HUMAN CAPITAL IN AGRICULTURE: BARRIERS TO INDUSTRY 4.0

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Abstract: The aim of this paper is to identify the challenges to Industry 4.0 implementation in agriculture with emphasis on the human factor, which is an issue not sufficiently dealt with in the current literature. Investments in Industry 4.0 technologies and tools enable enterprises to increase labour productivity, to more accurately predict future developments, and allow employees (operators, managers and executives) to make informed day-to-day decisions based on real-time data, facilitating in-house departmental collaboration. Over the period 2019–2020, the authors conducted a survey (semi-structured face-to-face interviews) among almost thirty representatives of agricultural enterprises, advisers and secondary school head teachers. Primary data showed significant agricultural labour shortages, which is one of the reasons why farm managements decide to automate and robotize the production process. In addition to high financial costs, barriers to the digital technologies include concerns about power outages and subsequent data losses. The present survey results also indicate possible impacts on the workforce, the feeling of losing touch with farming practice in particular.

Keywords: Industry 4.0, agriculture, robotization, labour market, employment, barriers

1 Introduction

In recent years, the concept of Industry 4.0 (Fourth Industrial Revolution) in agriculture has been increasingly embraced. In the primary sector, too, future innovation trajectories are to be designed and particular technologies prioritized (Levidow et al. 2012; Schlaile et al. 2017; Klerkx and Begemann 2020; Klerkx and Rose 2020). Industry 4.0 in agriculture is still ambiguously defined, often confused with the terms smart/precision/digital agriculture, bio/circular economy or aquaponics (Regan 2019; Klerkx and Rose 2020; Hermans 2018; Junge et al. 2017; Pigford et al. 2018). It is associated with various emerging technologies (Klerkx a Rose 2020) such as artificial intelligence, drones, robotics and gene modification. It will revolutionize current agricultural values and identities (Eastwood et al. 2019; Fielke et al. 2020). However, without a clear indication of which technologies are involved in this process, it is difficult to determine how they are perceived by different stakeholders, and what their unequal effects on society may be.

Advances in technologies have always raised concerns that they will redraft the map of the required professions, leading to unemployment and social instability (David 2015; Mokyr et al. 2015). Despite its seriousness, this problem resists conceptualization and methodical approach (Mokyr et al. 2015). Industry 4.0 offers many opportunities and benefits such as competitive advantages, making companies more attractive to the young workforce in particular. Investments in Industry 4.0 technologies and tools enable enterprises to increase labour productivity, to more accurately predict future developments, and allow employees (operators, managers and executives) to make informed day-to-day decisions based on real-time data, facilitating in-house departmental collaboration.

The transformational power of Industry 4.0 will also affect agriculture (connecting farms, introducing smart machinery, tractors, vehicles, etc.). This will make labour productivity and environmental protection more effective. It will also bring about changes in the value chain and business models with a greater emphasis on know-how gathering, analysis and exchange. This will be reflected in the labour market and the structure of employment. Industry 4.0 in agriculture is currently being developed within a conceptual framework, not taking into account possible barriers, drawbacks or detrimental effects on human resource management.

While the Industry 4.0 implementation in the manufacturing sector has been covered in the professional literature (industrial application is principally simpler and more advanced, Industry 5.0 already gaining ground (Demir et al. 2017; Özdemir and Hekim 2020)), Industry 4.0 agricultural agenda, on the other hand, still remains to be mapped out in more detail. Therefore, it is the very latter sector that is the focus of the present survey undertaken on a sample of selected respondents.

The aim of this paper is to present the results of qualitative research focused on the barriers of Industry 4.0 in agriculture with particular interest in human capital. After a brief introduction, the article is divided into four sections. The literature review gives an outline of the existing body of knowledge about the issue of Industry 4.0 in the sector of agriculture. The following section explains the method employed, i.e., semi-structured interviews with agricultural managers, advisers and school headmasters. The results of the research are presented and discussed in the third and summarized in the final section

2 Literature references

Industry 4.0, or the so-called Fourth Industrial Revolution, brought about radical changes to both organizations and employees. Mayer (2020) points out that the former must cope not only with major technological innovations and new concepts of labour and employment, but also with the latter's perception of the rapid change.

Having been introduced at the Hannover Trade Fair in 2011, Industry 4.0 agenda became the official German strategic initiative in 2013 (Kraft et al. 2017; Xu et al. 2018). Industry 4.0 is considered a kind of industrial revolution of the 21st century which is rapidly transforming the management, organizational structures and competencies, subjecting them to more intensive scrutiny. As Geissbauer et al. (2016) claim, Industry 4.0 has proven to be a promising technological framework for integrating and expanding production processes both internally and externally.

Regarding agricultural production, the above transformational drive will result particularly in farm mergers and the application of smart solutions to farm machinery. Farming of the future will make greater use of sophisticated technologies (e.g., robots, temperature and humidity sensors, aerial photos and GPS technology), allowing agricultural businesses to become more profitable, efficient, safer and more environmentally friendly. In agriculture, the concept of smart environment emerged later than in industry, although some related technologies such as precision farming or the farm management information system have long been in operation.

Zheng et al. (2011) explain how ICT is applied to the visualization, design, monitoring and control of agricultural buildings and processes in the so-called digital agriculture, also known as "smart farming" or "e-agriculture". The similarity between Industry 4.0 technologies and digital agriculture was highlighted by Zambon et al. (2019).

According to Pivota et al. (2019), the main obstacles preventing farmers from participating in Industry 4.0 concept are unreliable internet connections, especially in rural areas, and the amount of data to be entered into the system, for which smaller farmers are not properly trained.

Imran et al. (2021) draw particular attention to three major barriers to the implementation of Industry 4.0 in agri-food supply chains. The main obstacle (according to 80 % of survey respondents) is insufficient funding for investment in modern

technologies. Another limitation (67 %) is organizational inertia caused by employees' change resistance, lack of motivation and distorted awareness of technology benefits. The last barrier (57 %) is the poor sharing of resources between partners.

Seeing Industry 4.0 barriers from different angles, Stentoft et al. (2019) emphasize executive management's misunderstanding of the strategic importance of the 4.0 business model, and staff's ignorance of its principles, which requires further training. The authors also point to a lack of funds, skilled workforce and legal regulations, as well as poor cyber security provision.

The trend towards the knowledge society is reflected not only in the broader social context, but also in the required qualifications and the labour market in general. Fundamental changes in nature of work affect the organizational structure as well as the roles of employees and job descriptions requiring new skills. Employment developments are shaped by the above trends, too. The question of whether technological progress, especially automation, will lead to a net increase in unemployment is widely discussed. Until now, after completing retraining programmes, the unemployment rate has usually recovered, new jobs emerging. As regards the types of jobs that are likely to disappear due to automation, most research studies agree that routine work is most at risk (Flynn et al. 2017).

3 Methods

Primary data were drawn from semi-structured interviews conducted over the period 2019–2020. The method of qualitative sociological research was chosen for its flexibility, allowing to react to personal attributes of each participant. Following the prescribed instructions, the method made it possible to conduct in-depth well-arranged face-to-face interviews. The disadvantage, however, is the duration and psychological complexity; the interviewer is supposed to have a perfect knowledge of the issue and the ability to adapt to the interviewee. The questions covered the two areas (in modified variants for a given group of respondents):

- Industry 4.0 and human resources
- Perception of barriers to Industry 4.0

Interviews were conducted with the following three groups of respondents:

- Group 1 (GR1) – farm managers / team leaders

9 respondents participated in the research, all holding positions in top management – 2 each in livestock and crop production, 5 in mixed production. The criterion for their selection was experience in agriculture of more than 20 years. Their attitudes to and experience with the impacts of automation and other 4.0 solutions on production processes and the agricultural labour market were examined.
For a more comprehensive view of the issue addressed, interviews with respondents who have work experience in agriculture but are not management members were also conducted.

- Group 2 (GR2) – farm advisers (for production and administration)

7 respondents took part in the research – 4 for crop and animal production, 2 advisors-agronomists and a director of the Agrarian Chamber. All of them had agricultural consulting experience of over 20 years.

- Group 3 (GR3) – agricultural secondary school headmasters

13 respondents with at least 20-year experience in education related to farming participated in the survey.

The following three research questions were asked:

Question 1: What are the main barriers to the implementation of Industry 4.0 concept in agriculture from the respondents' point of view?

Question 2: How do the identified barriers differ from those reported in the literature?

Question 3: What impact do the elements of Industry 4.0 in agriculture have on human capital?

The information obtained from the interviews was processed using a smart software tool for qualitative data analysis and organization MAXQDA (version 18.2.5).

4 Results and discussion

Of the total number of respondents, 58 % are aware of Industry 4.0 concept, 49 % being actively engaged in it. 45 % of respondents admit that they know the idea superficially, mainly from the media, 29 % not knowing it at all. Those who are familiar with Industry 4.0 most often refer to the use of advanced technology (15 respondents) and GPS and sensors (15).

84 % of respondents believe that there are human work activities that cannot be replaced by robots. Especially livestock farming will still require a "human touch", e.g., in insemination and animal health control. (As one interviewee put it, "new technologies can make work easier, but a robot won't cure an animal".) The introduction of 4.0 technologies may, however, improve the image and attractiveness of agriculture in public. According to the respondents, greater promotion and awareness among young people in particular would help.

Respondents who are not familiar with Industry 4.0 concept cite lack of interest in adopting new technologies, especially if there is no reason to make changes in the established procedures. This is the way the respondents working in crop production think, not enjoying the benefits of automation that are evident in livestock farming.

The headmasters of agricultural secondary schools (GR3) state that they have been dealing with the concept for one to four years, outsourcing lectures, using practical examples, and incorporating information about technology advances operatively in classes. 36 % of head teachers say that they have modernized their school farms. As barriers to Industry 4.0, they recognize the complexity of Industry 4.0 agenda, considering the lack of student interest and poor funding for the acquisition of advanced educational facilities and equipment.

53 % of GR1 respondents report that they have been implementing automation elements for more than ten years. (One participant said that they had been driving automated processes on their farm for about two decades. As an example, he cited air conditioning computer control in stables – automatic fan starters and ventilation openers – which is no longer perceived as something innovative.) Among Industry 4.0 technologies, respondents mention GPS-controlled precision sowing, fertilization, care and harvesting of crops, as well as technologies for operating a weather station, monitoring nutrition and livestock conditions, and automatic feeding. ("Layer poultry farming, broiler fattening, and pig farming are far more advanced in terms of automated machinery than other agricultural production. Due to the long-term development and improvement, automatic feeding, ventilation, egg collection and manure removal systems work very well", one participant boasted.)

4.1 Industry 4.0 and human resources

The majority of GR1 respondents answered positively the question whether automation/robotics has already proved its worth in their respective farm establishments. One of the most common motivational effects of pursuing Industry 4.0 agenda, confirmed by 60 % of survey participants, is the successful recruitment of new labour force. Nevertheless, despite the increase in salaries, the same percentage of respondents remain sceptical about the number of suitable staff available in the future, especially in the lowest positions in rather unpopular livestock farms. It is thus understandable that respondents

mostly claim that they would not dismiss workers due to their "redundancy", but would try to find an appropriate retraining course and/or another job for them. (The above-mentioned trends may be affected by the persisting unflattering public sentiments about and prejudices against farming.)

35 % of GR1 respondents, on the other hand, state that it is the declining attractiveness of (i.e., the growing lack of interest in) working in agriculture that forced them to seriously meet the challenge of introducing labour-saving robotic systems.

ICT has become part of every industry including agriculture. The assumption prevails that the more complex the technology, the higher the requirements for more comprehensive staff training. (Managers, however, are realistic, knowing that, as one respondent put it, "there are still workers who are afraid to touch a computer". For the older generation of farmers in particular, digital technologies remain a deterring factor.)

Despite the objective reduction in the number of agricultural workers, all GR1 respondents agree that the human factor is crucial as not all farming activities can be fully automated.

The two remaining groups of participants also commented on the issue of labour shortages and interest in 4.0 technologies. Agricultural advisers (GR2) admit that the high motivation to introduce innovations is given by their perceived objective need. Along with the labour unattractiveness of agriculture, the problem seems to be the high cost of the latest technologies and their complex administration. Respondents expect that robotics has a future in livestock farming in particular, while in crop production technologies help more with navigation. (Milking robots and feeding machines in the former, and advanced field mechanization in the latter sector, e.g., precise sowing, spraying, and fertilizing, are already a commonplace.)

Both GR2 and GR3 respondents agree that farm enterprises are switching to automation and robotization due to the lack of suitable manpower in the labour market, the recruitment of new staff and retention of skilled workers posing a key personnel problem (Urbancová and Hudáková 2017). Secondary school headmasters argue that the improvement in the qualification structure of agricultural labour force ultimately depends on an overall increase in graduate levels. Naturally, quality teaching of Industry 4.0 principles is a prerequisite for their successful application and ensuing long-term cost savings, which are an important motivational factor driving technology modernization. 93 % of survey participants acknowledge that technology adoption requires skilled labour, the ability and willingness to embrace state-of-the-art technologies being a prerequisite for effective digital transformation. The minimum standard, in general, is secondary education. Employees with an inadequate level of education can undergo the necessary training, which may cause problems especially for older workers. Manual work is supposed to be taken over by robots.

4.2 Industry 4.0 implementation and its barriers

According to the respondents, weather fluctuations and difficult-to-predict natural phenomena are objective obstacles to the implementation of Industry 4.0 project in the crop cultivation sector, while in livestock farming, there are concerns about special pressure group interests or energy outages and subsequent data losses. However, the survey participants are most concerned that "digitization" will erode the life-giving connection with the soil and farm animals. (As one of the interviewees emphatically put it, "if a cow gets sick, will a robot cure her? When she starts limping, will it cure her? There must still be a vet technician. It won‘t work without a human touch.") School head teachers share the concerns of agricultural managers that Industry 4.0 threatens to depersonalize and "over-engineer" agriculture which may lead to the alienation from nature with its environmental implications. They are also afraid of rising unemployment and a shortage of skilled workers, as well as farmers' dependence on external services resulting in increased production costs not covered by subsidies.

Investments in robotics will be effective if the sales of products made by robots are sufficient, half of GR2 respondents believe. ("There is a lack of funding to modernize the whole sector and, moreover, the urban dwellers’ opinion persists that the farmers are only ’recipients‘ of subsidies who produce toxic foods that are therefore not sold," argues one respondent.)

According to the survey participants, in addition to high financial demands, the implementation of Industry 4.0 solutions is limited by interest group pressure on "industrialization" and unpredictability of weather conditions affecting livestock and crop farming, respectively. Other feared factors are possible power outages and subsequent database corruption. The greatest concern, however, is the separation from the living base of farming, replacing immediate careful contact with soil and farm animals by looking through a computer monitor.

In detecting barriers to 4.0 technologies, the present survey is consistent with the literature, highlighting the financial demands and cybersecurity (fear of losing data). Unlike other sources, respondents mention weather dependence and loss of contact with the farming environment (human touch is irreplaceable, especially in livestock production) more often.

As 90 % of respondents agree, agricultural enterprises are forced to meet challenges of Industry 4.0 – automating, digitizing and robotizing farming production – to compensate for the current shortage of labour.

5 Conclusion

The aim of this paper was to identify the obstacles to achieving the goals of Industry 4.0 in agriculture with a focus on human capital. Semi-structured interviews were conducted with a small sample of respondents available. While in the secondary manufacturing sector of the economy the potential and limits of Industry 4.0 are already being examined in detail, for the primary sector, including agriculture, its barriers are still insufficiently defined.

The majority of all the three groups’ representatives of agricultural enterprises, consultants and schools admit that the current labour shortage forces them to adopt Industry 4.0 solutions, human labour being too expensive and therefore prone to be reduced. Moreover, automation, robotics and overall digitization of production create a more efficient and friendly work environment for employees, and the potential for higher profits for employers, respectively. The jobs of the future require both technologically and socially skilled candidates (Grodek-Szostak et al. 2020).

Respondents consider the loss of human contact with farming to be the biggest barrier to the introduction of Industry 4.0 technologies in agriculture. The other most common concerns are the pressure to further mechanize livestock production, more frequent energy outages and data losses, high financial costs and, finally, unpredictable natural effects on crop production.

The statements of farm representatives that were agreed upon by other respondents concern the general shortage of labour and a specific lack of interest in hard work in farming, which is related to the shared view that technology might improve its unattractive public image. The prevailing opinion is that animal production will continue to require a "human touch" that will remain a prevention of "technological alienation" and the consequent loss of contact with the living substance of agriculture.

Further research could be extended to develop a more inclusive approach to barriers to grasp technological opportunities that Industry 4.0 offers to agriculture both in the Czech Republic and abroad.

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