies necessary to execute the business model. Partner network refers to the network of cooperative agreements with other companies necessary to efficiently offer value. The business models of competitors could be completely different. A competitor who selects the best model and implements it effectively can win the trade and competition. The different reasons could force the organizations to change their previous business model. Investments and innovations, information systems, human capital, and new technologies are some of the numerous examples of business model innovation driving forces. Of course, the aim of agility is not just to inactively respond to the environment changes, it is also to take advantages of changes (Dove 1994, Kidd 1994, Sharifi–Zhang 1999).

Innovation in a business model does not simply mean the innovation in services/products or technology (Lindgadt et al. 2009, Massa–Tucci, 2013, Mitchell–Bruckner 2004). Lindgardt et al. (2009) believe that when innovation in a business model occurs at least two components are reinvented, and innovation in just product/service does not count as a business model innovation. According to them, the two main elements of the business model are the value proposition model and the operating model. The value proposition model includes the following components: target segment, products/services offering, revenue model, operating model, comprises value chain, cost model, and organization. Innovation in the business model has been always recommended, due to the fact that sustainable competitive advantage is created in business model innovation (Giesen et al. 2007, Mitchell–Bruckner 2004). Massa and Tucci (2013) also argue that business model innovation consists of innovation in content, structure and governance. Innovators need to dynamically trace the trends and to have a proper change management to be able to respond on time to these changes (Mitchell–Bruckner 2004). Of course, the aim of agility is not just to inactively respond to the environmental changes but to take advantage of changes (Sharifi–Zhang 1999, Dove 1994, Kidd 1994).

According to the Lindtgard model, we examine all the necessary elements for the introduction and professional application of agriculture 4.0 and compare them with the practical experience from Hungarian surveys. This way we can identify the factors where improvement is needed.

3. Results

We summarize our results in Table 1, which highlights which points according to the Lindtgard et al. (2009) model should be met in the case of agriculture 4.0, and where the current Hungarian general agricultural practice is. As the table shows, change is needed in all elements, not only in the use of the new technology, but also in gaining background knowledge related to the technology and connecting more closely with members of the value chain.

Table 1 Changes of business model element by Lindgardt et al. (2009) due to the adaptation of Agriculture 4.0 technology

Components of business model	Agriculture 4.0 requirements and effects	Missing factors in case of Hungarian farmers
TARGET SEGMENT	B2C: conscious food consumer with moderate environmentally friendly attitude who wants to know how to trace the source of the food B2B: agrobusiness sector (for whom the comprehensive system of traceability is very important)	Most farmers do not know the final consumer and their needs. Aim: understand the costumer behaviour
PRODUCT OFFERING	Agricultural products e.g. crops, vegetables, fruits.	Farmers do not want to give their data to the buyers. Aim: improve the trust in the supply chain.
REVENUE MODEL	With Agricultural 4.0 technologies the yield and income volatilities become less general because of the more rational input usage.	The data goodness mainly depends on the IT knowledge of the person who analyses the data. Aim: improve the IT knowledge of farmers

VALUE CHAIN	The last agricultural revolution does not make changes in the value chain.	Without the trust between the members of the value chain the system does not work.
COST MODEL	According to FADN, cost structure included crop-specific inputs, total farming overhead, depreciation of capital assets estimated at replacement value, and total external cost.	The farmers must understand the connection between the costs and the benefits. Aim: help the farmers understand the importance of cost analysis.
ORGANIZATION	The Agriculture 4.0 technologies are very sensitive to the digital skills of the staff.	The employee in the agricultural holdings is not well qualified or well educated. Aim: improve digital skills and help deepen commitment to new technology.

Source: own research

4. Conclusion

Hungary is not lagging behind the developed agricultural countries (like Denmark, Germany, USA, etc.) in the availability of latest technologies (like, for example, spraying drones). All the latest innovations are available for Hungarian farmers. It is very positive that the average Hungarian farmers have heard about the equipment of Agriculture 4.0 and they know a lot about its theory,but for some reasons they do not use these innovations. If the government wants to extend the adaptation of Agriculture 4.0 in Hungary, they need to make an effort in the following fields: improve trust in the value chain, improve digital skills of farmers, and give financial support to farmers who use modern agriculture equipment.

References

Agronapló (2018): A precíziós technológia hazai elterjedésének legfőbb gátjai, Agronapló, 2018. 04. 10., https://www.agronaplo.hu/szakfolyoirat/2018/04/gepesites/ a-precizios-technologia-hazai-elterjedesenek-legfobb-gatjai

Amit, R. – Zott, C. (2012): Creating value through business model innovation. *MIT Sloan Management Review*, 5, 3, 41–44.

Berta O. (2018): Információs technológiák használata a magyar mezőgazdasági vállalkozások menedzsmentjében: avagy egy digitális agrárgazdasági kutatáseredményei. *Gazdálkodás*, 62, 4, 337–352.

Farm Accountancy Data Network (FADN): https://circabc.europa.eu/sd/a/16d411ec-33fe-404b-ab4c-efcfdbbf9935/RICC%20882%20rev9.2%20Definitions%20of%20Variables. Accessed: 2021. July.

Dove, R. (1994): Agile and otherwise, series of articles on agile manufacturing. *Production Magazine*, November.

Fodor L. – Bai A. – Balogh P. – Bujdos Á. – Czibere I. – Gabnai Z.– Kovách I. (2020): Szabályozási problémák a precíziós gazdálkodás hazai helyzetének társadalomtudományi elemzése alapján. *Miskolci Jogi Szemle* 15, 1, 5–23.

Gaál M. – Illés I. (2020): A precíziós szántóföldi növényermesztés helyzete és ökonómiai vizsgálata, NAIK AKI, 156, http://repo.aki.gov.hu/3655/1/2020_01_T_Precizios%20kiadvany_web_pass2.pdf

Giesen, E. – Berman, S. J. – Bell, R. – Blitz, A. (2007): Three ways to successfully innovate your business model. *Strategy & Leadership*, 35, 6, 27–33. https://doi.org/10.1108/10878570710833732

Kemény G. – Lámfalusi I. – Molnár A. (ed.) – Gaál M. – Kiss A. – Péter K. – Sulyok D. – Takács György K. – Domán Cs. – Illés I. – Kemény Horváth Zs. (2017): A precíziós szántóföldi növénytermesztés összehasonlító vizsgálata [Comparative study of precision arable crop production]. Agrárgazdasági Könyvek. Budapest: Agrárgazdasági Kutató Intézet. http://repo.aki.gov.hu/2488/1/2017_K_03_Precizios_konyv_web_pass.pdf

Kidd, P. T. (1994) *Agile Manufacturing: Forging New Frontiers*. Wokingham–Reading, MA: Addison-Wesley.

Kovács I. – Husti I. (2018): The role of digitalization in the agricultural 4.0 – how to connect the industry 4.0 to agriculture? *Hungarian Agricultural Engineering*, Published online: http://hae-journals.org/ ISSN 2415-9751 doi: 10.17676/HAE.2018.33.88

Lejon E. – Frankelius P. (2015) Sweden innovation power—Agritechnica 2015, Elmia, Jönköping, Sweden. https://www.academia.edu/28862722/Sweden_Innovation_Power_Agritechnica_2015

Lencsés E. (2014): A precíziós (helyspecifikus) növénytermelés gazdasági értékelése. PhD értekezés. https://szie.hu/file/tti/archivum/Lencses_Eniko_ertekezes.pdf. Accessed: 2021. July.

Lencsés E. – Mészáros K. (2021): Business model innovation with precision farming technology from the farmers point of view. *Hungarian Agricultural Engineering*, 38, 79-81., http://doi.org/10.17676/HAE.2020.38.79

Lindgardt, Z. – Reeves, M. – Stalk, G. – Deimler, M. S. (2009): *Business Model Innovation. When the Game Gets Tough, Change the Game*. Boston: The Boston Consulting Group. https://doi.org/10.1002/9781119204084.ch40

Massa, L. – Tucci, C. L. (2013): Business model innovation. In: Dodgson, M. – Gann, D. M. – Philips, N. (eds) *The Oxford Handbook of Innovation Management*. Oxford: Oxford University Press, 420–441. https://doi.org/10.1093/oxfordhb/9780199694945 .013.002.

Mitchell, D. W. – Bruckner Coles, C. (2004) Business model innovation breakthrough moves. *Journal of Business Strategy*, 25, 1, 16–26. https://doi.org/10.1108/02756660410515976.

NAK (2019): Nemzeti Agrárgazdasági Kamara: Egyre többen végeznek precíziós gazdálkodást, http://nak.hu/en/agazati-hirek/mezogazdasag/146-novenytermesztes/ 99560-egyre-tobben-vegeznek-precizios-gazdalkodast. Accessed: 2021. July.

Osterwalder, A. – Pigneur, Y. – Tucci, C. L**. (**2005): Clarifying business models: Origins, present, and future of the concept. *Communications of the association for Information Systems*, 16, 1, https://pdfs.semanticscholar.org/4d60/687583e42658fa1c47c9a a02813ce428da4b.pdf. Accessed: 2021. July.

Pólya Á. – Varanka M. (2015): Információszerzés és döntés-támogatás az agráriumban. Piackutatási jelentés. AgroStratéga http://agrostratega.hu/letoltesek/AgroStratega_kutatasi_jelentes_2015_standar d.pdf. Accessed: 2021. July.

Popp J. – Erdei E. – Oláh J. (2018): A precíziós gazdálkodás kilátásai Magyarországon (Outlook of precision farming in Hungary); *International Journal of Engineering and Management Sciences* (IJEMS) 3, 1, DOI: 10.21791/IJEMS.2018.1.15.

Rose D. C. – Chilvers J. (2018): Agriculture 4.0: Broadening responsible innovation in an Era of Smart faming; *Frontiers in Sustainable Food Systems*; doi: 10.3389/fsufs.2018.00087 https://www.frontiersin.org/articles/10.3389/fsufs.2018.00087/full

Sharifi, H. – Zhang, Z. (1999): A methodology for achieving agility in manufacturing organisations: An introduction. *International Journal of Production Economics*, 62, 1, 7–22. https://doi.org/10.1016/S0925-5273(98)00217-5.

Szőke V. – Kovács L. (2020): Mezőgazdaság 4.0 – relevancia, lehetőségek, kihívások, Gazdálkodás, 64, 4, 289–304.

Takács-György K. – Takács I. (2011): Risk assessment and examination of economic aspects of precision weed management. *Sustainability* 3: 1114–1135. DOI 10.3390/su3081114

Takácsné Gy. K. (2015): Agrárinnováció a gyakorlatban – avagy miért ilyen lassú a helyspecifikus növénytermelés terjedése. *Gazdálkodás*, 59, 6, 517–526.

Varga P. (2018): Stratégiai beavatkozási rendszer, https://www.slideshare.net/iier/digitlis-agrr-stratgia-beavatkozsi-rendszere. Accessed: 2021. July.

Wolfert S. – Ge L. – Verdouw C. – Bogaardt M. J. (2017): Big Data in Smart Farming–A review. *Agricultural Systems*, 153, 69–80. doi:10.1016/j.agsy.2017.01.023