Czech University of Life Sciences Prague
Faculty of Economics and Management

agris on-line

Papers in Economics and Informatics

http://online.agris.cz

ISSN 1804-1930
XIV, 2022, 3

International scientific journal
Prague

Agris on-line Papers in Economics and Informatics

The international reviewed scientific journal issued by the Faculty of Economics and Management of the Czech University of Life Sciences Prague.

The journal publishes original scientific contributions from the area of economics and informatics with focus on agriculture and rural development.

Editorial office

AGRIS on-line Papers in Economics and Informatics
Department of Economics of FEM CZU Prague
Kamýcká 129, 165 00 Praha-Suchdol
Czech Republic
Phone: +420 224 382 056
E-mail: agrisonline(at)pef.czu.cz

Publisher

Faculty of Economics and Management
Czech University of Life Sciences Prague
Kamýcká 129, 165 00 Praha-Suchdol
Czech Republic
Reg. number: 60460709

ISSN 1804-1930

XIV, 2022, 3
30th of September 2022
Prague

Agris on-line
Papers in Economics and Informatics

ISSN 1804-1930

XIV, 2022, 3

Agris on-line Papers in Economics and Informatics

Volume XIV Number 3, 2022

Content:

Estimating E-workability Components Across Central European Countries

Michal Beňo

Institute of Technology and Business in Ceske Budejovice, Czech Republic

Abstract

At present, shifting the workforce to a home-based work environment was and is a necessary response to Covid-19 crisis. In the post-pandemic work environment, e-working may continue being popular even in agribusiness. The study objective was to examine the motives for adopting face-to-display working environments within selected V4 countries and Austria in 2019, with the study being done in terms of the various components related to the spread of e-working. The study adopted Spearman's Rho correlation using 16 numerical variables to measure the strength of association between two variables (e-working and 16 numerical variables). This study investigated the impact of 16 selected factors in determining e-workability in V4 countries and Austria. The study found that when e-working and the percentage of GDP services are considered, a very strong positive correlation is indicated: As the GDP increases, the probability of e-working increases. High levels of education and of technology reveal a strong positive correlation. When the number of highly educated employees decreases, the number of e-workers decreases. In respect of technology, greater utilisation of digital public services, internet access and computer access from the home increase the likelihood of e-working. A medium education level and the use of the internet show a strong negative correlation: When the medium educational attainment level rises, e-working decreases. As the utilisation of the internet increases, the proportion of e-working falls. These components affected higher e-workability. Through the examination of the motives for adopting face-to-display working environments, this study advances the knowledge in the e-working field of the selected countries..

Keywords

Agribusiness, e-working, e-workability, Spearman's Rho correlation, V4 and Austria.

Beňo, M. (2022) "Estimating E-workability Components Across Central European Countries", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 3-16. ISSN 1804-1930. DOI 10.7160/aol.2022.140301.

Introduction

In the past, globalisation has been about the trading of goods, not services. Globalisation has intensified the world's economic growth. This began with mechanisation (Industry 1.0), mass production (Industry 2.0) and automation (Industry 3.0); we are now in the stage of Industry 4.0, with the Internet of Things and services. In response to Industry 4.0, the new term Industry 5.0 appeared (a kind of revolt against the dehumanisation of industry that was manifested in the concept of collaboration between man and robot in specific jobs). We understand this as a return of the human touch or contact in production.

The services sector was the biggest contributor to GDP in 2018 (Worldbank, 2020a). E-working can be seen as the catalyst that unlocks workplaces (remote professional services) in further globalisation. According to Davies (2021), the main obstacle to the remote working environment in some rural areas and for some inhabitants is the urban-rural digital divide, as is also confirmed by the EPRS study (EPRS, 2015). A recent study further stresses the greater urgency and necessity for a renewed focus on digital divides (Doyle et al., 2021). Low-paid and low-skilled jobs are the most vulnerable, as the next industrial revolution is rapidly increasing automation and robotics. Workplaces globally are also threatened by industrialisation. There is evidently a concern about job losses as a result of the digital transformation. But not all jobs are affected, and not all are discontinued. The outcome depends on routine vs. non-routine and cognitive vs. manual tasks.

Globally, many companies work remotely. Is it possible to sustain different components with e-working? E-working situations are directly dependent on the industry sector and the job requirements needed to complete the assigned tasks.

Our study adds to the literature by providing evidence of e-workability changes in selected countries. Analysing this data allows us to understand the spread of e-working among these countries. We interpret the results obtained as showing an increase of working remotely.

The study objective was to examine the motives for adopting face-to-display working environments within selected V4 countries (the Czech Republic, Hungary, Poland and Slovakia) and Austria in 2019, with the study being done in terms of the various components related to the spread of e-working. Our propositions is that different components (socio-economic and societal) affect the demand for e-workable jobs in the surveyed countries. Correlations were used to find answers to the following research questions: (i) RQ1: Is it possible to sustain different components with e-working?; (ii) RQ2: Do diverse components affect the scope of e-working agreements?; and (iii) RQ3: What causes a higher level of e-working in selected countries?

E-working

Interest in the idea of telework first arose during the oil crises and the skyrocketing fuel prices of the 1970s. Since then the term has varied within the literature. Over these periods, interest in teleworking began. It subsequently slowly but steadily increased around the world, and now the number of e-workers is generally climbing.

There is still no uniform definition of teleworking. There are broader approaches of this kind of work, some requiring specific regularity and location, while others are fairly traditional about regularity and location. The concept of ICT (information and communications technology) enabled work from afar or telework, also known as remote work, virtual work or telecommuting (Gajendran and Harrison, 2007). Telecommuting involves (1) members of an organisation (2) performing their regular work away from the central workplace at a remote location, (3) while using technology to complete the work (Pinsonneault and Boisvert, 2001). “Since the idea of telecommuting has been around for decades now, it makes sense that new words and phrases would come to replace what is, in theory, a not-so-new workplace concept” (Parris, 2018, para. 7).

While a range of definitions has been implemented, we understand e-working as, in effect, working using ICT at home or other places instead of in business premises on a full- or part-time basis. There are two types of remote workers: e-workers (fully remote workers) and hybrid e-workers (those who work partly from home and partly at the office).

E-working presents mixed results due to a focus on many factors, e.g. individuals, managers or cubicle colleagues, gender, before and after starting to e-work, culture.

The concept of work ability was introduced into medical literature by Ilmarinen et al. (1991). The potential for being able to work remotely varies a great deal among different occupations, especially in customer-facing service providers (AlAzzawi, 2021). The author adds that a major factor of e-working is having the necessary tools. Academic works demonstrate diverse factors of the emergence and development of e-working from different points of view. One factor is the workplace culture of encouraging employees to work remotely when they are sick (Ahmed et al., 2020). Next is work-life flexibility (Kossek and Lautsch, 2018). Furthermore, the inability to work remotely and lack of paid sick leave and income are associated with working employees’ ability (Blake et al., 2010). Moreover, digital inequalities combine with race, class, gender and other offline axes of inequality (Robinson et al., 2015). Besides, Mas and Pallais (2020) emphasize that college graduates have a 28% higher rate of home work. López-Calva (2020) compares a higher GDP per capita to a higher rate of e-working. López-Igual and Rodríguez-Modroño (2020) summarise the principle determinants of e-working such as self-employment, a higher educational level and non-manual occupations, especially highly skilled ones. The authors also add that age, living in urban areas, higher status and better working conditions lose importance in the face of the strong expansion of e-working. Home-based e-working is predominant among the analytical workforce (Thulin et al., 2019). Recent studies show how the Covid-19 pandemic has greatly affected the way of working in social services, which was practically entirely face-to-face work (Morilla-Luchena et al., 2021). Remote work encourages employees to relocate to less congested urban and rural locations, therefore promoting balanced regional development (DoETaE, 2021). The OECD (2021) study highlights the positive aspects and opportunities for rural areas. Beňo (2021b) states that improving the status of e-working can reanimate rural development.

Dingel and Neiman (2020) found that 37% of jobs in the US can be carried out exclusively at home.

In the same vein, Sostero et al. (2020) estimate that the same rate of dependent employment in the EU is currently e-workable. Bonavida Foschiatti and Gasparini (2020) conclude that 26% to 29% of jobs in Argentina can be performed remotely. In Uruguay, 20% to 34% of jobs can be done as distance work (Guntin, 2020). The percentage of individuals who are able to work from home varies from 7% in Guatemala to 16% in the Bahamas according to Delaporte and Peña (2020). Boeri et al. (2020) estimate face-to-display work as 23.95% in Italy, 28.22% in France, 28.70% in Germany, 25.44% in Spain, 30.74% in Sweden and 31.38% in the UK. In Portugal, about 30% of all occupations can be probably be performed remotely (Martins, 2020), and in Greece up to 37% of all salaried jobs can be done remotely (Pouliakas, 2020).

As modern technology advanced, it became possible for agriculturalists to use multiple platforms to engage their farm supply companies or to work from a home office or anywhere else in agribusiness (da Silva and Pilla, 2009). Agribusiness clearly indicates the application of theories and practice of business administration to organisations engaged in agriculture and agriculture-related products and services (Van Fleet, 2016). As stated by Krievina et al. (2012), a decrease in employment in agribusiness can also influence the public and private sectors that serve people in a rural environment. But in MENA countries, construction and agriculture have a very low level of teleworkability (AlAzzawi, 2021). There is a need for a mix of accurate technology tools to enable smooth and uninterrupted farm operations similar to the 5G RuralFirst project (5GruralFirst, 2020) and the needs of talented people (Puri, 2012). This also confirms Herbst's (1976) statement that in the global demand for food, a considerable amount of work is required in agrieducation.

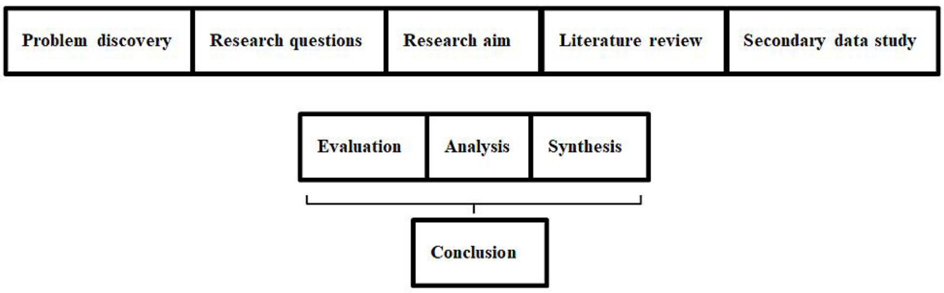
Materials and methods

In this paper, we go beyond the literature review dealing with the feasibility of e-working and focus on different socio-economic and societal characteristics covering the entire field of e-working as it is distributed in the examined countries. This is done by using comparable data. With this, we identify a specific group for an examination. The sample included member countries of the EU. Additionally, the difference between the low proportion of e-working in all V4 countries and the high proportion of e-working in Austria among all member states was significant for the analysis. Moreover, the field of the author's research interest played an important role in the selection of the target country sample.

This study aims to look at the nature and extent of e-workability of a group of five countries (V4 and Austria). Our research is based on processing secondary data and deriving relevant conclusions as shown in Figure 1.

We combine different sources of data to develop measures for e-workability: GDP, agriculture, risk poverty, CO_2, education, DSL, Internet and computer access and DESI Index from various databases, as shown in Table 1.

Generally, it cannot be said with certainty which coefficient is more suitable. It depends more on the research questions. The correlation coefficient according to Pearson processes the metric distances, while Spearman's coefficient only establishes the ranking of the measured values, regardless of the distances between the values. We can explain this as follows: Imagine a sprint race with three competitors. Two are in top shape and finish in 9.90 and 9.91 seconds. The third one gets injured, but crosses the line after 16 seconds. Pearson's coefficient notices that the first two are



Source: Author's illustration

Figure 1: Flow chart of research methodology.

	Austria	Czech Rep.	Hungary	Poland	Slovakia
E-working	12.1	5.4	3.4	9.8	5.8
GDP per capita USD	38170	18330	13260	13000	15860
Services % of GDP	62.6	56.2	55.3	56.9	58.1
Agriculture	3	3	5	9	2
Risk poverty	17.5	12.2	19.6	18.9	16.3
CO_2 per capita	0.19	0.29	0.14	0.93	0.1
Education low	12.7	5.6	13.7	6.3	7.8
Education medium	50.7	68.4	58.2	56.4	63.6
Education high	36.6	26.1	28	37.3	28.7
DSL	96.9	97.4	95.5	83.5	89.7
Internet access	89.9	87	86.2	86.7	82.2
Computer access from home	85.4	82.2	79.7	81.8	81.8
Connectivity	47.22	44.94	59.82	51.33	47.5
Human capital	56.7	48.7	41.9	37.3	41.8
Use of Internet	54	54.1	56	49.6	53.4
Integration of digital technology	40.5	49.6	25.3	26.2	32.5
Digital public services	80.8	62.4	57.8	67.4	55.6

Source: Author's own compilation based on Eurostat, 2019a,b;, 2020a,b; European Commission, 2020a; OECD, 2020a,b; Publications Office of the EU, 2020; Ritchie and Roser, 2020; Worldbank, 2020a,b.

Table 1: E-working ratio and 16 variables of selected countries.

almost equally fast, but the third lags far behind. For Spearman's coefficient, on the other hand, there is only ranking: first, second and third; the size of the differences does not matter. To determine the existence of dependency between e-working and 16 individual dimensions (as shown in Table 1), Spearman's Rho correlation (non-parametric test) in SPSS was applied because each variable has only five values. It will allow the calculation and measurement of the strength and the direction of the relationships between two ranked variables. Similarly, as stated by Walker and Maddan (2012, p. 254): "it is a measure of association for the ranks of the data."

By making use of correlations, answers were sought for the research questions: Is it possible to sustain different components with e-working? Do diverse components affect the scope of e-working agreements? What causes a higher level of e-working in selected countries?

The descriptive statistics method was used to analyse and describe the basic features of the data in developing results and drawing conclusions.

Results and discussion

The main idea of conducting this examination was to validate the different rate of e-working in the surveyed countries and the e-workability of each component. Table 2 shows Spearman's Rho correlations that test relationships among the study variables.

Components	Correlation coefficient	Sig. (2-tailed)
GDP per capita	0.300	0.624
Services in % of GDP	**0.900**	**0.037**
Agriculture	-0.051	0.935
Risk poverty	-0.100	0.873
CO_2 per capita	0.300	0.624
Education low	-0.100	0.873
Education medium	**-0.700**	**0.188**
Education high	**0.800**	**0.104**
DSL	-0.200	0.747
Internet Access	**0.500**	**0.391**
Computer Access from home	**0.667**	**0.219**
Connectivity	-0.300	0.624
Human capital	0.100	0.873
Use of internet	**-0.700**	**0.188**
Integration of digital technology	0.300	0.624
Digital public services	**0.700**	**0.188**

Source: Author's own compilation

Table 2: Correlations – Spearman's Rho (N=5).

E-working situations rely directly on the industry and the specific job requirements needed to complete the assigned tasks. E-working and the percentage of GDP services have a very strong positive correlation: As the GDP increases, the probability of e-working increases. There is therefore a direct correlation with GDP services. This confirms a recent study showing that the employment and the GDP effects of lockdown policies are U-shaped in income per capita (Behrens et al., 2021). While workers in rich countries have a substantially higher ability to work from home, which mitigates the declines in employment and GDP, poor countries concentrate employment and value-added production in essential sectors that are not shut down. Middle-income countries see the largest declines as they feature a relatively large share of employment in non-essential sectors and a relatively low work-from- home ability (Gottlieb et al., 2020). Additionally, an IMF study highlights the dependency between the level of economic development and the ability to work remotely. This suggests that workers in emerging and developing economies could face daunting challenges in continuing to work during periods of hard lockdowns (Brussevich et al., 2020). Further findings indicate that the extent to which jobs are amenable or responsive to being done from home increases with the level of economic development of the country (Hatayama et al., 2020). It seems that, in general, countries with higher GDP per capita also tend to have a higher share of teleworkable jobs (López-Calva, 2020).

High levels of education and technology have a significant positive relationship. When the rate of highly educated employees decreases, the number of e-workers decreases. Leščevica and Kreituze (2018) stress that executives are required to be organised for mutual cooperation with education and research institutions in order to gain higher added value (especially in rural areas). Our data confirm the statement of Anghel et al. (2020) that higher education means a higher share of e-workers. According to data from Aguilera et al. (2016), highly skilled and autonomous workers are the most likely to work remotely. This is similar to Sarbu (2015), where higher education levels, tenure and computer skills increase the probability of working remotely. Nicholas (2009) found that the level of education had a significant association with an interest in e-working. "Partial support was found for the effect of autonomy and work/life balance toward the preference to telework." Men were more interested in teleworking than women (Nicholas, 2009). Although, in reality the educational system still exposes students to a socialisation process that is strongly based on face-to-face education (Steizel, 2011) instead of face-to-display.

In technology, greater utilisation of digital public services, internet access and computer access from home mean more possibility of e-working. Sanchez et al. (2020) emphasize that the correlation between GDP per capita and the feasibility of home-based work strengthens when internet connectivity is taken into consideration. Grant et al. (2013) found that differentiating factors between e-workers included access to technology, ability to work flexibly and individual competencies. Greer and Payne (2014) identified that strategies for coping with teleworking included using advanced technology.

A medium education level and the use of the internet had a significantly strong negative correlation. When the number of workers who have attained a medium level of education increases, e-working decreases. As the utilisation of the internet increases, the portion of e-working falls. Overall, these results indicate that countries with a high GDP, higher level of education and a greater spread of technology experience a higher ratio of e-working. When e-working increases, the ratio of a medium level of education and the use of the internet decreases. A recent study confirms that developed countries with higher levels of internet access, a mix of occupations and pro-worker policies naturally fared the best in transitioning to remote work; these include Belgium, Canada, and Sweden. Developing and middle-income countries such as Brazil, China and Nigeria face the most obstacles, including low internet quality and large, intergenerational families that can make it challenging to work at home (Bana et al., 2020).

E-working is steadily becoming common due to the increase of ICT at the workplace. The share of e-workable jobs is 9% points higher in cities than in rural areas (Eurocities City Dialogue, 2020). But promoting e-working can revitalise rural development (Beňo, 2021a). The e-working experiment has begun. A remote workforce offers many opportunities, but it also comes with its share of challenges (Beňo, 2021b).

Preliminary results show that e-working increased when it was obligatory under lockdowns (Beno, 2021a). But this was a novelty for most workers, and it was a test of a new workplace culture mediated by technology and Covid-19 pandemics. This is similar to a recent study from Japan, where the ratio of e-working was low due to organisational, technological and environmental barriers (Hosoda, 2021). Nevertheless, when we delve further into the detailed data, the striking results are that it is possible to sustain GDP in services, technology and education with this kind of work flexibility. Clearly, there is a strong asymmetry of workplaces dividing workers into two groups: e-workers (working from everywhere) and on-site workers (being on location), and the unequal access to e-working.

When e-working and the percentage of GDP services are considered, a very strong positive correlation is indicated: As the GDP increases, the probability of e-working increases. This is the opposite of Hatayama et al.'s (2020) data, which shows a positive correlation between e-working and GDP per capita. According to the data, the distribution of economic activity across sectors also reflects the type of work that is developed and that distinguishes workers in terms of their access to working remotely. This is in the same vein as recent data showing that the industry where the employee is occupied identifies the e-workability (Gaduena and Alcantara, 2021). Correspondingly the latest results demonstrate that very few agricultural jobs can be done remotely; more importantly, there is no correlation between GDP and working remotely (Sanchez et al., 2020). In addition, Nakanishi's (2016) data highlight that only a few factors of GDP can be estimated quantitatively in regard to e-working. Another analysis advises that e-working makes the greatest contribution in terms of decreasing GDP loss (Zaballos et al., 2020).

We find that high levels of education and technology reveal a strong positive correlation. When the number of highly educated employees decreases, the number of e-workers decreases. This is equivalent to a current study that reveals a positive correlation between e-working and PISA results (Hvorecký and Beňo, 2021). Other authors emphasize that college graduates have a 28% higher rate of home work than workers with a high-school qualification (Mas and Pallais, 2020). Gaduena and Alcantara (2021) emphasize that the education levels attained correlate with the greater likelihood of being able to do telework. In respect of technology, greater utilisation of digital public services, Internet access and computer access from the home increases the likelihood of e-working. Our data confirm how digital and automation inequality moderates the impact of e-workability. A medium level of education and the use of the Internet show a strong negative correlation: When the medium level of education rises, e-working decreases. As the utilisation of the Internet increases, the proportion of e-working falls. These components affect higher e-workability. It has to be pointed out that the correlation between GDP per capita and the feasibility of e-working strengthens with Internet connectivity (Sanchez et al., 2020). Noticeably, low adoption of modern technology and low rates of educational attainment are connected with adaptation of e-working processes (Chinn et al., 2010; Dewan et al., 2010). Working in a virtual environment will vary across organisations and will depend on actions taken (Jain, 2021, p. 30).

But would things be much worse without e-working if we were not in an e-society with ICT possibilities? This pandemic shows us winners in many fortunate sectors of our economy that are e-working already; many are not losers. The key question is how long this workplace disorganisation will last, because in the post-Covid-19 era the face-to-display will not be the preferred workplace for all employees. Bloom (2020) highlights that cities may suffer while suburbs and rural areas benefit from the relocation of organisations. Could our data in this study be described as showing a structural change in the workplace, or do they symbolise the effect of economic and societal changes? A recent publication highlights that organisations must rethink their work and the role of offices in creating safe, productive, and enjoyable jobs and lives for employees (Boland et al., 2020). The latest data show that companies must now support a hybrid work environment for in-office and remote employees with work flexibility, increased cleanliness and the right collaboration technology (Cisco, 2020). One might claim that the increase in the share of e-workability models represents the response of the seven factors obtained in this study and many others, such as occupation (Gädecke et al., 2021), GDP per capita, sector, worker characteristics (Brussevich et al., 2020) and cultural differences (Beňo, 2021a). Dingel and Neiman (2020) make a further distinction between e-workable and non-e-workable jobs. The positive effect of e-workability is stronger for workers in automatable jobs (Hou et al., 2021).

In this study we imply that extending labour markets into home-based premises or beyond the specific localisation of the companies increases the possibility of finding missing talents in workplaces. In addition, food and agribusiness can leverage e-working to attract potential talent (IFAC, 2019). Therefore, it is important that future policies should respond to e-working strategies for the ongoing digital transformation to facilitate the creation of suitable conditions for the workforce, as well as for society and the economy. Our study demonstrates that countries should increase investments in digital inequality, including digital gaps in education (soft skills), and improve technologies to boost the positive effect of e-workability. The data show the potential impact of social and economic policies at national level.

A recent publication demonstrates that the pandemic has resulted in widespread unemployment in the surveyed countries and indicates that the younger generation is more affected than older generations (Beno, 2021b). E-working has allowed the workfoce to continue to work and to maintain social distancing (Beno and Hvorecky, 2021). E-workability varies worldwide depending on different factors, especially sectoral composition, including education, as confirmed in our results and among professional groups with the necessary skills. It is clear that changes in attitudes to work combined with modern ICT do not affect only employees, but managers too (Beňo et al., 2021, p. 94). Investigators find that in two-thirds of jobs, where e-working is practicable, face-to-face interaction plays a fundamental part (Sostero et al., 2020). Malkov (2020) stresses the long-term consequences on the employment outlook and earnings of a workforce that had non-e-workable or high-contact-intensity jobs at the onset of the Covid-19 outbreak. Digital skills (as stated in the results section on educational level) are essential when working remotely in potential e-workability environments. This is in the vein of Waschek (2021), who stresses that the "skills gap" in the agriculture industry seems to have been hit the hardest.

Does e-working work in agribusiness? A recent study from Romania demonstrates that Romanian employees in different sectors, including agriculture, are willing to have flexibility in the number of working days per week (Davidescu et al., 2020). Another conducted survey shows that to keep recent skilled employees, 25% of participating agriculture owners were providing flexible schedules for them, even higher than the 19% that were keeping work-from-home policies (Johnson, 2021). Generally, in MENA countries, construction and agriculture have a very low level of teleworkability (AlAzzawi, 2021). Similarly, McKinsey and Company's (2020) data highlight lower e-workability in occupations like retail services and agriculture. This corresponds with Oliver et al.'s (2016) evidence showing that agriculture, manufacturing and retail find it harder to adjust to e-working given the place-based nature of the work. This means that those occupations which require physical and manual activities, including agriculture, are not skewed toward e-working, but on the contrary agribusiness represents an essential potential through e-working.

Are V4 and Austria ready for e-working or not? This kind of work varies a great deal because only part of the work can be done remotely. This depends on many factors. As demonstrated in this study, the first factor is consideration of rich or poor, the second is the robustness of modern technology and the third is education. According to statistical data, it can be said that V4 and Austria are almost, but not completely, ready. This is in line with the EBRD report of the percentage rate of jobs that can be done remotely, which ranges from the highly developed economy of Austria, followed by Poland, the Czech Republic and Slovakia, and down to the lowest rate of e-workability in Hungary (EBRD, 2021). We agree with Gschwind and Vargas (2019) that the possibility of e-working correlates strongly with the shift in the economy (away from manufacturing) towards information and telecommunication enabled service and a knowledge workforce. This explains the e-working rates among those countries.

We conclude that the main implication of this study is the re-emphasis of the effect of e-working on the labour market because by implementing policies for remote working that enable hiring outside their immediate geographic areas, organisations ensure that residents, companies and communities all profit (Sutton Fell, 2017).

Conclusion

There is still no universal statistical definition, and therefore measuring and evaluating the level of e-working is difficult.

The study found that when e-working and the percentage of GDP services are considered, a very strong positive correlation is indicated: As the GDP increases, the probability of e-working increases. High levels of education and of technology reveal a strong positive correlation. When the number of highly educated employees decreases, the number of e-workers decreases. In respect of technology, greater utilisation of digital public services, internet access and computer access from the home increase the likelihood of e-working. A medium education level and the use of the internet show a strong negative correlation: When the medium educational attainment level rises, e-working decreases.

As the utilisation of the internet increases, the proportion of e-working falls. These components affected higher e-workability.

E-workability (also in agribusiness sector) is attracting more and more attention in organisation-related literature. We are of the opinion that this implies that a better understanding may affect workplace vulnerabilities. Our study adds to the literature by providing evidence of changes relating to e-workability in selected countries. This study has presented important information that should be taken into consideration in regard to maintaining or improving work participation in the selected countries. The results of the present investigation should consequently be given careful consideration in other countries too. Data from this study include important information for the labour market. The interventions should concentrate on the identified determinants in respect of e-workability in order to increase work participation and prolong the rate of working remotely. Our data from this study indicate that V4 and Austria may have optimal possibility of reaching the full development of their e-working efforts. However, the impact it has on the economies of these countries is not well understood. But the lasting success of e-working depends strongly on the right vision, including these three important key factors: business models, digital access and education.

This paper has certain limitations. Firstly, the literature review does not include publications in languages other than English and includes online-based data. An important limitation is the selection of variables for examination and the sample size of five countries. Therefore, some caution is needed in the generalisability of the study results in other countries. Another limitation lies in the nature of Spearman's correlation that the data must be linear, independent from each other and there should be between 10 and 30 pairs of data. The impact of Covid-19 on the workplace environment across sectors and countries depends on its adaptability on the basis of records of previous crises. The data in this study point out two major factors: on the one hand, GDP services, and on the other the educational level. These factors are associated with an increase of e-working. Taken together, these results suggest that further investigation in the area of the e-workability of face-to-display workers is necessary. Future research should focus on a broader perspective, including individual or job level. By verifying data from this study a new hypothesis could be formed, namely that e-workability could be perceived to be more advantageous in Nordic and Western than in Eastern and Mediterranean countries, which could form the basis of potential future investigation.

Acknowledgements

This research was supported by project No. IVSUPSOO3, "Current Trends in Human Resource Management", sponsored by the Institute of Technology and Business in Ceske Budejovice.

Corresponding authors:
Mgr. Bc. Michal Beňo, PhD.
Institute of Technology and Business in České Budějovice
Okružní 517/10, 370 01 České Budějovice, Czech Republic
E-mail: 28265@mail.vstecb.cz

References

[1] Aguilera, A., Lethiais, V., Rallet, A. and Proulhac, L. (2016) "Home-based telework in France: Characteristics, barriers and perspectives", *Transportation Research Part A: Policy and Practice*, Vol. 92, No. 1, pp. 1-11. ISSN 0965-8564. DOI 10.1016/j.tra.2016.06.021.

[2] Ahmed, F., Kim, S., Nowalk, M. P., King, J. P., Van Wormer, J. J., Gaglani, M., Zimmerman, R. K., Bear, T., Jackson, M. L., Jackson, L. A., Martin, E., Cheng, C., Flannery, B., Chung, J. R. and Uzicanin, A. (2020) "Paid leave and access to Telework as Work Attendance Determinants during acute Respiratory illness, United States, 2017–2018", *Emerging Infectious Diseases*, Vol. 26, No. 1, pp. 26-33. E-ISSN 1080-6059, ISSN 1080-6040. DOI 10.3201/eid2601.190743.

[3] AlAzzawi, S. (2021) "Lives Versus Livelihoods: Who Can Work from Home in MENA?", *ERF Working Papers Series*, Working Paper No. 1471, p. 36.

[4] Anghel, B., Cozzolino, M. and Lacuesta, A. (2020) "Teleworking in Spain". [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3678038 [Accessed: Jul. 12, 2021]. DOI http://dx.doi.org/10.2139/ssrn.3678038.

[5] Bana, S. H., Benzell, S. G. and Solares, R. R. (2020) "*Ranking How National Economies Adapt to Remote Work*". [Online]. Available: https://sloanreview.mit.edu/article/ranking-how-national-economies-adapt-to-remote-work/ [Accessed: Jul. 12, 2021].

[6] Behrens, K., Kichko, S. and Thisse, J.-F. (2021) "*Working from Home: Too much of a good thing?*". [Online]. Available: https://cepr.org/active/publications/discussion_papers/dp.php?dpno=15669 [Accessed: Jul., 12, 2021]. DOI 10.2139/ssrn.3768910.

[7] Beno, M. (2021a) "Face-to-Display Working: Decarbonisation Potential of not Commuting to Work before Covid-19 and during and after Lockdowns", *Academic Journal of Interdisciplinary Studies*, Vol. 10, No. 3, pp. 17-24. ISSN 2281-3993. DOI 10.36941/ajis-2021-0060.

[8] Beno, M. (2021b) "The Impact of Pandemics on Workforce Joblessness in Central Europe in pre-Covid Era and during Pandemic", *International Journal of Business and Social Science Research*, Vol. 2, No. 3, pp. 1-16. E-ISSN 2219-6021, ISSN 2219-1933. DOI 10.47742/ijbssr.v2n3p1.

[9] Beňo, M. (2021a) "E-working: Country Versus Culture Dimension", *AGRIS on-line Papers in Economics and Informatics*, Vol. 13, No. 2, pp. 23-34. ISSN 1804-1930. DOI 10.7160/aol.2021.130202.

[10] Beňo, M. (2021b) "The Advantages and Disadvantages of E-Working: An Examination using an ALDINE Analysis", *Emerging Science Journal*, Vol. 5, pp. 11-20. ISSN 2610-9182. DOI 10.28991/esj-2021-SPER-02.

[11] Beňo, M. (2021b) "E-working: Country Versus Culture Dimension", *AGRIS on-line Papers in Economics and Informatics*, Vol. 13, No. 2, pp. 23-34. ISSN 1804-1930. DOI 10.7160/aol.2021.130202.

[12] Beňo, M., Hvorecký, J. and Cagáňová, D. (2021) "From Face-To-Face to Face-To-Display Management: An Online Survey", *Advances in Business-Related Scientific Research Journal*, Vol. 12, No. 1, pp. 78-100. ISSN 1855-931X.

[13] Beno, M. and Hvorecky, J. (2021) "Data on an Austrian Company's Productivity in the Pre-Covid-19 Era, During the Lockdown and After Its Easing: To Work Remotely or Not?", *Frontiers in Communication*, Vol. 6, No. 641199, pp. 1-10. E-ISSN 2297-900X. DOI 10.3389/fcomm.2021.641199.

[14] Blake, K. D., Blendon, R. J. and Viswanath, K. (2010) "Employment and Compliance with Pandemic Influenza Mitigation Recommendations", *Emerging Infectious Diseases*, Vol. 16, No. 2, pp. 212-218. E-ISSN 1080-6059, ISSN 1080-6040. DOI 10.3201/eid1602.090638.

[15] Bloom, N. (2020) "*How working from home works out*". [Online]. Available https://siepr.stanford.edu/sites/default/files/publications/PolicyBrief-June2020.pdf [Accessed: Oct. 7, 2021].

[16] Boeri, T., Caiumi, A. and Paccagnella, M. (2020) "*Mitigating the work-safety trade-off*". [Online]. Available: https://cepr.org/sites/default/files/news/CovidEconomics2.pdf [Accessed: Jul. 12, 2021].

[17] Boland, B., De Smet, A., Palter, R. and Sagnvhi, A. (2020) "*Reimagining the office and work life after COVID-19*". [Online]. Available: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Organization/Our%20Insights/Reimagining%20the%20office%20and%20work%20life%20after%20COVID%2019/Reimagining-the-office-and-work-life-after-COVID-19-final.pdf [Accessed: 12 Jul. 2021].

[18] Bonavida Foschiatti, C. and Gasparini, L. (2020) "*El Impacto Asimétrico de la Cuarentena, Documentos de Trabajo del CEDLAS Nº 261*", April, 2020, CEDLAS-FCE-Universidad Nacional de La Plata. (in Spanish).

[19] Brussevich, M., Dabla-Norris, E. and Khalid, S. (2020) "*Who will Bear the Brunt of Lockdown Policies? Evidence from Tele-workability Measures Across Countries*". [Online]. Available: https://www.imf.org/en/Publications/WP/Issues/2020/06/12/Who-will-Bear-the-Brunt-of-Lockdown-Policies-Evidence-from-Tele-workability-Measures-Across-49479 [Accessed: Jul. 12, 2021].

DOI 10.2139/ssrn.3652506.

[20] Chinn, M. D. and Fairlie, R. W. (2010) "ICT Use in the Developing World: An Analysis of Differences in Computer and Internet Penetration", *Review of International Economics*, Vol. 18, No., 1, pp. 153-167. ISSN 0965-7576. DOI 10.2139/ssrn.936474.

[21] Cisco (2020) "*The Rise Of The Hybrid Workplace*". [Online]. Available: https://www.cisco.com/c/dam/en/us/products/collateral/collaboration-endpoints/global-workforce-survey.pdf [Accessed: Jul. 12, 2021].

[22] Da Silva, G. and Pilla, B. S. (2009) "*Impacts of Telework in a Company of Agribusiness Sector*". [Online]. Available: https://www.ifip.org/wcce2009/proceedings/papers/WCCE2009_pap130.pdf [Accessed: Jul. 12, 2021].

[23] Davidescu, A. A., Apostu, S-A., Paul, A., Casuneanu, I. (2020) "Work Flexibility, Job Satisfaction, and Job Performance among Romanian Employees-Implications for Sustainable Human Resource Management", *Sustainability*, Vol. 12, No. 15, pp. 1-53. E-ISSN 2071-1050. DOI 10.3390/su12156086.

[24] Davies, A. (2021) "COVID-19 and ICT-Supported Remote Working. Opportunities for Rural Economics", *World*, Vol. 2, pp. 139-152. E-ISSN 2673-4060. DOI 10.3390/world2010010.

[25] Delaporte, I. and Peña, W. (2020) "*Working From Home Under COVID-19; Who Is Affected? Evidence from Latin American and Caribbean Countries*". [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3610885 [Accessed: Jul. 12, 2021].

[26] Department of Enterprise, Trade and Employment (2021) "*Making Remote Work. National Remote Work Strategy*". [Online]. Available: https://enterprise.gov.ie/en/Publications/Publication-files/Making-Remote-Work.pdf [Accessed: Oct. 7, 2021].

[27] Dewan, S., Ganley, D. and Kraemer, K. L. (2010) "Complementarities in the Diffusion of Personal Computers and the Internet: Implications for the Global Digital Divide", *Information Systems Research*, Vol. 21, No. 4, pp. 925-940. ISSN 1047-7047. DOI 10.1287/isre.1080.0219.

[28] Dingel, J. I. and Neiman, B. (2020) "*How Many Jobs Can be Done at Home?*". [Online]. Available: https://bfi.uchicago.edu/wp-content/uploads/BFI_White-Paper_Dingel_Neiman_3.2020.pdf [Accessed: Jul. 12, 2021]. DOI 10.3386/w26948.

[29] Doyle, A., Hynes, W. and Purcell, S. M. (2021) "Building Resilient, Smart Communities in a Post-COVID Era: Insights From Ireland", *International Journal of E-Planning Research*, Vol. 10, No. 2, pp. 18-26. ISSN 2160-9926. DOI 10.4018/IJEPR.20210401.oa2.

[30] EBRD (2021) "*Teleworking, AI and the Labour Force*". [Online]. Available: https://2021.tr-ebrd.com/teleworking-ai-and-the-labour-force/ [Accessed: May 14, 2022].

[31] EPRS (2015) "*Bridging the digital divide in the EU*". [Online]. Available: https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/573884/EPRS_BRI(2015)573884_EN.pdf [Accessed: Oct. 7, 2021].

[32] Eurocities City Dialogue (2020) "*Mitigating The Economic, Social And Fiscal Impact Of The Covid-19 Crisis On Cities*". [Online]. Available: https://nws.eurocities.eu/MediaShell/media/OECD_socioeco_impact_covid_cities_Eurocities_dialogue.pdf [Accessed: Jul. 12, 2021].

[33] European Commission. (2020a) "*The Digital Economy and Society Index (DESI)*". [Online]. Available:https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi [Accessed: Jul. 12, 2021].

[34] European Commission (2020b) "*Who can telework today? The teleworkability of occupations in the EU*". [Online]. Available: https://ec.europa.eu/jrc/sites/jrcsh/files/policy_brief_-_who_can_telework_today_-_the_teleworkability_of_occupations_in_the_eu_final.pdf [Accessed: Jul. 12, 2021].

[35] Eurostat (2019a) "*Archive: People at risk of poverty or social exclusion*". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/People_at_risk_of_poverty_or_social_exclusion [Accessed: Jul. 12, 2021].

[36] Eurostat (2019b) "File:Share of the population by educational attainment level and selected age groups, 2019 (%)". [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Share_of_the_population_by_educational_attainment_level_and_selected_age_groups,_2019_(%25).png [Accessed: Jul. 12, 2021].

[37] Eurostat (2020a) "Employed persons working from home as a percentage of the total employment, by sex, age and professional status (%)". [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/show.do?query=BOOKMARK_DS-052914_QID_6E0BB9BE_UID_-3F171EB0&layout=TIME,C,X,0;GEO,L,Y,0;SEX,L,Z,0;FREQUENC,L,Z,1;AGE,L,Z,2;WSTATUS,L,Z,3;UNIT,L,Z,4;INDICATORS,C,Z,5;&zSelection=DS-052914WSTATUS,EMP;DS-052914FREQUENC,USU;DS-052914INDICATORS,OBS_FLAG;DS-052914AGE,Y15-64;DS-052914SEX,T;DS-052914UNIT,PC;&rankName1=WSTATUS_1_2_-1_2&rankName2=TIME_1_0_0_0&rankName3=UNIT_1_2_-1_2&rankName4=GEO_1_2_0_1&rankName5=AGE_1_2_-1_2&rankName6=FREQUENC_1_2_-1_2&rankName7=INDICATORS_1_2_-1_2&rankName8=SEX_1_2_-1_2&sortC=ASC_1-FIRST&rStp=&cStp=&rDCh=&cDCh=&rDM=true&cDM=true&footnes=false&empty=false&wai=false&time_mode=ROLLING&time_most_recent=false&lang=EN&cfo=%23%23%23%2C%23%23%23.%23%23%23 [Accessed: 12 Jul. 2021].

[38] Eurostat (2020b) "Real GDP per Capita". [Online]. Available:https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/table?lang=en [Accessed: Jul. 12, 2021].

[39] 5GRuralFirst (2020) "*Impacts of Telework in a Company of Agribusiness Sector*". [Online]. Available: https://www.5gruralfirst.org/project-conclusion-report/ [Accessed: Jul. 12, 2021].

[40] Gajendran, R. S. and Harrison, D. A. (2007) "The good, the bad, and the unknown about telecommuting: Meta-analysis of psychological mediators and individual consequences", *Journal of Applied Psychology*, Vol. 92, No. 6, pp. 1524–1541. E-ISSN 1939-1854, ISSN 0021-9010. DOI 10.1037/0021-9010.92.6.1524.

[41] Gädecke, M., Struffolino, E., Zagel, H. and Fasang, A. (2021) "*KOMPAKK Index of Occupations' Teleworkability in Germany*". [Online]. Available: https://data.gesis.org/sharing/#!Detail/10.7802/2263 [Accessed: Jul. 12, 2021].

[42] Gaduena, A. and Acantara, S. (2021) "*Teleworkability and Disadvantaged Socioeconomic Groups: Who Holds These Teleworkable Jobs?*". AIM RSN PCC Discussion Paper 2021-003, 33 p. DOI 10.2139/ssrn.3827854.

[43] Gottlieb, Ch., Grobovsek, J., Poschke M. and Saltiel, F. (2020) "*Lockdown Accounting*". [Online]. Available: http://ftp.iza.org/dp13397.pdf [Accessed: Jul. 12, 2021]. DOI 10.2139/ssrn.3636626.

[44] Grant, C. A., Wallace, L. M. and Spurgeon, P. C. (2013) "An exploration of the psychological factors affecting remote e-worker's job effectiveness, well-being and work-life balance", *Employee Relations*, Vol. 35, No. 5, pp. 527-546. ISSN 01425455. DOI 10.1108/ER-08-2012-0059.

[45] Greer, T. W. and Payne, S. C. (2014) "Overcoming telework challenges: Outcomes of successful telework strategies", *The Psychologist-Manager Journal*, Vol. 17, No. 2, pp. 87-111. ISSN 1550-3461. DOI 10.1037/mgr0000014.

[46] Gschwind, L. and Vargas, O. (2019) "Telework and Its effects in Europe", in *Telework in the 21th Century*, chap.1, pp. 36-75. DOI 10.4337/9781789903751.00007.

[47] Guntin, R. (2020) "*Trabajo a Distancia y con Contacto en Uruguay*". [Online]. Available: http://www.rguntin.com/research/employment_uru_covid_new.pdf [Accessed: Jul. 12, 2021]. (in Spanish).

[48] Hatayama, M., Viollaz, M. and Winkler, H. (2020) "*Jobs' Amenability to Working from Home, Evidence from Skills Surveys for 53 Countries*". [Online]. Available: http://documents1.worldbank.org/curated/en/673341589224762491/pdf/Jobs-39-Amenability-to-Working-from-Home-Evidence-from-Skills-Surveys-for-53-Countries.pdf [Accessed: Jul. 12, 2021]. DOI 10.1596/1813-9450-9241.

[49] Herbst, J. H. (1976) "Employment: Agricultural and Agribusiness Occupations", *NACTA Journal*, Vol. 20, No. 1, pp. 4-9. ISSN 0149-4910.

[50] Hosoda, M. (2021) "Telework amidst the COVID-19 pandemic: effects on work style reform in Japan", *Corporate Governance*. ISSN 1472-0701. DOI 10.1108/CG-09-2020-0390 .

[51] Hou, J., Liang, Ch., Chen P-Y. and Gu, B. (2021) "*Workplace Flexibility and Worker Resilience: The Role of Teleworkability in the COVID-19Pandemic*". [Online]. Available: https://open.bu.edu/bitstream/handle/2144/42020/Teleworkability%20and%20Workers%20Resilience%20in%20the%20Eye%20of%20the%20COVID-19%20Pandemic%202020.11.28.pdf?sequence=1&isAllowed=y [Accessed: Jul. 12, 2021].

[52] Hvorecký, J. and Beňo, M. (2021) "Linkages between PISA Results and E-Working", *Emerging Science Journal*, Vol. 5, No. 3, pp. 294-304. ISSN 2610-9182. DOI 10.28991/esj-2021-01277.

[53] IFAC (2019) "*Food and Agribusiness 2019*". [Online]. Available: https://a.storyblok.com/f/41780/x/eb86dba169/ifac-food-and-agribusiness-2019-web.pdf [Accessed: Jul. 12, 2021].

[54] Ilmarinen, J., Tuomi, K., Eskelinen, L., Nygård, C. H., Huuhtanen, P. and Klockars, M. (1991) "Summary and recommendations of a project involving cross-sectional and follow-up studies on the aging worker in Finnish municipal occupations (1981—1985)", *Scandinavian Journal of work, environment & health*, Vol. 17, No. 1, pp. 135-141. ISSN 0355-3140.

[55] Jain, A. (2021) "*Impact of digitalization and artificial intelligence as causes and enablers of organizational change*". [Online]. Available: https://ficsa.org/fileadmin/user_upload/Impact_of_Digitalization_and_AI_-_Implications_for_the_international_civil_service_-_Final_report.pdf [Accessed: Jul.12, 2021].

[56] Johnson, B. (2021) "Would flexible hours attract more farm talent?". [Online]. Available: https://www.farmprogress.com/commentary/would-flexible-hours-attract-more-farm-talent [Accessed: Nov. 10, 2021].

[57] Kossek, E. E. and Lautsch, D. A. (2018) "Work–Life Flexibility for Whom? Occupational Status and Work–Life Inequality in Upper, Middle, and Lower Level Jobs", *Academy of Management Annals*, Vol. 12, No. 1, pp. 5-36. ISSN 1941-6067. DOI 10.5465/annals.2016.0059.

[58] Krievina, A., Leimane, I. and Miglavs, A. (2012) "The Role of Agribusiness in Maintenance of Future Rural Employment in Latvia", *Proceedings of the Latvia University of Agriculture*, Vol. 28, No. 1, pp. 38-47. E-ISSN 2255-8535, ISSN 1407-4427. DOI 10.2478/v10236-012-0013-2.

[59] Leščevica, M. and Kreituze, I. (2018) "Prospect Possibilities of Remote Work For Involvement of Latvian Diaspora's in Economy and Businesses of Latvia", *Research For Rural Development,* Vol. 2, pp. 173-179. ISSN 1691-4031.

[60] López-Calva, L. F. (2020) "*Working in Times of Pandemic: Only one in five workers in LAC can actually work from home*". [Online]. Available: https://www.latinamerica.undp.org/content/rblac/en/home/presscenter/director-s-graph-for-thought/working-at-a-distance--the-availability-of-teleworkable--jobs-an0.html [Accessed: Jul. 12, 2021].

[61] López-Igual, P. and Rodríguez-Modroño, P. (2020) "Who is Teleworking and Where from? Exploring the Main Determinants of Telework in Europe", *Sustainability*, Vol. 12, No. 21, pp. 1-15. E-ISSN 20711050. DOI 10.3390/su12218797.

[62] Malkov, E. (2020) "*Nature of Work and Distribution of COVID-19 Risks: Evidence from Occupational Sorting, Skills, and Tasks*". [Online]. Available: https://ssrn.com/abstract=3643287 [Accessed: Jul. 12, 2021]. DOI 10.2139/ssrn.3643287.

[63] Mas, A. and Pallais, A. (2020) "*Alternative Work Arrangements*". [Online]. Available: https://www.nber.org/system/files/working_papers/w26605/w26605.pdf [Accessed: Jul. 12, 2021]. DOI 10.3386/w26605.

[64] Martins, P. S. (2020) "*O potencial do teletrabalho em Portugal*". [Online]. Available: https://observador.pt/especiais/o-potencial-do-teletrabalho-em-portugal/ [Accessed: Jul. 12, 2021]. (in Portuguese).

[65] McKinsey & Company (2020) "*What's next for remote work: An analysis of 2,000 tasks, 800 jobs, and nine countries*". [Online]. Available: https://www.mckinsey.com/featured-insights/future-of-work/whats-next-for-remote-ork-an-analysis-of-2000-tasks-800-jobs-and-nine-countries[Accessed: Jul. 12, 2021].

[66] Morilla-Luchena, A., Muñoz-Moreno, R., Chaves-Montero, A. and Vázquez-Aguado, O. (2021) "Telework and social services in Spain during the COVID-19 pandemic", *International Journal of Environmental Research and Public Health*, Vol. 18, No. 2, pp. 11-14. E-ISSN 1660-4601. DOI 10.3390/ijerph18020725.

[67] Nakanishi, H. (2016) "Economic Impact of Telework in Japan", In *Proceedings of the International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government*, Athens, pp. 121-127.

[68] Nicholas, A. (2009) "*Millennial Interest in Teleworking: A survey of generational attitudes*", VDM Verlag Dr. Müller, 208 p. ISBN 10 3639139798.

[69] OECD (2020a) "*Access to computers from home*". [Online]. Available: https://data.oecd.org/ict/access-to-computers-from-home.htm [Accessed: Jul. 12, 2021].

[70] OECD (2020b) "*Internet Access*". [Online]. Available: https://data.oecd.org/ict/internet-access.htm#indicator-chart [Accessed: Jul. 12, 2021].

[71] OECD (2021) "*Implications of remote working adoption on place based policies: A focus on G7 countries*". [Online]. Available: https://www.oecd.org/regional/PH-Remote-working-G7.pdf [Accessed: Oct. 7, 2021].

[72] Oliver, Z., Schoewe, D. and Lawrence, S. (2016) "*Attracting Talent Who Can Live and Work Anywhere*". [Online]. Available: https://webcache.googleusercontent.com/search?q=cache:6jx_1LLb_5gJ:https://www.darenc.com/home/showdocument%3Fid%3D1239+&cd=1&hl=de&ct=clnk&gl=at&client=firefox-b-d [Accessed: Nov. 10, 2021].

[73] Parris, J. (2018) "*Remote Work or Telecommute: What's the Difference*". [Online]. Available: https://www.workflexibility.org/remote-work-vs-telecommute-whats-the-difference/ [Accessed: Jul. 12, 2021].

[74] Pinsonneault, A. and Boisvert, M. (2001) "The impacts of telecommuting on organizations and individuals: A review of the literature", In *Telecommuting and virtual offices: Issues and opportunities*, pp. 163-185. ISBN 1878289799. DOI 10.4018/978-1-878289-79-7.ch010.

[75] Pouliakas, K. (2020) "*Working at Home in Greece: Unexplored Potential at Times of Social Distancing*". [Online]. Available: http://ftp.iza.org/dp13408.pdf [Accessed: Jul. 12, 2021]. DOI 10.2139/ssrn.3636637.

[76] Publications Office of the EU. (2020) "Broadband coverage in Europe 2019". [Online]. Available: https://op.europa.eu/en/publication-detail/-/publication/077cc151-f0b3-11ea-991b-01aa75ed71a1 [Accessed: Jul. 12, 2021].

[77] Puri, V. (2012) "Agribusiness: A Great Career Opportunity for Talented People", *International Food and Agribusiness Management Review*, Vol. 15, No. A, pp. 1-4. ISSN 1096-7508.

[78] Ritchie, H. and Roser M. (2020) "P*er capita: How much* CO_2 *does the average person emit?*". [Online]. Available: https://ourworldindata.org/co2/country/austria?country=AUT~CZE~POL~SVK~HUN [Accessed: Jul. 12, 2021].

[79] Robinson, L., Cotton, S. R., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., Schulz, J. and Hale, T. M. (2015) "Digital Inequalities and why they matter", *Information, Communication & Society*, Vol. 18, No. 5, pp. 569-582. ISSN 1369118X. DOI 10.1080/1369118X.2015.1012532.

[80] Sanchez, D. G., Parra, N. G., Ozden, C., Rijkers, B., Viollaz, M. and Winkler, H. (2020) "*Who on Earth Can Work from home?*", [Online]. Available: http://documents1.worldbank.org/curated/en/225881596202941026/pdf/Who-on-Earth-Can-Work-from-Home.pdf [Accessed: Jul. 12, 2021].

[81] Sarbu, M. (2015) "Determinants of Work-at-Home Arrangements for German Employees", *Labour*, Vol. 29, No. 4, pp. 444-469. E-ISSN 1467-9914. DOI 10.1111/labr.12061.

[82] Sostero, M., Milasi, S., Hurley, J., Fernandez Macias, E. and Bisello, M. (2020) "*Teleworkability and the COVID-19 crisis: a new digital divide?*". [Online]. Available: https://ec.europa.eu/jrc/sites/jrcsh/files/jrc121193.pdf [Accessed: Jul. 12, 2021].

[83] Steizel, S. (2011) "*University Training in Virtual Work. An Experience with Virtual Teams*". [Online]. Available: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/47003/133385.pdf [Accessed: Jul. 12, 2021].

[84] Sutton Fell, S. (2017) "*Connecting Rural Areas to Remote Work*". [Online]. Available: https://www.gov1.com/technology/articles/connecting-rural-areas-to-remote-work-pv7cC0uy8l1IEJKE/ [Accessed: Oct. 7, 2021].

[85] Thulin, E., Vilhelmson, B. and Johansson, M. (2019) "New Telework, Time Pressure, and Time Use Control in Everyday Life", *Sustainability*, Vol. 11, No. 11, pp. 1-17. E-ISSN 2071-1050. DOI 10.3390/su11113067.

[86] Van Fleet, D. (2016) "What is Agribusiness: A Visual Description", *Amity Journal of Agribusiness*, Vol. 1, No. 1, pp. 1-6. E-ISSN 2456-1525, ISSN 2455-9873.

[87] Walker, J. T. and Maddan, S. (2012) "*Statistics in Criminology and Criminal Justice: Analysis and Interpretation*", Burlington, Jones & Bartlett Learning, 592 p. ISBN 10 1449688608.

[88] Waschek, M. (2021) "*COVID-19 and Its Impact on Talent Management in Agribusiness*". [Online]. Available: https://www.croplife.com/management/employees/covid-19-and-its-impact-on-talent-management-in-agribusiness/ [Accessed: Nov. 10, 2021].

[89] Worldbank. (2020a) "*Services, value added (% of GDP)*". [Online]. Available: https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS [Accessed: Jul. 12, 2021].

[90] Worldbank, (2020b) "*Employment in Agriculture (% of total employment)*". [Online]. Available: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS [Accessed: Jul. 12, 2021].

[91] Zaballos, A. G., Iglesias, E., Cave, M., Elbittar, A., Guerrero, R., Mariscal, E. and Webb, W. (2020) "*The Impact of Digital Infrastructure on the Consequences of COVID-19 and on the Mitigation of Future Effects*". [Online]. Available:https://publications.iadb.org/publications/english/document/The-Impact-of-Digital-Infrastructure-on-the-Consequences-of-COVID-19-and-on-the-Mitigation-of-Future-Effects.pdf [Accessed: Jul. 12, 2021].

Predicting the Impact of Internet of Things on the Value Added for the Agriculture Sector in Iran Using Mathematical Methods

Hanieh FaghihKhorasani, Abbas FaghihKhorasani

Faculty of Social Sciences, University of Tehran, Iran

Abstract

In terms of water resources, Iran has less fresh water than its population demands. Also, due to climate change, inefficient management and excessive consumption of this vital resource, the water shortage situation is becoming more critical day by day. Searching for a solution for sustainable use of water sources, this study proposes utilizing the Internet of things technology in order to implement smart irrigation in agricultural lands in Iran. Investigating the economic impact of the Internet of Things in Iran's agriculture sector is the purpose of this article. The most important advantages of using smart irrigation are decreasing water consumption and increasing the productivity of agricultural yields (e.g., fruits, vegetables, etc.). This research attempts to predict Iran's economic growth in the event of smart irrigation implementation in agricultural fields and farms. The effect of investment in smart irrigation on water consumption and agricultural production is estimated by regression with cross-sectional data. In the end, by using the information obtained through the mathematical method, Iran's economic growth through GDP growth is estimated in the case if the Internet of things technology is fully implemented and the full benefits of using this technology are gained.

Keywords

Internet of Things, technology, smart irrigation, economic growth, gross domestic product, Iran.

FaghihKhorasani, H. and FaghihKhorasani, A. (2022) "Predicting the Impact of Internet of Things on the Value Added for the Agriculture Sector in Iran Using Mathematical Methods", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 17-25. ISSN 1804-1930. DOI 10.7160/aol.2022.140302.

Introduction

Iran is one of the member countries of the Middle East and North Africa[1] region. All the countries in MENA top the list of the countries enjoying least water resources (in terms of freshwater) in the world. Due to the climate change, these countries are going through frequent, severe, and prolonged droughts that have left them in high water stress. Thus, these countries will be the first victims of the water shortage crisis in the world (Perry and Steduto, 2017).

Iran, with approximately 1.22 percent of the world's landmass and 1.16 percent of the world's population, accounts for only 0.25 percent of the world's freshwater resources (Vallée and Margat, 2003); Iran's rank in terms of its share of freshwater in the total existing in the world is 54th from the end (Perry and Steduto, 2017). Moreover, about 72.6% of the total renewable freshwater resources are being used in Iran (World Trade Report ,2013) which 92.2% of it is used in agriculture. Despite the limited water resources of the country and the irregular use of this irreplaceable source, the use of water in the agricultural sector is not optimal and its efficiency is very low. In other words, not only is water used much more than other countries with similar climates, but the amount of Iranian agricultural products is very low compared to them.

A beneficial factor which can help reduce water consumption and increase productivity is the use of new technologies. In this day and age, Internet of Things (IOT) technology and its applications in various fields have attracted a lot of attention and are of great importance for the economy and society (Li, 2011). Governments, corporations, and consumers utilize the Internet of Things to introduce new business models, improve service delivery, enhance productivity and increase their overall quality (Garrity et al., 2015). The Internet of Things is used in various fields and sectors of the economy; one of which is in agriculture (Manyika et al., 2015). IoT technology has been introduced in smart irrigation, control and maintenance of agricultural machinery

[1] MENA

and tracking the status of livestock and poultry in a farm (Kim et al., 2008). Although the Internet of Things is a fairly new concept in Iran and it has a long way to be fully implemented in the agriculture sector, some first steps have been taken toward this goal.

The remainder of the article is organized as follows. The Materials and methods chapter is consist of three sections; the presentation of Iran's economic sectors and its current status is the objective of Section 1. In Section 2, we introduce the Internet of Things technology and its application in various areas. Finally, section 3 endeavors to explain the way the article was conducted. The result of the survey will be discussed in details in Results and discussion chapter. The last chapter is the conclusion of this study.

Materials and methods

Agriculture in Iran

Iran is a country in Southwest Asia and in the Middle East region with an area of 1,648,195 square kilometers. It is the 17th largest country in the world. Iran's gross domestic product (GDP) in 2018 is estimated to be 18619 thousand billion Rials[2]. Iran has four economic sectors as follows: "Agriculture", "Oil", "Industries and Mines" and "Services". The share of these groups in GDP is equal to 10, 12.3, 22.7 and 57.1 %, respectively (Central Bank of Iran[3]).

In terms of population, it is the second most populous country in the MENA region after Egypt, with a population of about 83.99 million (Central Bank of Iran). Iran is faced with impending water crisis as the climate changes. Iran has only 0.25% of the world's freshwater resources and, abysmally, 92.2 % of Iran's water consumption is used in the agriculture sector. The average use of water per capita in Iran's agricultural sector was 1,420 m^3 in 2011. Agricultural water consumption in Iran has an ascending trend such that the water usage had have increased from 63 BCM (billion cubic meters) in 2008 to 81 BCM in 2011(Hamdi et al., 2018).

The total area under cultivation in 31 provinces of Iran was 12,192,846 hectares in 2020; additionally, the total amount of agricultural products comprising 48 different fruits and vegetables was 91,793,888 ton (Deputy of Strategic Planning and Supervision of the Agriculture Ministry in Iran, 2020). The productivity, how much yields were harvested per hectare of land, of agricultural products in Iran was approximately 7528 kilogram per hectare; Iran's agricultural productivity is notably low compared to countries with similar climates.

Repercussions of the climate change are inevitable; they should be addressed in water resources management (Heydari and Morid, 2020). Iran's economy will suffer severely in case of prolonged and consecutive droughts if the country does not prepare to face such phenomenon. Salami (2009) reports that in 1999-2000 drought, it was considered to be the worst one in Iran's history, the amount of money which was lost directly from agriculture sector was 1,605 million dollars and the overall GDP dropped 4.4 precents in that year (Salami et al., 2009). Enhanced water management and long-term resiliency to disasters and climate change are achievable by the use of digital technologies (Sarni et al., 2019). What we believe is that the Internet of Things is the technology which can not only help us to reach sustainable water use but it also will bring us economic prosperity.

The Internet of Things

The Internet of Things, sometimes referred to as machine-to-machine communication technology, comprises of a set of smart devices equipped with sensors and microchips that are connected through a network, usually the Internet (Atzori et al., 2010; Li et al., 2014; Saidu et al., 2015). More than 9 billion devices worldwide are currently connected to the Internet, including computers and smartphones. This number is expected to increase dramatically in the next decade; the McKinsey Institute estimates it could reach 1 trillion devices (Manyika et al., 2015).

There are five necessary technologies in order to make IoT technology widely used: Radio Frequency Identification (RFID), Wireless Sensor Networks (WSN), Middleware, Cloud Computing and IoT application software (Atzori et al., 2010). In the ensuing paragraphs these technologies are defined.

Radio Frequency Identification: This technology which allows microchips to be designed for wireless data communications, has led to major advances in embedded communication devices. They help to automatically identify everything to which an electronic barcode is attached (Gubbi et al., 2013).

Wireless Sensor Networks (WSN): These networks include devices equipped

[2] Iran's currency

[3] This is the latest report available

with independent distributed sensors and are capable of monitoring physical and environmental conditions; WSN can work with radio frequency detection systems to monitor the status of factors such as location, temperature and motion (Atzori et al., 2010).

Middleware: it is a software layer that sits between software applications making it easier for software developers to communicate between input and output. The middleware hides details of various technologies that are irrelevant to IoT developers (Gubbi et al., 2013).

Cloud Computing: One of the most important results of IoT is the creation of an unprecedented amount of data (Gubbi et al., 2013). Many IoT applications require massive data storage, high processing speeds for real-time decision making, high-bandwidth networks, and high-speed data streams, either audio or video. Cloud computing provides an ideal solution for managing the data flow and processing it for countless IoT devices and humans in real time (Lee and Lee, 2015).

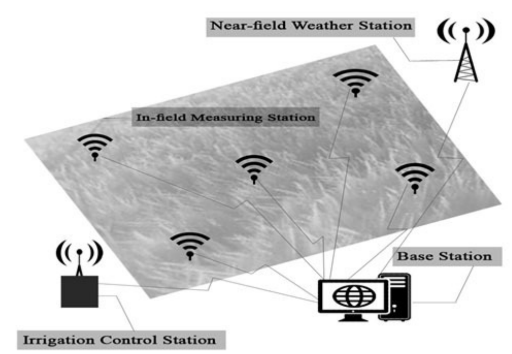
IoT application software: While devices and networks provide physical connectivity, IoT software provides reliable and robust device-to-device and human-to-device communication. IoT applications on devices must ensure that data and messages are received in a timely manner and they function properly (Lee and Lee, 2015).

Diverse areas can become the subject of IoT utilization; however, the specific area which this article is interested in is how the Internet of Things is implemented in agriculture.

In developing countries, irrigation is one of the main problems in agriculture (Nandurkar et al., 2014). In Iran, irrigation is done manually through traditional ways; so that the farmer irrigates at regular intervals, which sometimes leads to excessive use of water or in some cases the farmer neglects to irrigate diligently. Lack of water would slow the plant's growth, results in dehydration or small fruit and eventually leads to wilting the plant. Conversely, if there is more water than the plant's need, the nutrients in the soil would wash away culminating in plants' withering.

Smart irrigation helps farmers to prevent water wastage, minimize runoffs, improve the quality of their lands and crops by irrigation at the right time, accurately determine the soil's moisture level, eliminate human error (e.g. forgetting to turn off the valve after irrigating the land) and helps to save valuable energy, time and resources. Installation and configuration of intelligent irrigation systems are generally relatively simple. Estimating the water need, though, is somewhat difficult. There are different variables which must be taken into consideration; variables such as crop size, soil quality, irrigation process, precipitation, soil ability to retain moisture, temperature, and so forth can play a role in how much water a specific plant needs in a particular day.

The main technology used for smart irrigation is Wireless Sensor Networks; it enables irrigation systems to be very efficient and consume little water. An image of the distribution system of Wireless Sensor Networks in farmland is shown in Figure 1. This system consists of some measuring stations distributed throughout the land, an irrigation control station and one base station. In-field measuring stations are responsible for monitoring the soil's moisture, the soil's temperature and the air temperature. Nonetheless, a near-field weather station monitors meteorological information in the area such as: air temperature, relative humidity, precipitation, wind speed, wind direction and solar radiation. All data received from measuring stations is transmitted wirelessly to the base station. The base station processes the data through the decision programs and sends control commands including irrigation's time, the amount of water which is needed, direction the water should be sprayed and irrigation's speed to the irrigation control station; the irrigation control station becomes updated accordingly. Each existing sprinkler under the command of the control station would specifically irrigate the amount of water which is needed for each location on the ground (Kim et al., 2008).



Source: FaghihKhorasani and FaghihKhorasani (2022)

Figure 1: System layout of wireless sensor network for site-specific irrigation.

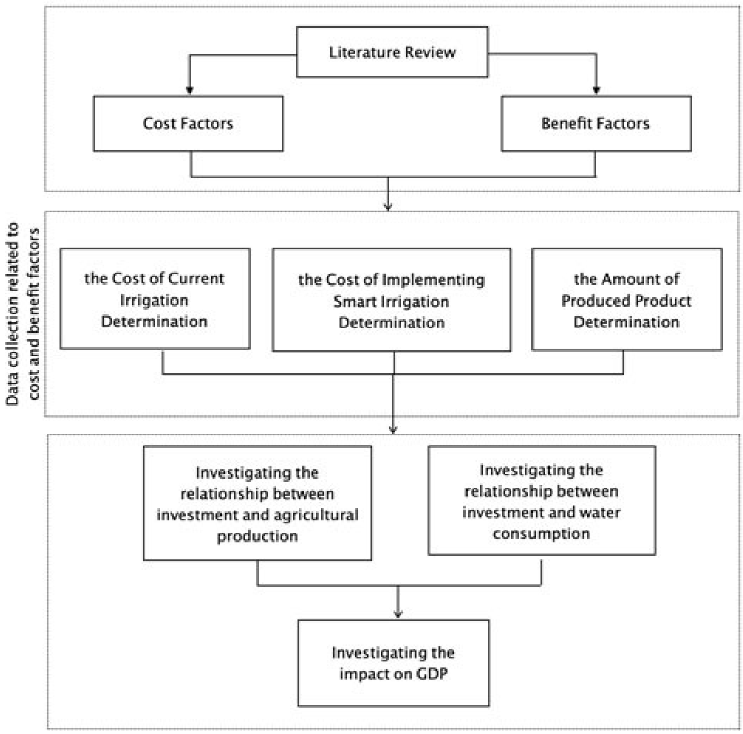
Using IoT in agriculture, the land is divided into smaller sectors where each sector receives customized treatments based on their location, soil type, and historical records (how much irrigation, fertilizers, seeds, and other farm inputs that specific sector used to receive by traditional farming). The Internet of Things' goal is to transform yields production and farm productivity dramatically by implementing better management (Raj et al., 2021). Thus, the first and the most important advantage of using IoT technology in smart irrigation is reducing water consumption between 20 to 40 %. The next major benefit resulting from irrigating plants just as much as they need is yield efficiency increase. If smart irrigation were implemented, agricultural yields would increase up to 20 % (Manyika et al., 2015).

Methodology

The first step taken to accomplish this study was literature review (Figure 2). To determine the economic impact of IoT, benefit-cost analysis was used in this paper. Therefore, throughout the literature review, it was tried to find the answer to two questions. What are the cost factors of implementing smart irrigation technology in agricultural lands in Iran? What are the benefits of implementing smart irrigation technology in agricultural lands? It was elucidated in section 3 that the advantages which are the boons of IoT implementation are decrease in water consumption and increase in agricultural yields. These factors should be converted into commensurable units in order to calculate the economic impact. The cost factors for employing smart irrigation are: sensors, solenoid valves, servers, IoT software, central control board and so forth; the cost factors were extracted from several pilot smart irrigation projects in Iran.

Furthermore, for attaining the cost of irrigation in Iran, the amount of water consumption for each 48 agricultural yields was extracted from the report "number 47" provided by UNESCO in 2010[4] (Mekonnen and Hoekstra, 2010). By knowing the cost of water in Iran, the total cost of irrigation using traditional approaches was calculated. Total 69,630.97 million cubic meters of water is consumed in Iran for the purpose of irrigating 48 kinds of agricultural products. The price for each cubic meter of water is 600 Rials for agricultural consumption. The amount of each fruit and vegetable cultivated in Iran was gathered from the report of the Deputy of Strategic Planning and Supervision

[4] This report is the newest source available on water consumption for Iran.



Source: FaghihKhorasani and FaghihKhorasani (2022)

Figure 2: Schematic of article's methodology.

of the Ministry of Iran's Agriculture (2020). The products' price per kilogram are also procured in this report. The total Iran's revenue from agricultural yields was determined using these data. The first fifteen crops which comprise the most cultivated area in Iran are mentioned in Table 1[5].

Results and discussion

In order to compute the evaluating relationship between the smart irrigation investments and either water consumption or agricultural production the ensuing steps have been taken. The cost of smart irrigation implementation was gained through further investigation in those pilot projects. Based on assembled information, the present cost of employing IoT was considered 1.05 billion Rials per hectare for further calculation. Annual costs of investing in smart irrigation was calculated from the following equation (McKinney and Savitsky, 2006).

Equation 1:

$$F = P(1 + i)^n \quad (1)$$

- F: the future value of investing in smart irrigation technology.
- P: the present value of investing in smart irrigation technology.

[5] Due to high volume of data, the first fifteen crops with the most cultivated area are mentioned in Table 1. Further information is available through online sources.

- i: Interest rate (it is considered 15 %; it is equal to one-year bank's interest in Iran).
- n: number of operation years (in calculations, it is considered 10 years).

To obtain the relationship between the impact of investment and value-added resulted from each benefit (decrease in water consumption and increase in agricultural yields) of implementing smart irrigation, the following relationship is considered Equation 2:

$$Y = c + f(x) + \varepsilon \quad (1)$$

- Y: value-added resulted from each benefit that is a dependent variable and a function of the amount of investment.
- c: width of origin.
- $f(x)$: the amount of investment in smart irrigation that is an independent variable which affects the value added of each mentioned benefit.
- ε : a small amount that is considered for error.

In this study, using EViews 10, the impact of investment in smart irrigation on the value added resulted from water consumption saving and also the impact of investment in smart irrigation on value added resulted from increase in agricultural production is obtained by regression and cross-sectional data. The critical t is assumed to be equal to 2. The allowable error rate in this regression is 5 %. The F test is used for the significance test

Crop	Cultivated Area (Ha)	Yield (Ton)	Price (Rial / kg)	Water Consumption (Mm^3/yr)
Wheat	1,960,295	8,303,502	75,000	10,939.58
Rice, paddy	854,874	4,560,693	82,500	4,526.29
Barley	691,136	2,618,560	34,000	225.76
Pistachios	424,358	386,905	2,450,000	3,129.42
Apples	222,253	4,217,172	63,458	1,710.51
Grapes	218,263	3,141,837	140,000	0.09
Dates	210,333	1,301,642	92,000	2,064.74
Potato	152,802	5,636,507	12,015	963.83
Rapeseed	147,099	261,012	150,000	0.00
Walnuts	133,138	258,412	1,100,000	655.75
Maize	132,572	1,089,410	35,250	805.04
Tomatoes	131,663	6,359,703	10,000	1,014.51
Oranges	124,784	2,700,531	40,343	958.65
Sugar Beet	108,433	5,606,851	14,733	1,714.48
Beans, dry	104,619	249,001	79,791	272.1

Source: Deputy of Strategic Planning and Supervision of the Ministry of Iran's Agriculture report, 2020; Mekonnen and Hoekstra, 2010

Table 1: Crops and their related information in Iran.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Investments	0.007828	0.000644	12.14954	0.0000
c	16368.61	24425.27	0.670151	0.5061

Source: FaghihKhorasani and FaghihKhorasani (2022)

Table 2a: The relationship between the impact of investment and value-added resulted from savings in water consumption.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Investments	0.108973	0.012958	8.409537	0.0000
c	1726427.0	491243.8	3.514399	0.0010

Source: FaghihKhorasani and FaghihKhorasani (2022)

Table 2b: The relationship between the impact of investment and value added resulted from increasing of agricultural .

of the whole regression, in which the maximum allowable error is equal to 5 %. The result for each test is shown in Table 2.

The relationship between the impact of investment and value-added resulted from savings in water consumption is achieved from investments and *c* coefficients shown in Table 2a. It should be noticed that the Prob value for the investment, independent variable, is zero. This value is less than 0.05. Which means that the null hypothesis of the test is rejected. In the null hypothesis of the test, it is assumed that the coefficient of the independent investment variable is equal to zero. By rejecting it, it can be concluded that the coefficient of the independent variable of investment is a number other than zero and is equal to 0.007828 and is statistically significant. The value of Prob for *c* is 0.5061. This value is greater than 0.05. Which means that the null hypothesis of the test is accepted. In the null hypothesis of the test, it is assumed that the coefficient c is equal to zero, and if it is accepted, it can be concluded that the coefficient of the variable c is equal to zero.

$Y_1 = 0.007828 * x$

Similarly, the relationship between the impact of investment and value added resulted from increasing of agricultural production is gained from investments coefficient shown in Table 2b. It can be seen that the Prob value for the investment, the independent variable, is zero. This value is less than 0.05. Therefore, it can be concluded that the coefficient of independent investment variable is a number other than zero and is equal to 0.108973. The value of Prob for c is equal to 0.001. This value is also less than 0.05; hence, it can be concluded that the variable c is equal to 1726427.

$Y_2 = 1726427 + (0.108973 * x)$

It was elucidated through regression that the value added from each benefit has a meaningful correlation with the amount of investment; ergo, Iran's GDP was predicted for the hypothetical situation in which smart irrigation were implemented in all agricultural lands and all the promised benefits were acquired. The predicted GDP was computed using the following equation.

Equation 3:

$$GDP_{predicted} = GDP + \sum_{k} \sum_{g} x_g^k {Y_1}_g^k {Y_2}_g^k \quad (3)$$

- x_g^k: the amount of investment for product *k*[6] in area *g*[7].
- ${Y_1}_g^k$: value added resulted from savings in water consumption from product *k* in area *g*.
- ${Y_2}_g^k$: value added resulted from increase in production of product *k* in area *g*.

According to Central Bank of Iran[8], the value of gross domestic product in relation to prices in 2018 was equal to 18619 thousand billion Rials, which is obtained from the aggregation of value added of four sub-sectors of Iran's economy, including: agriculture, oil, industry, and mines and services. The share of the agricultural sector in GDP in relation to prices was equal to 1901 thousand billion Rials, which encompassed 10.2 % of GDP.

If smart irrigation is implemented in agricultural lands, it will save water and increase crop production. These factors will create added value in the amount of 1254.45 thousand billion Rials compared to prices in 2018. If we add this amount

[6] 48 different crops published in the report of the Deputy of Strategic Planning and Supervision of the Ministry of Iran's Agriculture

[7] 31 provinces mentioned in the report of the Deputy of Strategic Planning and Supervision of the Ministry of Iran's Agriculture

[8] The 2018 economy report from Central Bank of Iran is the latest report available online.

to the country's GDP in 2018, the value of GDP will increase to 19873.45 thousand billion Rials. Iran's GDP would grow 6.7 % accordingly.

Conclusion

The water crisis in Iran's agricultural sector continues in an increasingly complex manner. In a recent attempt, the water authority company tried to stop the excessive extraction of water by equipping the agricultural wells with smart meter technology. This was done while there was no plan for how agricultural water consumers should cope. This approach has fueled water tensions across the country. Our paper has tried to show the benefits of a way to reduce water consumption and increase efficiency in the agricultural sector. In a study process, we calculated the costs of implementing smart irrigation in existing farmlands. Then we showed that there is a meaningful correlation between the investment in this technology and water consumption as well as increased efficiency in the agricultural sector. Using a formula, we predicted that Iran's GDP rate will increase to 6.7 % if this technology is used.

It is important to keep in mind that in developing countries, there are also problems along the same path of making water distribution smart with all its advantages and necessity. The first issue is awareness of the benefits of the Internet of Things, which are not well known in these countries, especially among farmers. The infrastructure is still not complete, the Internet has limited availability and low quality and the access to related sensors and telecommunication devices are still marginal. The necessary standards for the implementation of irrigation intelligence have not been developed, the necessary training for the use of the Internet of Things in the farm has not been given, and farmers are reluctant to change.

The rate of water for agricultural use is next to nothing in Iran, as well as electricity used by water pumps. This results in low incentives for farmers to change the irrigation model or the type of cultivation. Government investment is an important factor in the transformation of traditional to smart irrigation. For this reason, the integrity of water governance is important in accepting the importance of making irrigation smart. Different governmental organizations with different and sometimes conflicting interests have reduced the coordinated implementation of policies in favor of reducing water consumption. The rate of change in our water governance is much slower than the rate of climate change. We weighed the economic and productivity benefits of water smartness to pave the way for accelerating this fundamental shift in water conservation.

Future studies can investigate the social issues of irrigation method transformation in developing countries.

Corresponding authors
Abbas FaghihKhorasani, Ph.D. candidate
Faculty of Social Sciences, University of Tehran, Jalal-e-Al-e-Ahmad Hwy, Tehran, Iran
Phone: (+98) 9121328942, E-mail: abbas.faghih@ut.ac.ir

References

[1] Atzori, L., Iera, A. and Morabito, G. (2010) "The internet of things: A survey", *Computer Networks*, Vol. 54, No. 15, pp. 2787-2805. ISSN 1389-1286. DOI 10.1016/j.comnet.2010.05.010.

[2] Central Bank of Iran’s report (n. d.) "*Summary of economic developments in the country*". [Online]. Available: https://www.cbi.ir/SimpleList/AnnualReview_fa.aspx [Accessed: Oct. 10, 2021]. (In Persian).

[3] Deputy of Strategic Planning and Supervision of the Agriculture Ministry of Iran (2020) "*Crop Statistics Report*". [Online]. Available: https://amar.maj.ir/Dorsapax/userfiles/file/omure-eghtsadi/gharardadha/89/amarzeraei-j1-gozaresh-98-99.pdf. https://amar.maj.ir/Dorsapax/userfiles/Sub65/baghbani-gozaresh-1399.pdf. [Accessed: Oct. 10, 2021]. (In Persian).

[4] Garrity, J., Biggs, P., LaSalle, C. and Polomska, A. (2015) "Harnessing the internet of things for global development", *SSRN Electronic Journal*, 61 p. E-ISSN 1556-5068. DOI 10.2139/ssrn.2588129.

[5] Gubbi, J., Buyya, R., Marusic, S. and Palaniswami, M. (2013) "Internet of things (IOT): A Vision, architectural elements, and Future Directions", *Future Generation Computer Systems*, Vol. 29, No. 7, pp. 1645-1660. ISSN 0167-739X. DOI 10.1016/j.future.2013.01.010.

[6] Hamdi, A. Y., Liaghat, A., Rasoulzadeh, A. and Ghaderpour, R. (2018) "Investigation of in the Capita Water Consumption Variation in Iran Based on the Past Two-Deca Diet", *Journal of Water and Soil Researches of Iran*, Vol. 1, No. 50, pp. 77-87. ISSN 2008-479X. DOI 10.22059/IJSWR.2018.246084.667795. (In Persian).

[7] Heydari, N. and Morid, S. (2020) "Water and agricultural policies in Iranian macro-level documents from the perspective of adaptation to climate change", *Irrigation and Drainage*, Vol. 69, No. 5, pp. 1012-1021. ISSN 1531-0353. DOI 10.1002/ird.2498.

[8] Kim, Y., Evans, R. G. and Iversen, W. M. (2008) "Remote Sensing and control of an irrigation system using a distributed wireless sensor network", *IEEE Transactions on Instrumentation and Measurement*, Vol. 57, No. 7, pp. 1379-1387. ISSN 1557-9662. DOI 10.1109/tim.2008.917198.

[9] Lee, I. and Lee, K. (2015) "The internet of things (IOT): Applications, investments, and challenges for enterprises", *Business Horizons*, Vol. 58, No. 4, pp. 431-440. ISSN 0007-6813. DOI 10.1016/j.bushor.2015.03.008.

[10] Li, L. (2011) "Application of the internet of thing in Green Agricultural Products Supply Chain Management", 2011 *4th International Conference on Intelligent Computation Technology and Automation*, pp. 1022-1025. DOI 10.1109/icicta.2011.256.

[11] Li, S., Xu, L. D. and Zhao, S. (2014) "The internet of things: A survey", *Information Systems Frontiers*, Vol. 17, No. 2, pp. 243-259. E-ISSN 1572-9419, ISSN 1387-3326. DOI 10.1007/s10796-014-9492-7.

[12] Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J. and Aharon, D. (2015) "*The Internet of Things: Mapping the Value Beyond the Hype*", San Francisco; McKinsey & Company. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/the%20internet%20of%20things%20the%20value%20of%20digitizing%20the%20physical%20world/the-internet-of-things-mapping-the-value-beyond-the-hype.pdf. [Accessed: Oct.10, 2021].

[13] McKinney, D. C. and Savitsky, A. G. (2006) "*Basic Optimization Models for Water and Energy Management*", The University of Texas at Austin, Thechnical Report. [Online]. Available: https://www.caee.utexas.edu/prof/mckinney/ce385d/Lectures/McKinney_and_Savitsky.pdf. [Accessed: Oct. 10, 2021].

[14] Mekonnen, M. M. and Hoekstra, A. Y. (2010) "*The Green, Blue And Grey Water Footprint of Crops and Derived Crop Products*", The Netherlands; UNESCO-IHE Institute for Water Education. [Online]. Available: https://waterfootprint.org/media/downloads/Report47-WaterFootprintCrops-Vol2_1.pdf. [Accessed: 10 Oct., 2021].

[15] Nandurkar, S. R., Thool, V. R. and Thool, R. C. (2014) "Design and development of Precision Agriculture System Using Wireless Sensor Network", *2014 1st International Conference on Automation, Control, Energy and Systems (ACES)*. pp. 1-6. DOI 10.1109/aces.2014.6808017.

[16] Perry, C. J. and Steduto, P. (2017) "Does Improved Irrigation Technology Save Water? A review of the evidence". DOI 10.13140/RG.2.2.35540.81280.

[17] Raj, M., Gupta, S., Chamola, V., Elhence, A., Garg, T., Atiquzzaman, M. and Niyato, D. (2021) "A survey on the role of internet of things for adopting and promoting agriculture 4.0", *Journal of Network and Computer Applications*, Vol. 187. ISSN 1084-8045. DOI 10.1016/j.jnca.2021.103107.

[18] Saidu, C., Usman, A. and Ogedebe, P. (2015) "Internet of things: Impact on economy", *British Journal of Mathematics & Computer Science*, Vol. 7, No. 4, pp. 241-251. ISSN 2456-9968. DOI 10.9734/bjmcs/2015/14742.

[19] Salami, H., Shahnooshi, N. and Thomson, K. J. (2009) "The economic impacts of drought on the economy of Iran: An integration of linear programming and macroeconometric modelling approaches", *Ecological Economics*, Vol. 68, No. 4, pp. 1032-1039. ISSN 0921-8009. DOI 10.1016/j.ecolecon.2008.12.003.

[20] Sarni, W., White, C., Webb, R., Cross, K. and Glotzbach, R. (2019) "*Digital Water: Industry leaders chart the transformation journey*", International Water Association and Xylem Inc. [Online]. Available: https://iwa-network.org/wp-content/uploads/2019/06/IWA_2019_Digital_Water_Report.pdf. [Accessed: Oct. 10, 2021].

[21] Vallée, D. and Margat, J. (2003) "*Review of World Water Resources by Country. Rome; Food and Agriculture Organization of the United Nations*". [Online]. Available: https://www.fao.org/3/Y4473E/y4473e.pdf. [Accessed: Oct. 10, 2021].

[22] World Trade Report (2013) "*Fundamental economic factors affecting international trade*", International Trade. [Online]. Available: https://www.wto-ilibrary.org/content/books/9789287042224s004-c005/read. [Accessed: Oct. 10, 2021].

Volume XIV Number 3, 2022

A Historical Cum Empirical Overview of Agriculture Spending and Output Nexus in India

Samir Ul Hassan[1], Shafi Ahmad Khanday[2], Masroor Ahmad[3], Biswambhara Mishra[4], Motika Sinha Rymbai[4]

[1] Anil Surendra Modi School of Commerce (ASMSOC), NMIMS University, Mumbai, India

[2] Department of History, North Eastern Hill University, Shillong, Meghalaya, India

[3] Department of Economics, Central University of Kashmir, Jammu and Kashmir, India

[4] Department of Economics, North Eastern Hill University, Shillong, Meghalaya, India

Abstract

This research aims to have a holistic view of the relationship between agriculture outcome/output and agricultural spending in India. The unique part of the study is that it highlighted the nexus between agriculture outputs from a historical point of view. The empirical part of this study is analyzed using the development of the co-integration method followed by the VECM model. The empirical analysis shows -a long-run association between agriculture spending and production, and this feedback is bidirectional. Agricultural production positively responds to agricultural spending in India both in the short and long run, especially in sowing seasons. However, the exciting finding of the study is that the speed of adjustment of agricultural spending on output is plodding. This implies that any shock of the agricultural production can be corrected by agricultural spending by just 20 percent, and it will take more than four years to stabilize the agricultural output with agricultural expenditure. Thus the tendency of agrarian spending to stabilize agrarian output in India is not so encouraging.

Keywords

History, agriculture, output; spending, institutions.

Hassan, S. U., Khanday, S. A., Ahmad, M., Mishra, B. and Rymbai, M. S. (2022) "A Historical Cum Empirical Overview of Agriculture Spending and Output Nexus in India", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 27-41. ISSN 1804-1930. DOI 10.7160/aol.2022.140303.

Introduction

India is the second-largest producer and exporter of food grains, fruits, vegetables, and wheat (Mukherjee, et.al, 2019). Agriculture is considered the backbone of the Indian economy. A vast majority of our total population is dependent on their livelihood from agriculture. The agricultural sector plays a vital role in developing the Indian economy (Arjun, at the time of independence. As a legacy from British Colonialism, age-old and traditional techniques were applied in agriculture (Burton, 1998). The productivity was inferior and high taxation (Bayly, 1985). Due to its low productivity, agriculture could manage only subsistence livings to Indian peasants under feudal structure (Pradhan, 2007).

The Indian economy has continued being predominantly agrarian both in terms of its Gross Domestic Product (GDP) and providing employment to the country’s labor force (more than 60 percent of the workforce is still engaged in agriculture) (Ghose, 1982). As being primarily dependent on monsoons, the initial challenge was to build irrigation infrastructure that began even before Britishers' independence (Habib, 2006). By 1947 the network of irrigation canals was only 17% of the net sown area. Almost 80% of the cultivable area was still dependent on monsoons, resulting in low crop production and was prone to famines (Subramaniam, 2008).

However, after independence, the rapid growth accelerated but was quite low than the non-farming sector. A long way from the chronic food-deficit country to a self-sufficient food country had been a commendable achievement (Roy, 2002). During the early phase of independence, agricultural policy witnessed tremendous growth. Agrarian reforms, institutional changes, development of major irrigation projects, and strengthening cooperative credit institutions were key features of early plans (Kumar 2005; Pradhan 2007; Subramaniam, 2008). Land reforms' most important contribution was abolishing intermediaries and giving land titles to the actual cultivators (Travers, 2004). This released productive forces, and the owner cultivators put in their best to augment production on their holdings. Land reforms were significant in increasing agricultural production during this phase (Balakrishnan and Parameswaran, 2007).

A new phase started in Indian agriculture during the mid-1960s by adopting a new agricultural strategy (Green revolution). The new agricultural strategy relied on high-yielding varieties of crops, multiple cropping, the package approach, Credit facilities, modern farm practices, and the spread of irrigation facilities (Kumat et al., 2010; Tirthakar, 2002). During the early 1980s, India started witnessing the process of diversification, which resulted in fast growth in non-food grains output like milk, fishery, poultry, vegetables, fruits, etc. which accelerated growth in agricultural GDP during the 1980s (Bannerjee, 2005).

Recent studies show that India has witnessed a significant increase in food grain production (green revolution), oilseeds (yellow revolution), milk (white revolution), fish (blue revolution), and fruits and vegetables (golden revolution) (Mahadevan, 2003). Now, India is marching towards what is called as ICT (information and communication technology) Revolution in agriculture (Bharti, 2018). The food safety net for every of the over a billion citizens - a growing number - requires enhanced agricultural production and productivity in the form of a Second Green Revolution (Saradhi et al., 2020; Ramakumar, 2020; Mozumdar, 2012). Further, special attention is required for achieving higher production and productivity levels in pulses, oilseeds, fruits, and vegetables, which had remained untouched in the First Green Revolution but are essential for nutritional security. In this regard, achieving high poultry production, poultry, and fisheries (Manida and Nedumaran, 2020).

In contrast to India, the EU agricultural area has reduced slightly, mainly driven by decreasing cereals and oilseed acreage (Schebesta and Candel, 2020). However, land use for pasture, fodder, and protein crops has grown. The areas for barley and wheat have decreased, while maize areas have compensated for this by meeting the demand for cereal feed (European Commission, 2020; Baldos et al., 2019). Overall there has been a decline of 12 percent in agricultural production in the EU in the last decade. The decline in agricultural output would tighten the EU food supply, resulting in price increases impacting consumer budgets (Beckman et al., 2018; Schebesta and Candel, 2020). In trade, EU exports of agriculture have strengthened thanks to converging EU and world prices and proximity to importing markets, primarily in the Mediterranean region and sub-Saharan Africa (Beckman et al., 2018). There has been a decline in the farm workforce due to structural changes at the EU level and that has slowed down to 1% per year, primarily from technological progress in machinery and equipment (Schebesta and Candel, 2020). However, the real income per worker has increased by 0.5% per year, slowing down from 1.9% in the past decade (Rossi et al., 2012). The above trends in agriculture production in the EU are due to public and private investment in agricultural research and development (R&D), spurring innovation in the field (Fuglie, 2018; Garnett et al., 2013). The investment in agricultural research and development (R&D), the technology treadmill, Insurance support to farmers, marketing facilities, and the strategies goal put forward by EU in 2020 has resulted from growth in agricultural production (Maggi et al., 2019; Skevas and Oude Lansink, 2020; Bastiaans et al., 2008; Chikowo et al., 2009).

On the other hand, Public expenditures on agriculture have been the most important driving force for agricultural output. The expenditure includes short-term costs and long-term investments (Pardey, Roseboom and Craig, 1992; Rosegrant and Evenson, 1992). Investment in agriculture and forestry includes government expenditures directed to agricultural infrastructure, research and development, and education and training (Evenson et al., 1991). Comparisons between developed and developing countries reveal, a more significant variation among developing countries than industrial countries (Chavas and Aliber, 1993). Investment in infrastructure has been cited as an essential source of growth in agriculture (Jayne et al., 1994). Public investment in forms of human capital: education, extension, training, and technology research have also been shown to increase productivity (Antholt, 1994; Beal, 1978; Evenson and McKinsey, 1991; Pray and Evenson, 1991; Zdráhal, 2021). Egwu (2016) also examined the impact of agricultural financing on agricultural output, economic growth, and poverty alleviation in India from 1980 to 2010. The study found that commercial bank credit to the agricultural sector and agricultural credit guarantee scheme fund loan to the agricultural sector is significant to agricultural sector output percentage to gross domestic product.

As far as the state of Indian Agriculture is concerned, Agriculture is the livelihood for a majority of the population and can never be underestimated.

Although its contribution to the gross domestic product (GDP) has reduced to less than 20 percent and the contribution of other sectors increased faster, agricultural production has grown. This has made us self-sufficient and taken us from being a begging bowl for food after independence to a net exporter of agriculture and allied products. GDP from Agriculture in India increased to 6364.44 INR Billion in the fourth quarter of 2020 from 3802.39 INR Billion in the third quarter of 2020 (Government of India, 2019).

Total food grain production in the country is estimated to be a record 291.95 million tonnes, according to the second advance estimates for 2019-20. This is news to be happy about, but as per the Indian Council for Agricultural Research (ICAR) estimates, demand for food grain would increase to 345 million tonnes by 2030. The share of agriculture in the gross domestic product (GDP) has reached below 20 percent for the first time in the last 17 years, making it the only bright spot in GDP performance during 2020-21, according to the (Economic Survey 2020-2021).

The resilience of the farming community in the face of adversities made agriculture the only sector to have clocked a positive growth of 3.4 percent at constant prices in 2020-21 when other sectors slid. The share of agriculture in GDP increased to 19.9 percent in 2020-21 from 17.8 percent in 2019-20 (Government of India, 2019). The last time the agriculture sector's contribution in GDP was at 20 percent was in 2003-04. This was also when the industry clocked 9.5 percent GDP growth, after the severe drought of 2002 when the growth rate was negative.

The growth in GVA (gross value added) of agriculture and allied sectors has fluctuated over time. However, during 2020-21, while the GVA for the entire economy contracted by 7.2 percent, growth in GVA for agriculture maintained a positive growth of 3.4 percent. The continuous supply of agricultural commodities, especially staples like rice, wheat, pulses, and vegetables, also enabled food security (Handbook of India Economy, 2020). In 2019-20 (according to fourth advance estimates), total food grain production (296.65 million tonnes) in the country was higher by 11.44 million tonnes than in 2018-19. It was also higher by 26.87 million tonnes than the previous five years (2014-15 to 2018-19) average production of 269.78 million tonnes (Reserve Bank of India, 2020). The production also boosted allocation of food grains under the National Food Security Act (NFSA) increased by 56 percent in 2020-21, compared to 2019-20

As far as agricultural spending in India is concerned, the revenue expenditure budget estimate on agriculture and allied services in India by the state and central governments amounted to an estimated 4.1 trillion Indian rupees in 2018 (Bharti, 2018). This was a significant increase compared to the fiscal year 2009 (De and Dakhar, 2018). However, the expenditure on agriculture has not yielded the dividend to India as expected (Amarnath and Prasad, 2009; Mozumdar, 2012; Subramaniam, 2008). The Indian government has also made several other efforts to finance the agricultural sector to improve its contribution to annual income in the economy (Recent schemes include the Pradhan Mantri Krishi Sinchai Yojana, National Scheme of Welfare of Fishermen, KCC for animal husbandry and fisheries, Pradhan Mantri Kisan Samman Nidhi, Pradhan Mantri Kisan Maan Dhan Yojana, Interest subvention for the dairy sector, Credit facility for farmers, Crop insurance schemes. Despite these vast sums of money allocated to the industry through these schemes over the years, the contribution of agriculture in India remains doubtful (Saradhi et al., 2020; Ramakumar, 2020).

Therefore, the above-mentioned trends and discussion have called for the need for empirical investigation of the relationship between government agricultural spending and agricultural output in India spanning 1980 to 2019. Therefore, the study aimed to examine the nature of causation between government agricultural spending and agricultural output in India and the extent to which government agricultural spending affects agricultural output in India. Further, it is pertinent to re-examine the relationship between government agricultural spending and agricultural output in India using recent data and employing the best fit methodology to address the endogeneity issues among the explanatory variables. The study also aimed to explore the effective variables that can be targeted through government spending to boost the long-run agricultural output.

Material and methods

This study is primarily based on time series secondary data for the period 1980-2019. The data has been collected from many sources, including the state finance reports, RBI, MOSPI, NABARD, and India's Ministry of Agriculture government.

Model specification

To capture the effect of government agricultural spending on agricultural output in India, the study adopts the essence of Cobb-Douglas production function with modifications. Thus, decomposing capital into government agricultural spending, the value of loans guaranteed by NABARD to the agricultural sector and commercial bank loans to the agricultural sector, the interest charged on loans to the sector and agricultural labor force, the functional form of the model can be stated as:

$$OPt = f(Op\ t\text{-}i + GAt + CBt + NABARDt + It + + Alt) \quad (1)$$

Expressing equation (1) in stochastic form and taking the natural logarithm (ln), the model can be stated as:

$$Op_t = \alpha_0 + \beta_0 \ln GA_t + \beta_1 \ln CB_t + \beta_2 \ln NABARD_t + + \beta_3 \ln I_t + \beta_4 \ln AL_t + \mu_t \quad (2)$$

Where:

OP is Agricultural output at the time, *T, GA* is Government expenditure on Agriculture, *CB* is loaned to Agriculture from commercial banks, *NABARD* is loans and assistances from NABARD, *I* is the interest rate on loans for Agriculture, and *AL* is the agriculture labor force. α_0 is Constant Intercept; β_0, β_1, β_2, β_3, β_4 are Slope of Coefficients of the explanatory variables and μ_t is Stochastic disturbance term.

Estimated model

The econometric framework adopted in this paper is based on developments in the co-integration and error correction model suggested by Johansen (1988) and Johansen and Jusellious (1995). By applying VECM techniques to the time series data, based on the results of the unit root and multi-variate co-integration test, we can approximate a dynamic structure in which initially all the variables in both the models are treated as endogenous. Most time series analysis de- demonstrates nonstationary characteristics in their mean or trending pattern. If the data is trending, then some form of de-trending is needed. The most common de-trending practices are differencing and time-trend regressions (Junková, 2011; Tyrychtr, 2015). Thus, the first step in co-integration modeling is often taken by testing for unit roots to determine whether trending data should be differenced or regressed on deterministic functions of time.

After employing unit root and co-integration modeling for the time series data set of each determinant function, we can constitute a model free of spurious properties and having a dynamic robustness structure. Based on the unit root and co-integration results, we identify the VECM suitable for generating powerful results in agricultural output. As stated above, this study employs Johansen's multivariate co-integration approach developed by Johansen (1988) and Johansen and Jusellious (1995), specified as a reduced-form VAR model of order *p*. Therefore, in this study, the VECM model is used to assess the short- and long-run determinants of Agriculture output through various institutional inputs.

$$y_t = A_1 y_{t-1} + \ldots + A_i y_{t-i} + \ldots + A_p y_{t-p} + Bx_t + e_{t-1} \quad (3)$$

The above equation (3) states that the procedure by which the dependent variables in yt vary about their time-invariant means is entirely determined by the parameters in A_i and *B*, and the (infinite) past of y_t itself, the exogenous variables x_t, and the history of independently and identically distributed shocks, e_{t-1}, e_{t-2}, .. Therefore, the joint distribution of y_t is determined by the distributions of x_t and e_t and the parameters *B* and A_i.

However, according to the Granger representation theorem (Granger, 1988), if co-integration is established among a vector of variables in the model, then a valid error correction model may be estimated; if not, then VAR is used. Therefore, in this study, the choice of whether to use VAR or VECM for estimations follows the Granger representation theorem; that is, it is based on co-integration results.

Estimation procedure

Nonstationary data leads to spurious regression due to non-constant mean and variance (Dimitrova, 2005). If a series is stationary without any differencing, it is said to be I(0) or integrated of order 0. However, if a series is stationary after first difference is said to be I(1) or integrated of order 1. To this end, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests have been adopted to examine the stationary, or otherwise, of the time series data. The lowest value of the Akaike information criterion (AIC) has been used in this to decide the optimal lag length in the ADF and PP regression. These lags were used in ADF and PP regression to make sure that the error term is white noise. If all the variables in an equation are in integral order of I(1) and the resulting residuals are I(0). According to Engle and Granger (1988), it can be declared that there resides a corresponding error correction mechanism (ECM or e_{t-1}), and the basic models will be transformed accordingly. The regression from the ADF test is of the following form:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta y_{t-j} + \varepsilon_t \qquad (4)$$

where D is the first-difference operator, y_t is the respective variable of expenditure over time, p is lag, a_0 is constant, a_1 and g_j is parameters, and e_t denotes stochastic error term.

If $a_1 = 0$, then the series is said to have a unit root and is nonstationary. Hence, if the hypothesis, $a_1 = 0$, is not accepted according to the equation, it can be concluded that the time series does not have a unit root and is integrated of order I(0). In other words, it has stationarity properties.

Similarly, the regression from Phillips-Perron (PP) test is in the following form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2(t-T/2) + \mu_t \qquad (5)$$

Where α_0 is the intercept, a_1 and a_2 are the expected least squares regression coefficients, the hypotheses of stationarity to be tested is H0: $a_1 = 0$ and $\alpha_0 = 0$.

Co-integration test

After analyzing whether the series is stationary in levels or first difference or integrated in the same order, then Johansen's co-integration method is used to verify whether there exists a co-integrating vector among the variables or not (Johansen, 1988). Johansen's co-integration test employs two test statistics to identify the number of cointegrating vectors: the Trace test and the Maximum Eigenvalue test. The Trace statistics tests the null hypothesis of r co-integrating vectors/equation in the given series against the alternative hypothesis of no co-integrating equations. The Trace statistics test is calculated by using the following expression:

$$LR_{tr}(r/n) = -T * \sum_{i=r+1}^{n} \log(1 - \check{Y}_1) \qquad (6)$$

where

$\check{Y}$ is the Trace statistics value, n is the number of variables in the system, and r = 0, 1, 2, .. ., n - 1 co-integrating equation.

The test statistic for Max Eigenvalue is computed as:

$$LR_{max}(r/n+1) = -T * \log(1 - \check{Y}) \qquad (7)$$

where

$\check{Y}$ is the Max Eigenvalue and T is the sample size.

In case the Max Eigenvalue statistic and the Trace statistic yield different results, then trace test statistic will be preferred as suggested by Alexander (2001).

VECM Models for Nexus

After the Johansen co-integration test, the next is to fit the suitable time series model. If co-integration has been established between the variables, this implies a long-run relationship between the variables under the integration equation. Hence, the VECM is applied to determine the short-run relationships of co-integrated variables. On the other hand, if there exists no co-integration, then the VECM is transformed to Vector autoregressive (VAR) model, followed by impulse analysis, variance decomposition, and the Granger causality tests to determine casual links and response. The study used VECM to account for the endogeneity that could exist. This is because it avoids simultaneous equation bias in the case of endogeneity among explanatory variables. Applying a VECM specification to equation (2) since the variables or series were stationary at the first difference and co-integrated, the models can be specified as:

$$\begin{aligned} DlnOP_t = \alpha_0 &+ \sum_{i-1}^{p} \beta_1 DlnOP_{t-i} + \sum_{i-1}^{p} \beta_2 DlnGA_{t-i} + \\ &+ \sum_{i-1}^{p} \beta_3 DlnCB_{t-i} + \sum_{i-1}^{p} \beta_4 DlnNABARD_{t-i} + \\ &+ \sum_{i-1}^{p} \beta_5 DlnI_{t-i} + \sum_{i-1}^{p} \beta_6 DlnAL_{t-i} + \\ &+ \prod ECT_{t-i} \end{aligned} \qquad (8)$$

where

D is the difference level of the variable; ln is the natural log form of the respective variable and α_0 is the intercept coefficients. Parameters β_1, β_2, β_3, β_4, β_5 *and* β_6 *are coefficients of the equation. The coeffici*ent of error correction term (ECT) in the equations represents $\prod ECT_{t-1}$ shows the speed of adjustment towards the long-run equilibrium. The coefficient of adjustment should be negative and statistically significant for convergence. The study further uses the Granger causality testing at the end to understand the feedback and direction of effect between the variables.

Diagnostic tests

The diagnostic tests applied in the restricted equations of the government expenditure and demographic variables are: the Breusch-Godfrey Serial Correlation or LM Test done for serial correlation of the model, ARCH Test (autoregressive conditional heteroskedasticity) has been carried for Heteroskedasticity. Similarly, the model's parameter stability test has been performed by the CUSUM statistics. The Normality test has been done through the Jarque-Bera test. All the diagnostic tests are estimated through the null hypothesis, which is tested through the test statistic value of each test at the probability value at a 5% level of significance.

Result and discussion

Unit Root test

The results of the ADF test are shown in the Table 1. The results show that trend nd constant are significant for OP, GA, and CB while only constant is significant for I and AL at a 5% level of significance.

The table shows that the variables are non-stationary at level, but after the first difference, the variables are stationary. This explains that the order of integration for the given variables is I(1).

Table 2, reveals that there is cointegration among the variables. This is because the trace statistic of 119.5858 and 79.5859 is greater than the critical values of 95.75366 and 69.818 at a 5% level of significance, respectively. The study, therefore, rejects the null hypothesis of at most one hypothesized number of co-integrating vectors. This means that there is two cointegrating equation(s) at the 5 percent level. This implies that there is a long-run relationship among the variables incorporated in the model.Co-Integration Test

The Johansen and Juselius (1995) co-integration approach was applied to determine the number of cointegrating vectors. It offers two tests, the Trace test, and the Max-Eigen value test, to identify the number of co-integrating

Variables at Natural Lag	At level	First Difference	1%	Order of Integration
Agriculture Output (OP)	-0.872	-4.288	-4.227	I(1)
Prob.	0.949	0.0086*		
Expenditure on Agriculture (GA)	-1.762	-7.395	-4.227	I(1)
Prob.	0.703	0.0000*		
Commercial bank Loans (CB)	-2.487	-6.994	-4.227	I(1)
Prob.	0.332	0.0000*		
Loans from NABARD	-1.033	-5.556	-4.227	I(1)
Prob.	0.927	0.0003*		
Interest Rate (I)	-2.493	-6.840	-3.621	I(1)
Prob.	0.125	0.0000*		
Agriculture labor force (Al)	-1.119	-6.365	-3.621	I(1)
Prob.	0.698	0.0000*		

Note: * is the significant at 1 % level of significance; Prob. ss the probability
Source: Authors calculation

Table 1: Estimated results of ADF stationary test.

Null hypothesis	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.*
r = 0	None *	0.660	119.58	95.75	0.0004
r ≤ 1	At most 1 *	0.644	79.58	69.81	0.0068
r ≤ 2	At most 2	0.437	41.35	47.85	0.1777
r ≤ 3	At most 3	0.344	20.03	29.79	0.4204
r ≤ 4	At most 4	0.111	4.412	15.49	0.8675
r ≤ 5	At most 5	0.001	0.045	3.841	0.8308

Note: * is the significant at 1 % level of significance;
Source: Authors calculation

Table 2: Result of Unrestricted Cointegration Rank Test (Trace).

relationships. The results are shown in the Table 2 and the Table 3.

Also, the Eigenvalue test rejects the null hypothesis if the Maximum-Eigen value test statistics 3exceeds the respective critical values. The Table 3 reveals that there is cointegration among the variables. The Eigenvalue statistics of 59.99 and 38.23 are greater than the critical values of 40.07 and 33.87 at a 5% level of significance, respectively. The study rejects the null hypothesis of at most one hypothesized number of co-integrating vectors. This means that there is two cointegrating equation(s) at the 5 percent level. Hence, the Maximum-Eigen value statistic indicates two (2) co-integrating equations at a 5 percent significance level. As evidenced from the Trace and Max-Eigen test statistics, there is a long-run relationship between government agricultural spending and agricultural output in India.

Agricultural Spending and Agricultural Output Nexus

Given that the series are non-stationary and the need to account for the effect of lagged values of variables on the current values on others within a VAR framework, the study estimated the VEC Granger Causality/Block Exogeneity Wald test. The results of the granger causality test are presented in Table 4.

The Table 4 shows the results of the VECM

Null hypothesis	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.*
r = 0	None *	0.660	59.99	40.07	0.0110
r ≤ 1	At most 1 *	0.644	38.23	33.87	0.0142
r ≤ 2	At most 2	0.437	21.31	27.58	0.2576
r ≤ 3	At most 3	0.344	15.62	21.13	0.2475
r ≤ 4	At most 4	0.111	4.367	14.26	0.8187
r ≤ 5	At most 5	0.001	0.045	3.841	0.8308

Note: * is the significant at 1 % level of significance;
Source: Authors calculation

Table 3: Result of Unrestricted Cointegration Rank Test (Maximum-Eigen value).

Sample: 1980-2019; Lags: 2				
Null Hypothesis:	**Obs**	**F-Statistic**	**Probability**	**Decision**
OP does not Granger Cause GA	37	2.55	0.024**	Rejected
GA does not Granger Cause OP		3.23	0.043**	Rejected
OP does not Granger Cause CB	37	5.135	0.008 *	Rejected
CB does not Granger Cause OP		0.742	0.539	Accepted
OP does not Granger Cause NABARD	37	3.361	0.039**	Rejected
NABARD does not Granger Cause OP		0.539	0.610	Accepted
OP does not Granger Cause IN	37	0.351	0.983	Accepted
IN does not Granger Cause OP		0.187	0.361	Accepted
AL does not Granger Cause OP	37	1.054	0.13 0	Accepted
OP does not Granger Cause AL		4.863	0.035**	Rejected
GA does not Granger Cause CB	37	2.56	0.08 6	Accepted
CB does not Granger Cause GA		0.35	0.789	Accepted
GA does not Granger Cause NABARD	37	0.288	0.255	Accepted
NABARD does not Granger Cause GA		0.790	0.517	Accepted
CB does not Granger Cause NABARD	37	1.168	0.492	Accepted
NABARD does not Granger Cause CB		4.79	0.031**	Rejected
AL does not Granger Cause NABARD	37	2.32	0.694	Accepted
NABARD does not Granger Cause AL		0.032	0.533	Accepted
AL does not Granger Cause CB	37	0.517	0.180	Accepted
CB does not Granger Cause AL		0.0204	0.178	Accepted

Sources: Authors calculation
Note * denotes rejection at 1% &** denoted as rejected at 5% levels respectively

Table 4: Results of VEC Granger Causality/Block Exogeneity Wald test.

Granger Causality/Block Exogeneity Wald test. The table depicts the bidirectional relationship or Granger causality between government agricultural spending and agricultural output at a 5% level of significance. Thus, the causality runs from government agricultural spending to agricultural output and agricultural output to government agricultural spending in India. The implication is that lagged values and current agricultural output can influence the current level of government agricultural spending in India. In contrast, the lagged government agricultural spending and current government agricultural spending influences the current performance of the agricultural sector. There is also a unidirectional relationship running from NABARD loans to commercial bank loans to agricultural in India at a 5% significance level. The implication is that the NABARD loans are orchestrated through commercial banks, hence, the causal effect. The result also shows that government agricultural spending has Granger caused agricultural NABARD loans at a 5% level of significance. The implication is that the amount of past and current spending on the agricultural sector affects the current amount of NABARD Loans in India. More so, there is a unidirectional relationship running from agricultural output to agricultural labor in India at a 5% level of significance. This implies that output from the agricultural sector can affect the agricultural labor force in India.

Estimated results of VECM for long-run and short-run

The Table 5 shows the estimated short and long-run results. The long-run estimated coefficient of Government expenditure on agriculture (GA) is positive theoretically plausible and statistically significant at a 5% critical value. This implies that an increase in Government expenditure on agriculture leads to an increase in agricultural output in India by 0.82 percent. These results are in line with (Evenson et al. al., 1991; Zdarhal, 2021). This might be because government expenditure on agriculture creates infrastructure for technology, research, agricultural marketing, transport, insurance, and credit, which indirectly increase productivity and production of agricultural output. Similarly, the estimated coefficients of Commercial banks (CB) to the agricultural sector and NABARD loans to agriculture are positive and theoretically plausible. They are statistically significant at a 5% critical value. This implies that an increase in expansion of Commercial banks loans to the agricultural sector and NABARD loans lead to an increase in agriculture output by 0.42 percent and 0.81 percent, respectively.

Long Run estimates: Equation 7			
Regressor	**Coefficient**	**Standard error**	**T-statistic**
LNOP(1)	1.000000		
LNGA(1)	0.62	.133	7.75**
LNCB(1)	0.42	0.180	3.45*
LNNABARD(1)	0.81	0.144	8.23**
LNI(1)	-0.14	0.263	3.41*
LNAL(1)	**18.20**	**10.21**	**6.66****
Dep. Var: Agricultural Output (OP)		**Equation 7**	
Ind. Variables	**Coefficient**	**t-Statistic**	**Prob.**
D(LNOP(-1))	0.440	2.016	0.045**
D(LNGA(-1))	0.123	0.587	0.112
D(LNCB(-1))	0.195	3.946	0.014*
D(LNNABARD(-1))	0.093	2.881	0.029**
D(LNI(-1))	-0.017	-0.893	0.652
D(LNAL(-1))	19.60	1.525	0.825
ECM or C(1)	-0.201	-1.710	0.017**
C	0.105537	2.352692	0.041**
R-squared	**0.632**	**Adj. R-Sq.**	**0.574**
Log-likelihood	**44.91**	**D.W**	**2.210**

Note * denotes rejection at 1% &** denoted as rejected at 5% levels respectively
Sources: Authors calculation

Table 5: Estimated results of VECM for short and long run.

The plausible explanation for these results is that the availability and accessibility of credit encourage the farmers to produce those crops in particular, which are either high market market-oriented or have had high yield. These results are in line with (Pardey et al., 1992; Amarnath and Prasad, 2009; Egwa, 2016)).

On the other hand, the estimated coefficient of interest rate (I) is negative. The coefficient is also statistically significant at a 5% critical value. This implies that an increase in interest rate (I) by banks leads to a decrease in agriculture output in India in the long run by 0.14 percent. Thus, there is a significant negative relationship between the interest rate (I) and agriculture output in the long run. This might be because an increase in interest rate increases the cost of money/loans and thus restrict farmers to get more credit from banks. Thus decrease in credit decreases agriculture output. These results are in line with Bharti (2008) and De and Dakhar (2018). Furthermore, the agricultural labor force (AL)'s estimated coefficient is in line with the a priori expectation and statistically significant at 0.5 %. This indicates that an increase in the agricultural labor force leads to an increase in agriculture output by 18.2 percent in the long run. In this way, there is a significant positive relationship between India's agricultural labor force and agricultural output. These results are in line with Bannerjee (2005) and Tirthaker (2002).

The short-run estimates and the speed of adjustment are used to eliminate the discrepancy that occurs in the short-run towards long-run equilibrium are also summarized in Table 5. The estimated coefficient of the agricultural output of the previous year has a positive and significant impact on the current year's agricultural output. This implies that a 1 percent increase in agricultural output in last year leads to an increase in agricultural output of the current year by 0.44 Percent. The results are in line with Mahadevan (2003). The government agricultural spending of the previous year shows a positive but statistically insignificant impact. This implies that an increase in government agricultural spending in the last year does not significantly lead to an increase in agricultural output in the current year in the short run.

Similarly, the -run estimated coefficients of Commercial Bank loans to the agricultural sector and NABARD loans show a positive and significant impact on the current years of agricultural. This implies that an increase in commercial bank loans to the agricultural sector and loans by NABARD in the previous year leads to an increase in agriculture output in the current year by 0.19 and 0.09, respectively. The results are in line with Nedumaran and Manida (2020) and Kumar et al. (2010). However, the table further shows that Interest rate and Agriculture labor don't affect agriculture output in the short run. The agricultural labor force is though positive in the short-run, but not statistically significant at a 5% level of significance.

On the other hand, the estimated coefficient of interest rate is negative in the short-run but not statistically significant, implying that an increase in interest rate in the previous year reduces agriculture output in the short run but is insignificance. The error coefficient of the Error Correction Term (ECT), which ECT denotes, is negative (-0.201) and statistically significant at a 5% level of significance. It reveals the evidence of a slow pace of response to bring equilibrium in agriculture output when there are shocks in the short run. The negative coefficient f the error correction model determines the speed of adjustment to long-run equilibrium by the independent variables. The negative coefficient is an indication that any shock that takes place in the short run by the independent variables mentioned in the above model would be corrected in the long run. It shows that any fluctuation caused in previous years or the short run will bring equilibrium in the long run by 20%. In other words, it means that it will take at least four years to restore any disequilibrium agriculture output. The rule of thumb is that the larger the error correction coefficient (in absolute terms), the faster the variables equilibrate in the long run when shocked (Acheampong, 2007). Therefore, this implies that the adjustment mechanism of agriculture output is not robust. The estimated coefficient of multiple determinations (R2) explains that the independent variables were found to jointly explain 63% of the movement in the dependent variable with the R^2-adjusted ($\overline{R}^2$) of 57%. The overall significance of the model is explained by the F-statistic of 10.9. Coefficients of the short-run dynamics show that government agricultural spending has insignificantly affected the agricultural output of the Indian economy.

Diagnostics testing

A diagnostic check is appropriate to establish whether the model is valid. In other words, a diagnostic check is applied to know if the model developed has a problem or not. Therefore, residual tests were conducted to see whether estimates are reliable and can yield reliable statistical inferences.

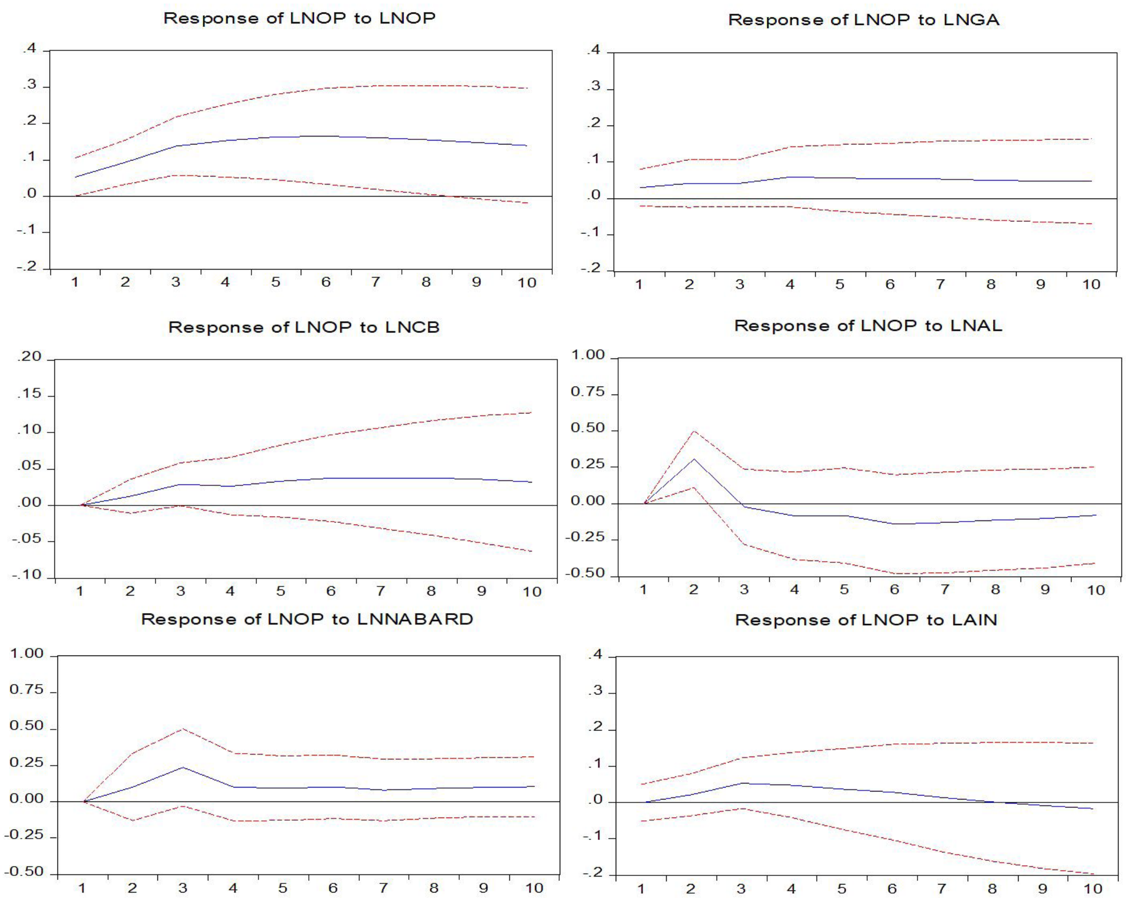
The result of Vector Error Correction VEC residual serial correlation Lagrange multiplier (LM) tests shows that there is no serial correlation at lag order 1. The multivariate normality test using Cholesky of variance was used for testing orthogonality. The study found that residuals are multivariate normal. The model used for the study was proven dynamically. This means that results or estimates produced are reliable and can stand statistical inferences. The overall significance of the model was good, indicating that the results or estimates are not spurious but valid for statistical inference.

Impulse response of agricultural output to government agricultural spending in India

The results of the impulse responses of agricultural output to shocks are presented in the Figure 1.

Results of the impulse response of the variables

The Figure 1 shows the response of government expenditure on agriculture, Commercial bank loans, NABARD loans, Interest rate, and Agriculture labor force to agriculture output. The result of the ten-year forecast shows that a positive shock of one-standard deviation to government agricultural spending in India would eventually positively impact agricultural output throughout the forecast. This implies that the response of agricultural output to shocks in government agricultural spending has exhibited a weakly upward trending pattern. Similarly, a one-standard-deviation shock to commercial bank loans to the agricultural sector and NABARD fund would positively affect agricultural output throughout the forecast. This implies that one standard deviation shock to commercial bank loans to the agricultural sector and NABARD fund would exact a positive response on agricultural output in India permanently. Also, a positive shock of one-standard deviation to interest rate would positively impact agricultural output in India in the short run and long run. On the other hand, one standard deviation shock to the agricultural labor force would exert a negative influence on agricultural output in India throughout the forecast period. From above, it can be deduced that agricultural output in India would respond positively to one standard deviation shock to government agricultural spending,



Sources: Calculated by author

Figure 1: Response to Cholesky One S. D. Innovations ± 2 S. D.

commercial bank loans to the agricultural sector, and NABARD loans to the agricultural sector. Shocks to agricultural output (own shocks) are estimated to positively impact agricultural output in India throughout the forecast period.

Conclusion

The study attempts to have a holistic view of the relationship between agriculture outcome/ output and agricultural spending in India. The unique part of the study is that it highlighted the nexus between agriculture outputs from a historical point of view as well. The empirical part of this study is analyzed using the development of the co-integration method followed by the VECM model. The empirical analysis shows a long long-run association between agriculture spending and output, and this feedback is bidirectional. The agricultural output positively responds to agricultural spending in India both in the short and long run, especially in sowing seasons. However, the interesting finding of the study is that the speed of adjustment of agricultural spending on output is very slow. Therefore, it can be concluded that Government spending on agriculture is weak but statistically significant in the long run. However, in the short-run spending on agriculture doesn't seem favorable. It might be due to the gestation period in agriculture where it takes more time to slip over the effect of government spending on agriculture. Other factors which lead to the significant change in agricultural output both in the short and long run are NABARD funds/schemes, Loans from commercial banks, and the Agricultural labor force. Given the findings, we recommend that Government expenditure on agriculture should be improved upon the funds allocated to the sector and made available to real farmers through the provision of fertilizers, improved seedlings, and grant aiding to farmers through farmers cooperatives. There is also the need to judiciously utilize the resources allocated to the Agricultural Sector as the increase in the percentage of budgetary allocation to the sector does not automatically increase the sector's performance if the resources are mismanaged. Consistently in government policies/programs is also needed to boost the sector's performance.

Corresponding authors
Dr. Samir Ul Hassan, Assistant Professor
Anil Surendra Modi School of Commerce (ASMSOC), NMIMS University
V. L, Pherozeshah Mehta Rd, Vile Parle West, Mumbai, Maharashtra 400056, India
E-mail: samirul.hassan@yahoo.com
ORCID: https://orcid.org/0000-0001-7706-1352

References

[1] Acheampong, I. K. (2007) "Testing McKinnon-Shaw thesis in the context of Ghana's financial sector liberalization episode", *International Journal of Management Research and Technolog*y, Vol. 1, No. 2, pp. 156-183. ISSN 02278-5612.

[2] Alexander, C. (2001) "*Market Models: A Guide to Financial Data Analysis*", John Wiley and Sons. ISBN 10 0471899755.

[3] Amarnath, T. and Prasad, A. R. (2009) "Agricultural Development in India Since Independence: A Study on Progress, Performance, and Determinants", *Journal of Emerging Knowledge on Emerging Markets*, Vol. 1, No. 1. pp. 12-28. ISSN 1946651X. DOI 10.7885/1946-651X.1007.

[4] Antholt, C. H. (1994) "Getting ready for the twenty-first century: technical change and institutional modernization in agriculture", In: *World Bank Technical Papers*. DOI 10.1596/0-8213-2510-8. ISBN 978-0-8213-2510-0. DOI 10.1596/0-8213-2510-8.

[5] Arjun, K. M. (2013) "Indian, Agriculture- Status, Importance and Role in Indian Economy", *International Journal of Agriculture and Food Science Technology*, Vol. 4, No. 4, pp. 343-346. ISSN 2249-3050. DOI 10.36106/ijsr.

[6] Auraujo Bonjean, C., Chambas, G. and Foirry, J. P. (1997) "Consequences de l'ajustement des finances publiques sur l'agriculture marocaine et tunisienne. Tunis (Tunisia)", FAO, SNEA, [Online]. Avaliable: https://agris.fao.org/agris-search/search.do?recordID=XF2016066113 [Accessed: Sept. 22, 2022]. (In French).

[7] Beckman, J., Gopinath, M. and Tsigas, M. (2018) "The Impacts of Tax Reform on Agricultural Households", *American Journal of Agricultural Economics,* Vol. 100, pp. 1391-1406. ISSN 0002-9092. DOI 10.1093/ajae/aay038.

[8] Balakrishnan, P. and Parameswaran, M. (2007) "Understanding Economic Growth in India: A Prerequisite", *Economic and Political Weakly*, Vol. 42, pp. 2915-2922. ISSN 0012-9976.

[9] Baldos, U. L. C., Viens, F. G., Hertel, T. W. and Fuglie, K. O. (2019) "R&D Spending, Knowledge Capital, and Agricultural Productivity Growth: A Bayesian Approach", *American Journal of Agricultural Economics*. Vol. 101, pp. 291-310. ISSN 0002-9092. DOI 10.1093/ajae/aay039.

[10] Bannerjee, A. and Iyer, L. (2005) "History, Institutions, and Economic Performance: The Legacy of Colonial Land Tenure Systems in India", *American Economic Review*, Vol. 95, No. 4, pp. 1190-1213. ISSN 0002-8282. DOI 10.1257/0002828054825574.

[11] Bastiaans, L., Paolini, R. and Baumann, D. T. (2008) "Focus on Ecological Weed Management: What Is Hindering Adoption?", *Weed Research*, Vol. 48, pp. 481-491. ISSN 1365-3180. DOI 10.1111/j.1365-3180.2008.00662.x.

[12] Bayly, C. A. (1985) "State and Economy in India over Seven Hundred Years", *The Economic History Review*, Vol. 38, No. 4, pp. 583-596. ISSN 0013-0117. DOI 10.2307/2597191.

[13] Beal, D.W. (1978) "Agricultural education and training in developing countries", In *FAO Studies in Agricultural Economics and Statistics*, 1952-1977. Rome, FAO, pp. 282-291. [Online]. Available: https://www.fao.org/3/x9447e/x9447e05.htm [Accessed: Sept. 10, 2022].

[14] Bharti, N. (2018) "Evolution of agriculture finance in India: a historical perspective", *Agricultural Finance Review*, Vol. 78, No. 3, pp. 376/392. ISSN 0002-1466. DOI 10.1108/AFR-05-2017-0035 .

[15] Burton (1998) "*A History of India*", Blackwell Publishing, ISBN 0-631-20546-2.

[16] Chavas, J. P. and Aliber, M. (1993) "An Analysis of Economic Efficiency in Agriculture: A Nonparametric Approach", *Journal of Agricultural and Resource Economics*, Vol. 18, No. 1, pp. 1-16. ISSN 10685502.

[17] Chikowo, R., Faloya, V., Petit, S. and Munier-Jolain, N. M. (2009) "Integrated Weed Management Systems Allow Reduced Reliance on Herbicides and Long-Term Weed Control", *Agriculture, Ecosystems & Environment*, Vol. 132, pp. 237-242. ISSN 01678809. DOI 10.1016/j.agee.2009.04.009.

[18] De, K. U. and Dkhar, D. S. (2018) "Public expenditure and agricultural production in Meghalaya India: An application of bound testing approach to co-integration and error correction model", *International Journal of Environmental Sciences and Natural Resource*, Vol. 8, No. 2, pp. 1-8. ISSN 2572-1119. DOI 10.2139/ssrn.3637238.

[19] Dimitrova, D. (2005) "The Relationship between Exchange Rates and Stock Prices: Studied in a Multivariate Model", *Issues in Political Economy*, Vol. 14, pp.1-25. ISSN 0022-3808.

[20] Economic Survey (2021) "*Economic Survey*", Vol. 1-2, Ministry of Finance, Government of India. [Online]. Available: indiabudget.gov.in/economicsurvey/ebook_es2021/index.html [Accessed: Sept. 10, 2022].

[21] Egwu, N. P. (2016) "Impact of agricultural financing on agricultural output, economic growth and poverty alleviation in India", *Journal of Biology, Agriculture and Health Care*, Vol. 6, No. 2, pp. 36-42. ISSN 2225-093X.

[22] Engle, F. R., and Granger, J. W. C., (1987) "Co-Integration and Error Correction: Representation, Estimation, and Testing", *Econometric*a, Vol. 55, No. 2, pp. 251-276. ISSN 0304-4076. DOI 10.2307/1913236.

[23] Evenson, R. E. and McKinsey Jr., J. W. (1991) "Research, extension, infrastructure and productivity change in Indian agriculture", In: Evenson, R. E. and Pray, C. E., eds. "*Research and productivity in Asian agriculture",* Ithaca, USA, Cornell University Press. ISBN 9781501734328. DOI 10.7591/9781501734328.

[24] European Commission (2020) "*EU Agricultural Outlook*", Luxembourg: Publications Office of the European Union. [Online]. Available: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term_en [Accessed: Sept. 22, 2022].

European Commission (2020) "*A Farm to Fork Strategy for a fair, healthy and environmentally friendly food system*", Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020) 381 final, European Commission, Brussels, Belgium. [Online]. Available: https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_cs [Accessed: Sept. 22, 2022].

[25] Ferreira, D. and Khatami, K. (1996) "*Financing private infrastructure in developing countries*", World Bank Discussion Paper, Washington DC, World Bank. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/15124 [Accessed:Sept. 20, 2022].

[26] Fuglie, K. (2018) "R&D Capital, R&D Spillovers, and Productivity Growth in World Agriculture", A*pplied Economic Perspectives and Policy*, Vol. 40, pp. 421-444. ISSN 1058-7195. DOI 10.1093/aepp/ppx045.

[27] Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., Burlingame, B., Dawkins, M., Dolan, L., Fraser, D., Herrero, M., Hoffmann, I., Smith, P., Thornton, P. K., Toulmin, C., Vermeulenand, S. J. and Godfray, H. C. J. (2013) "Sustainable Intensification in Agriculture: Premises and Policies", *Science*, Vol. 341, No. 6141, pp. 33-34. ISSN 0036 8075. DOI 10.1126/science.1234485.

[28] Ghose, A K. (1982) "Food Supply and Starvation: A Study of Famines with Reference to the Indian Subcontinent", *Oxford Economic Papers*, Vol. 34, No. 2, pp. 368-389. ISSN 0030-7653. DOI 10.1093/oxfordjournals.oep.a041557.

[29] Government of India (2008) "National Account statistics", Central Statistical Organization, Ministry of statistics and Programme Implementation, New Delhi.

[30] Government of India (2019) "National Account statistics". Central Statistical Organization, Ministry of statistics and Programme Implementation, New Delhi.

[31] Granger, C. W. J. (198) "Some Recent Developments in a Concept of Causality", *Journal of Econometrics*, Vol. 39, pp. 199-211. ISSN 0304-4076. DOI 10.1016/0304-4076(88)90045-0 .

[32] Habib, I. (2006) "*Indian Economy 1858–1914*", New Delhi: Tulika Books. pp. xii+149. ISBN 81-89487-12-6x.

[33] Jayne, T. S., Khatri, Y., Thirtle, C. and Reardon, T. (1994) "Determinants of productivity change using a profit function: smallholder agriculture in Zimbabwe", *American Journal of Agricultural Economics*, Vol. 76, pp. 613-618. ISSN 0002-9092. DOI 10.2307/1243675.

[34] Johansen, S. (1988) "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, Vol. 12, No. 2-3, pp. 231-254. ISSN 0165-1889. DOI 10.1016/0165-1889(88)90041-3.

[35] Johansen, S. and Juselius, K. (1995) "Maximum likelihood estimation and inference on cointegration - with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52, No. 2, pp. 169-210. ISSN 1468-0084. DOI 10.1111/j.1468-0084.1990.mp52002003.x.

[36] Junková, S. and Matušková, E. (2011) "The influence of crisis on the sector structure of economy focusing on agriculture", *Agris on-line Papers in Economics and Informatics*, Vol. III, No. 2, pp. 15-26. ISSN 1804-1930.

[37] Kumar, A, Krishna M. Singh and Shradhajali S. (2010) "Institutional credit to agriculture sector in India: Status, performance and determinants", *Agricultural Economics Research Review*, Vol. 23, No. 2, pp. 253-264. ISSN 0974-0279.

[38] Kumar, D, Raychaudhuri, T., Habib, I. and Desai, M. (eds.) (2005) "*The Cambridge Economic History of India, Vol. 2, c. 1757- c.200*3", Cambridge University Press. 2nd ed, 1078 p. ISBN 978-0-521-22802-2.

[39] Lachaal, L. (1994) "Subsidies, endogenous technical efficiency and the measurement of production growth", *Journal of Agriculture and Applied Economics*, Vol. 26, No. 1, pp. 299-310. ISSN 1074-0708. DOI 10.1017/S1074070800019386.

[40] Lin, J. Y. (1992) "Rural reforms and agricultural growth in China", *American Economic Review*, Vol. 82, pp. 34-51. ISSN 0002-8282.

[41] Mahadevan, R. (2003) "Productivity growth in Indian agriculture: the role of globalization and economic reform", *Asia-Pacific Development Journal*, Vol. 10, No. 1, pp. 57-72. ISSN 1020-1246.

[42] Maggi, F., Tang, F. H. M., la Cecilia, D. and A. McBratney, A. (2019) “PEST-CHEMGRIDS, Global Gridded Maps of the Top 20 Crop-Specific Pesticide Application Rates from 2015 to 2025", *Scientific Data*, Vol. 6, pp. 170. ISSN 2052-4463. DOI 10.1038/s41597-019-0169-4.

[43] McMillan, J., Whalley, J. and Zhu, L. (1989) "The impact of China's economic reforms on agricultural productivity growth", *Journal of Political Economy*, Vol. 97, No. 3, pp. 781-807. ISSN 0022-3808. DOI 10.1086/261628 .

[44] Mozumdar, L. (2012) "Agricultural productivity and food security in the developing world", *Bangladesh Journal of Agricultural Economics*, Vol. 35, No. 1-2, pp. 53-69. ISSN 0257-3539. DOI 10.22004/ag.econ.196764 .

Mukherjee, A., Goyal, T. M., Miglani, S. and Kapoor, A. (2019) "*SPS Barriers to India’s Agriculture Export Learning from the EU Experiences in SPS and Food Safety Standards*", Indian Council for Research on International Economic Relations. [Online]. Available: https://think-asia.org/handle/11540/9809. [Accessed: Sept. 20, 2022].

[45] Nedumaran, G. and Manida M. (2020) "E-Agriculture and Rural Development in India", *JAC: A Journal of Composition Theory,* Vol. XIII, No. 1, pp. 115-121. E-ISSN 0731-6755. DOI 10.2139/ssrn.3551994.

[46] Pardey, P. G., Roseboom, J. and Craig, B. J. (1992) "A yardstick for international comparisons: an application to national agricultural research expenditures", E*conomic Development and Cultural Change*, Vol. 40, pp. 333-349. ISSN 0013-0079.

[47] Pradhan, R. P. (2007) "Indian Agriculture in the Globalization Era: The Performance and Determinants", *Journal of Global Economy*, Vol. 3, No. 1, pp. 3-12. ISSN 1553-5304. DOI 10.2139/ssrn.1333025.

[48] Pray, C. E. and Evenson, R. E. (1991) "Research effectiveness and the support base for national and international agricultural research and extension programs", In: R.E. Evenson, R. E. and Pray, C. E. (eds.) "*Research and productivity in Asian agriculture*". Ithaca, USA, Cornell University Press. DOI 10.7591/9781501734328-016 .

[49] Ramakumar, R. (2020) "Agriculture and the Covid-19 Pandemic: An Analysis with Special Reference to India", *Review of Agrarian Studies*, Vol. 10, No. 1, pp. 1-39. ISSN 2248-9002. DOI 10.22004/ag.econ.308095.

[50] Reserve Bank of India (2020) "*Handbook of statistics on the Indian Economy 2020-21*". [Online]. Available: https://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20Economy. [Accessed: Sept. 22, 2022].

[51] Rosegrant, M. W. and Evenson, R. E. (1992) "Agricultural productivity and sources of growth in South Asia", A*merican Journal of Agricultural Economics*, Vol. 74, No. 3, pp. 757-761. ISSN 0002-9092. DOI 10.2307/1242590.

[52] Rossi, V., Caffi, T. and Salinari, F. (2012) "Helping Farmers Face the Increasing Complexity of Decision-Making for Crop Protection", *Phytopathologia Mediterranea*, Vol. 51, pp. 457-479. ISSN 1593-2095. DOI 10.14601/Phytopathol_Mediterr-11038.

[53] Roy, T. (2002) "Economic History and Modern India: Redefining the Link", *The Journal of Economic Perspectives*, Vol. 16, No. 3, pp. 109-130. ISSN 1944-7965. DOI 10.1257/089533002760278749.

[54] Saradhi,. B. P., Gowri, K, Narayan, R., Chakravathy, T. and Prasad, Ch. (2020) "Significant Trends in the Digital Transformation of Agriculture in India", *International Journal of Grid and Distributed Computing*, Vol. 13, No. 1, pp. 2703-2709. ISSN 2005-4262.

[55] Schebesta, H. and Candel, J. J. L. (2020) "Game-changing potential of the EU's Farm to Fork Strategy", *Nature Food*, Vol. 1, pp. 586-588. ISSN 2662-1355. DOI 10.1038/s43016-020-00166-9 .

[56] Skevas, I. and Lansink, A. O. (2020) "Dynamic Inefficiency and Spatial Spillovers in Dutch Dairy Farming", *Journal of Agricultural Economics*, Vol. 71, pp. 742-759. ISSN 1477-9552. DOI 10.1111/1477-9552.12369.

[57] Subramaniam, A. (2008) "*India's Turn: Understanding the Economic Transformation*", New Delhi: Oxford University Press. 237 p. ISBN 9780195693546 .

[58] Travers, T. R. (2004) "The Real Value of the Lands': The Nawabs, the British and the Land Tax in Eighteenth-Century Bengal", *Modern Asian Studies*, Vol. 38, No. 3, pp. 517-558. ISSN 1469-8099. DOI 10.1017/S0026749X03001148.

[59] Tyrychtr, J. and Vasilenko, A. (2015) "Transformation Econometric Model to Multidimensional Databases to Support the Analytical Systems in Agriculture", *Agris on-line Papers in Economics and Informatics*, Vol. VII, No. 3, pp. 71-77. ISSN 1804-1930. DOI 10.22004/ag.econ.231867.

[60] Wiens, T. B. (1983) "Price adjustment, the responsibility system and agricultural productivity", *American Economic Review*, Vol. 73 No. 1, pp. 319-324. ISSN 0002-8282.

[61] Zdráhal, I., Hrabálek, M., Kadlec, P. and Krpec, O. (2021) "Price adjustment, the responsibility system and agricultural productivity", *Agris on-line Papers in Economics and Informatics*, Vol. 13, No. 2, pp. 121-139. ISSN 1804-1930. DOI 10.7160/aol.2021.130210.

Volume XIV Number 3, 2022

Digital Agriculture in Viet Nam: Conditions and Prospect of Development

Nguyen Thi Ngoc Loi

Faculty of Economics, University of Danang – Campus in Kontum, Vietnam

Abstract

The real context of climate change and pandemic has emphasized the enormous significance of agriculture to society and paved a path to digitization. Each country's agricultural digitalization strategies must not only focus on the technological aspects of the production system but as well present an overview of how this field of study is establishing and developing. To address this issue, a research was carried out to identify priority research questions concerning digital agriculture in Viet Nam, but with a view to also informing international contexts. The study applied a combination of methods including descriptive statistics, review of related researches reflecting the application of digital technology in agriculture, as well as systematic and institutional approaches to create the conditions for the development of digital agriculture. Concurrently, taking into account the readiness limitation of economic actors' for digital transformation is also presented in this study. Viet Nam is in the early stages of digital transformation in agriculture. Digital readiness is critical to grasping and implementing existing technologies and transforming agriculture. In order for the digital transformation to come into play in a positive way, the institutional decisions of the authorities are crucial to the major challenges facing Viet Nam's agriculture, such as digital inequalities, human resources, financial, and infrastructure constraints and inadequate awareness of existing technologies.

Keywords

Digital agriculture, conditions, readiness, transformation, challenges, Viet Nam.

Loi N. T. N. (2022) "Digital Agriculture in Viet Nam: Conditions and Prospect of Development", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 43-55. ISSN 1804-1930. DOI 10.7160/aol.2022.140304.

Introduction

Viet Nam is an agricultural country with the rural sector accounting for 63%, the average production value accounting for 17% of the national GDP and employing 60% of the national labour force (General Statistics Office of Viet Nam, 2020). However, the agricultural sector is confronted by three major challenges: firstly small, insufficient production model and lack of chain linkages (Mai and Van, 2019; Nguyen and Mitrofanova, 2021); secondly, availability of natural resources such as fresh water and productive arable land are becoming increasingly depleted (Duong, 2020); thirdly, the dual consequences of climate change and the Covid pandemic, such as decline in agricultural exports, harvest failure, and business bankruptcy of businesses (IFAD, IPSARD and ADB, 2020). This will require an urgent transformation of Viet Nam's current agricultural system.

Today, digital technology has become an effective instrument for the development of the agricultural industry around the world. Japan is considered to have an intelligent contemporary agriculture, which has helped to fulfill domestic food demand with only 2 million agricultural labourers working on 1.5 million hectares of cultivated area. The countries that are most vulnerable to climate change or have restricted agricultural production expanse like Taiwan, LED technology has provided optimal and best quality crop yields; meeting the demands to ensure food quality and safety (Ryan, 2017). Other countries such as Russia, the United States and Ukraine are commonly characterized by a large area of agricultural land and rapid aging population that prompts the utilisation of robotic technology in automatic agricultural processes, which raised labour productivity by 50-70 times with higher precision compared to manual labour (ITU and FAO, 2020). Therefore, digital technology is a strong incentive for Viet Nam to improve labour productivity within the agricultural sector and the whole economy in general, enabling businesses to compete on the international market more successfully with existing conditions.

In reality, as a rule, agricultural production involves the usage of manual labour or mechanized equipment, which prevents a significant breakthrough in innovation and digital development (Davnis et al., 2019). The process of digital transformation in agriculture requires the formation of a scientific and practical foundation. Within this, the transformation methodology, the mechanisms to implement the terms and objectives of the program will be demonstrated (Ivanova et al., 2020). Therefore, the predominant purpose of this paper is to research the specifics of digital agriculture development in Viet Nam. In order to achieve this goal, we must first examine the concepts and characteristics of digital applications explicitly applied in agriculture, creating appropriate conditions for digital transformation in Vietnamese agriculture. Next, we research the extent of readiness in digital transformation within economic actors in agricultural production and identify their reported limitations. Our research questions are formulated as:

RQ1: What are the basic conditions in development of digital agriculture in Viet Nam?

RQ2: To what extent has digital agricultural transformation been employed in Viet Nam?

In order to address these questions, we employed a multi-method approach, as exploratory research indicated how digital applications have not been extensively utilized in Viet Nam. It must be noted that research results are aimed at generalizing the potential for digital transformation in Viet Nam within this sector, rather than identifying specific applications.

Materials and methods

In order to contribute to the development of digital agriculture in the literature related to the description, conditions and readiness for digital transformation in agriculture of a country, there is a lack of selection, extraction, assessment, evaluation and quantification of data from a number of research samples published in scientific journals.

The methodology applied here is based on standard systematic review procedures that incorporate search strategy, record extraction, and reporting of results (Kitchenham and Charters, 2007). Such assessment is appropriate as a research method when the objective is to explore specific topics, theoretical perspectives, problems within a field of study or expertise in order to determine elements of a concept or a new approach (Snyder, 2019). It is currently being employed on a large scale in agricultural research (Koutsos et al., 2019).

Therefore, we have created a category of scientific articles using keywords related to digital agriculture: digital(ization) agriculture, digital/smart farming, technology and agriculture 4.0. The majority of the documents were published between 2017 and 2021. Deductive content analysis is used to analyze retrieved documents, in order to identify conditions and potentials for digital agriculture development.

In response to ‘*RQ1: What are the basic conditions in development of digital agriculture in Viet Nam?*’, we reviewed the abstracts to verify that the topic was about agriculture with reference to applications of digital technology. Then, we systematized the concepts, nature of digital agriculture and extracted attributes that help us identify the necessary conditions for digital transformation in agriculture. Finally, with the assistance of official statistics, a general description has been advance for digital agricultural transformation in Viet Nam.

During the pandemic, the basis for the transformation, modernization of most sectors and areas of economic activity, as well as the emergence, development of new business models and forms of interaction adapting to the new reality is digitization. The indicators of the digital economy are determined to include whole complex relationships formed when using digital technology in the system of production, distribution, exchange and consumption of tangible and intangible goods (Mirolyubova et al., 2020). This approach allows attention to the need for interconnected operations of technology, economic and social subsystems where information management is a key determinant prompting value of the whole system. Therefore, to answer '*RQ2: To what extent has digital agricultural transformation been employed in Viet Nam?*', we searched within the materials for cases to identify ways in which digital technology has been applied in agricultural production in Viet Nam. In conclusion, we examined the results of the study and drew conclusions about the prospects for digital agriculture development in Viet Nam today.

Results and discussion

Literature review of digital agriculture

Agricultural modernization and the use of digital technology have fostered new concepts such as precision agriculture, digital agriculture and intelligent farming. Although these terms are often employed interchangeably, there is a subtle difference in the definition. Precision agriculture is defined as a modern farm management concept that utilizes digital technologies to monitor and optimize agricultural production processes (European Parliament, 2016). The crucial component is optimization. As opposed to employing a similar management amount of chemicals across the entire field, precision agriculture entails measuring soil variations on fields and accordingly adjusting management strategies. This leads to optimization of production units, saving costs and minimizing impact on the environment (Banu, 2015). Smart agriculture is the implementation of 4.0 achievements into agriculture. The focal point is on the permission to access technology data and information technology applications (cloud technology, drones, universal internet, sensors, robots, etc.) – how information accumulated could be intelligently utilized (Sundmaeker et al., 2016).

In the agricultural sector, digitalization format is considered as a function of four components, including: smart agriculture, smart technology, smart design and smart business (Elijah et al., 2018). Digital agriculture implies advancing beyond the presence and availability of data, initiating active intelligence and amplifying meaningful value from that data. According to the German Agricultural Association, digital agriculture is integrating both notions – precision farming and smart farming (German Agricultural Society, 2018). It has been perceived as the consistent application of precision and smart farming techniques, internal and external farm networking, and employment of web-based data platforms along with large data analytics.

Analysis of various digital agriculture notions and characteristics is immensely crucial for research. The nature of digitalization and its impact on economic development could be structured; this is grounded on generating value from data, including the following fundamental characteristics:

- Large information, data and machines become vital incentives with significant value in agricultural production. Along with traditional and developing resources that are closely interlinked with high technology, information and human intelligence. In particular, the development of digital technology enables data collection from various sources, constructing large data and the capacity of this data produces high agricultural production value (Wolfert et al., 2017);

- The development of Artificial Intelligence, robotics, universal internet, cloud computing are the foundations for a new qualitative infrastructure. Cyber physical systems play a predominant role in developing innovative solutions to monitor and manage procedure within agribusiness (Herlitzius, 2017), universal industrial internet components such as sensors and cloud computing are implemented to monitor soil parameters and weather conditions to activate smart irrigation solutions, preventing pests insects and the use of pesticide (Elijah et al., 2018). Smart sensors and applications will help scrutinize the occurrence of undesirable events and conditions that can ultimately pose potential risks, such as impacting the food production through the supply chain (Lioutas et al., 2019);

- The emergence of many advanced agricultural business models with intelligent methods of interaction and information operation (such as high-tech agribusiness models, e-commerce, online advertisement, etc.) are the prioritized solutions to satisfy consumer demands for high value-added products, minimize transaction costs, compliance with food safety and traceability regulations (Vlachopoulou et al., 2021). Moreover, only the participants' enforcement of digital software guarantees their access to the most advanced segments of the global market in the coming decades (Okenova, 2019). Practical development indicates that, if there’s no preparation for the digital infrastructure development, this won’t usher a fundamental change in any field of technology and production at the national level amid global competitiveness;

- Due to the complications in agro-production processes within digital agriculture, there are many business partners involved (farmers, businesses, agricultural contractors, consumers etc.), as well as a variety of information sources, extensive and distinguished communication structures. Common data from different parties within the production chain is gathered in a place that permits obtaining latest quality information, exploring designs, generating additional value for all parties involved, employing contemporary scientific resolutions and determining viable decisions to minimize risks, improving the manufacturer’s business operation and customer experience (Faskhutdinova et al., 2020).

Nevertheless, the digital transformation process in agriculture is inevitably confronted by a dispute between the old and contemporary operation of economic mechanisms, especially when the value system and mechanisms have not yet been formed. In order to shape digital transformation within different circumstances, fundamental conditions are required, such as infrastructure, internet connectivity, affordability, educational degree in information technology (IT) and institutional support. Moreover, there are factors that facilitate convenient conditions for technology implementation: the use of the internet, mobile phones, social media, digital skills, supporting corporate culture and innovation (Trendov et al., 2019, p.2). For example, Research on digital agriculture in Russia also demonstrated that there are two fundamental conditions required to achieve digital transformation: (1) an intelligent machine that can receive, send, produce (via sensors) and process data; (2) connected machines, communication and interface standards should provide unimpeded data exchange between machines, people and information (Faskhutdinova et al., 2020).

Therefore, various factors will impact the penetration of digital technology into the agricultural sector. This penetration is a long procedure that leads towards a high cohesion of infrastructure elements and the emergence of new forms of business partnerships – beginning with relations within scientific agriculture.

Conditions for the development of digital agriculture in Viet Nam

The revolutionary change in digital agriculture compared to traditional agriculture provides opportunities for farmers and businesses to elevate efficiency in utilizing resources, reducing labor, and minimizing damages caused by natural disasters, epidemics, environmental safety, saving costs at every stage in the supply chain (World Bank, 2019b; Klerkx and Rose, 2020). Technologies such as internet-connected sensors, LED technology, unmanned aerial vehicles, agricultural robots and smart financial farm management etc., assisted the agricultural industry to achieve high production efficiency (Herlitzuis, 2017; Elijah et al., 2018; Lioutas et al., 2019; Wolfert et al., 2021). The potential benefits of digital agriculture are convincing, but it will require major transformations in agricultural systems, rural economies, communities, and natural resource management. Therefore, in order for digital agriculture to become a reality in Viet Nam, from a macro-management perspective this requires the creation of necessary conditions.

First of all, forming suitable mechanisms and policies to develop digital agriculture

According to the macro-management approach, the state requires an appropriate strategy to maneuver the evolution of digital agriculture. Many economies worldwide have in advance incorporated strategic development plans for digital transformation in agriculture within their digital economy development national programs. For instance, in Russia, the Center for Digital Agriculture Competence was established in June 2018. It is expected that the project will pave a fundamental premise for the Smart Agriculture Strategy, contributing to the FoodNet initiative and being integrated into the Russian Digital Economy Program (ITU and FAO, 2020). The Department of Agricultural Engineering and Technology in Turkey was established under the General Department of Agricultural Reform. An associated unit has been appointed to develop policies and strategies regarding the use of advanced technology and mechanization in agriculture, operating with the public-private sectors and universities on digital transformation, conduct testing on suitability of new agricultural technologies in the agricultural sector, perform and disseminate the use of these technologies (ITU and FAO, 2020).

From 2005 until today, Viet Nam has issued many policies regarding the development of digital agriculture. Table 1 demonstrates the legal framework of the digital agriculture development in Viet Nam. This is a paramount legal basis for regulating behaviour and supporting the actors in economic interactions within the agricultural sector. It is also a critical condition for Viet Nam's agriculture to adapt to the robust digital economy development, enabling investors to invest with content.

The policies fundamentally guarantee conformity to socio-economic characteristics in Viet Nam, ensuring the vital conditions for digital agricultural development such as telecommunications infrastructure development, e-commerce market, network security, IT human resource development, etc. In particular, the steering committee was established to command the execution of tasks of the Ministry of Agriculture and Rural Development specified in the Decision No. 749/QD - TTg on 03/06/2020; research, propose policies, develop programs and schemes on digital agricultural transformation; promoting digitalization in business manufacture chain, constructing new smart rural areas across the country. However, there remains an inconsistency between the regulations proposed and the implementation of the documents. It is an inevitable fact that regulations often do not keep up with the speed of digitalization of the economy (Cameron et al., 2019) (Table 1).

Secondly, developing infrastructure for digital agriculture

Database systems, infrastructure and digital services are crucial factors that foster the foundation for digital agriculture development. The development of the information and communication technology industry in recent years has shown a shift and readiness in the digital transformation process of nations. Regarding information technology infrastructure, in comparison with other nations in the world, Viet Nam's average data speed is 20.66 Mbps, ranking 87 out of 224 countries (Cable, 2021). Inclusive Internet Index is ranked 56 out of 120 countries (Economist Intelligence Unit, 2020); E-Government development index measures the e-government development of the United Nations Member States based on three dimensions of online services, telecommunication connectivity, and human capacity. Viet Nam's E-Government development index moved from 0.45 in 2010 to 0.67 in 2020, which was above the world average of 0.60 (Union Nations, 2020).

In addition, Viet Nam possesses about 126 million mobile subscribers in 2019, including around 62.5 million subscribers using 3G and 4G. The proportion of the population is covered by 4G mobile network accounts for 95.3% (Ministry of Industry and Trade, 2021). The population using social network accounts for 37% (in which 73% are interactions served for work); new digital consumers grow steadily at an average of 63% per year; an average internet usage of about 4 hours/day; the annual increasing value of information technology and telecommunications equipment transactions has established an ideal platform to promote digital transformation (World Bank, 2019a).

Last but not least, improving the quality of human resources, especially digital human resources

In 2020, the population of Viet Nam was estimated to be approximately 97.58 million people. In comparison to the previous year, the labour force was estimated around 48.3 million people, reduced to 849.5 thousand people. The percentage of trained workers in 2020 with credentials and certifications from elementary onwards is 24.1%, 1.3 times higher than in 2019 (General Statistics Office of Viet Nam,

No.	Document	Text symbols
1	Intellectual property law	50/2005/QH11
2	Law on Electronic Transactions	51/2005/QH11
3	Law on Advanced Technology	21/2008/QH12
4	Decision of the Ministry of Information and Communication on approving the master plan on development of information technology human resources in Viet Nam to 2020	05/2007/QD-BTTT
5	Decree of the Government on internet services and electronic information on the internet	97/2008/ND-CP
6	Decision of the Prime Minister on competence, order and procedures for recognition of hi-tech agricultural enterprises	69/2010/QD-TTg
7	Government Decree on e-commerce	52/2013/ND-CP
8	Decision of the Prime Minister stipulating criteria, competence, order and procedures for recognition of hi-tech agricultural areas	66/2015/QD-TTg
9	Government Decree on financial support for rural development programs to advance agricultural research and technology transfer	57/2018 / ND-CP
10	Decision of the Prime Minister approving the National Digital Transformation Program until 2025	749/2020/QD-TTg
11	Decision of the Prime Minister approving the Master plan for e-commerce development for the period 2016 - 2020	1563/2017/QD-TTg
12	Decision of the Prime Minister approving the e-Government development strategy towards digital government in the period of 2021 -2025, with orientation to 2030	942/2021/QD-TTg
13	Decision of the Ministry of Agriculture on the establishment of a Steering Committee for Digital Transformation in the agricultural sector	2588/2021/QD-BNN-TCCB

Source: Compiled by the author from Legal documents that is available at https://thuvienphapluat.vn.

Table 1: Legal framework related to digital agriculture development.

2020). The number of employees in the information technology industry in Viet Nam consists of more than 1.1 million people, the number of working employees primarily oriented in the hardware sector account for more than 75% of the total number of employees within the industry (Ministry of Information and Communications, 2020). Abundant human resources, increasingly improved quality of human resources are considered as Viet Nam's strengths in the industrial revolution 4.0 era.

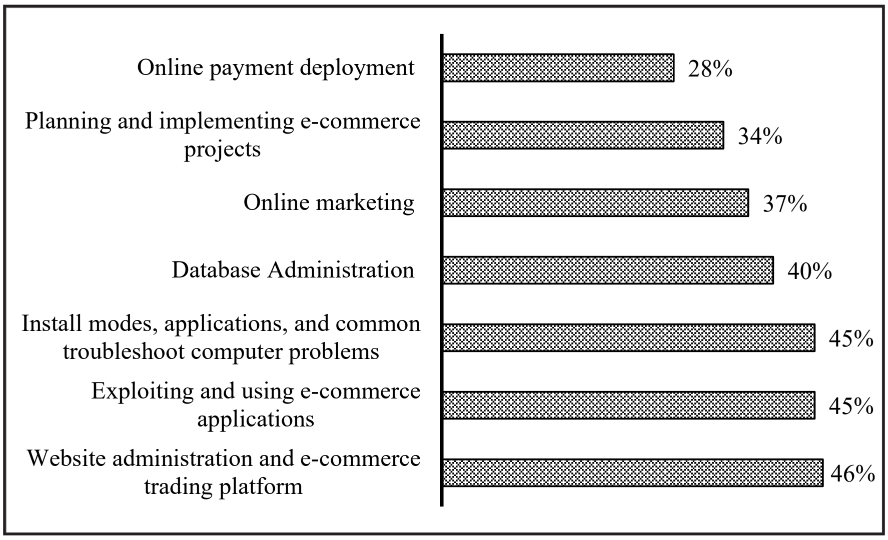
Although the demand for information technology human resources increases, Viet Nam's labour market remains in a constant state of shortage. In 2021, 500,000 people are required and predicted a shortage of 190,000 people (XM, 2020). In 2020, the survey results of the Ministry of Information and Communications indicates that information technology human resources remain with inadequate quality, insufficient dynamism and creativity, and have not fulfilled/met the standard skills proposed by employers (illustrated in Graph 1). This is a major barrier and restriction to Viet Nam's human resources in the 4.0 industrial revolution.

In contrast to other countries in Southeast Asia in terms of digital human resource index, Viet Nam is ranked behind Malaysia, Thailand, Philippines, and is only roughly equivalent to Cambodia (Cameron et al., 2019). The Logistics performance index in 2019 was ranked by the organization as 92/160 countries. Measures the ability to foster, attract, develop and retain talent. Furthermore, it measures degree of vocational, technical and global knowledge (such as knowledge, problem solving, and creativity) (INSEAD, 2019). English Proficiency Index (65 out of 100 countries) measures people's English proficiency (primarily over 18), who are still actively learning English (Education First, 2020).

Moreover, Viet Nam is deprived of an elite group to guide the digital transformation process. Creativity and innovation are yet to be Viet Nam's fundamental strengths; the most apparent evidence is that majority of recent Viet Nam's digital products are application platforms for different industries, with very few any new products, especially in the agricultural sector (Cameron et al., 2019).

Readiness for digital agricultural transformation in Vietnam

Digitization leads to the necessity of expanding cooperation in the value chain: involving new partners, developing new forms of interaction, providing new types of services (Rachinger et al., 2019). By integrating digital resolutions into the agricultural value chain therefore, parties involved are able to foster more informed decisions that address significant challenges in food production (Lezoche et al., 2020; Bura et al., 2021). This provides end-to-end solutions on the journey towards agricultural autonomy and operational excellence. Objects in the digital agriculture field can be categorized into three main groups, consisting of production, distribution and consumption. Each group possesses its own resources, needs and is confronted with its own challenges in which digital agriculture can offer solutions. The groups are not mutually exclusive; any particular individual can participate in many various groups.



Source: Ministry of Industry and Trade, 2021

Graph 1: Necessary skills in information technology that Vietnamese labour workers have not yet fulfilled requirements of employers.

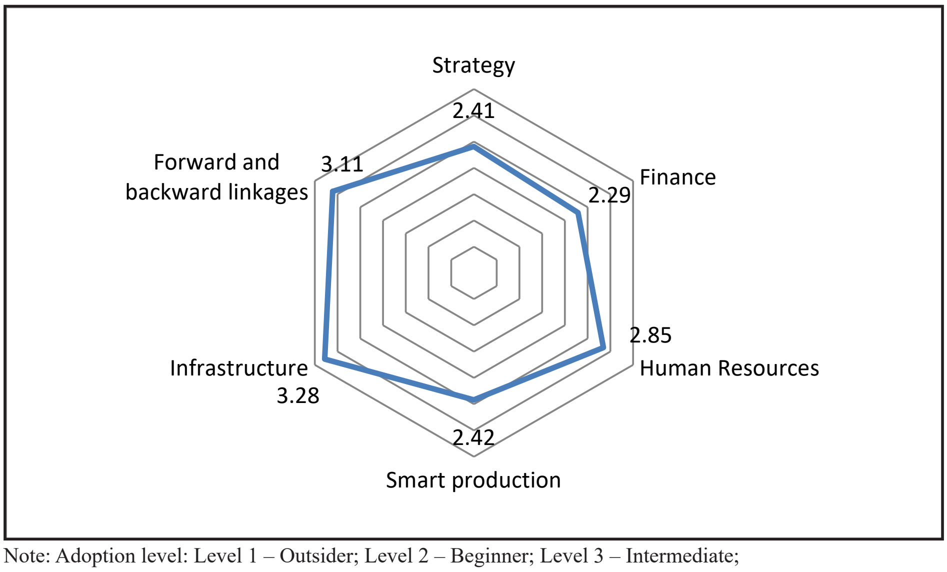
- Production group: fundamentally consists of farmers and actors that supply inputs to agricultural production, such as seeds, fodder, agrochemicals, machinery, and finance. In reality, the tendency of implementing digital technology in the horticulture field is advancing in Viet Nam (Pham, 2018; Vo, 2018; Ngo et al., 2019). The majority of basic digital technology groups in agriculture have been initiated or deployed for trial in our country. Within this trial, the technologies that are being utilized the most are digitized machinery systems, attached to sensors and connected to the internet (IoT sensors) and/or combined with nethouse, glasshouse, and membrane house systems to form an intelligent indoor farming system, which is controlled automatically or semi-automatically with a closed system, such as the rice production area of Loc Troi Group; VinEco's safe vegetable production areas, of Cau Dat Farm company, Da Lat GAP company etc.

Aside from sensor technologies, smart indoor farming systems, technology that uses monochrome LEDs to provide enough light to help generate plant growth has also been employed at many dragon fruit growing facilities from Binh Thuan to Tien Giang, or in mushroom and flower production in several localities such as Vung Tau, Ha Noi. The software applications applied in management, monitoring production and distribution processes of crop products have also been promoted by Vietnamese enterprises, such as Agricheck software of Dai Thanh Company; VIFARM's software globally connects each production package, enables to trace the source, origin, production process, processing procedure and preservation time (Hoang and Do, 2020).

Researchers also emphasized obstacles implementing 4.0 Industry. Some of the main challenges encountered, such as credit access, small farm scale, insufficient progress of land consolidation, poor infrastructure, inadequate market information and lack of well-organized distribution channels (Do, 2018). Moreover, the employment of digital technology remains restricted in Viet Nam, partially due low technology proficiency, investment and development in research is not appropriate (Le et al., 2014).

- Distribution group: includes all actors in the value chain between farmers and consumers; this involves traders, carriers, processors and others. The main distributors in Viet Nam are traditional outdoor markets and large supermarkets. Both subgroups have similar connection rates (i.e. SMS, 39 fixed broadband, mobile networks), but traditional distributors have less similar access potential, through technologies like smartphones. Both traditional distributors and supermarkets are also constrained by the lack of information sharing and communication with parties involved in the value chain (Burra et al., 2021).

Furthermore, the industry's readiness for digital transformation remains low, and due to technical and financial issues, Vietnamese enterprises face difficulties in exerting new technologies (Graph 2).



Note: Adoption level: Level 1 – Outsider; Level 2 – Beginner; Level 3 – Intermediate; Level 4 – Experienced; Level 5 – Pioneer/Expert
Source: Cameron et al., 2019

Graph 2: Digital Adoption levels across dimensions in agricultural enterprises.

The survey results also demonstrate that most agricultural enterprises have employed information technology in production, mainly in daily business management activities, contacting suppliers, customers via email and website. Farm households account for low adoption rate of 25%. Besides that, due to inadequate awareness in the role of digital technology, approximately 35% of formal enterprises in the agricultural sector have schemes to invest in smart technologies.

- Consumer group: involves consumers of both raw materials and processed agricultural products – in fact, the entire population. Among one of the fastest-growing internet economies within the region, Viet Nam's e-commerce market value reached around 12 billion U.S. dollars in 2020, ranking only after Indonesia, Thailand, and Singapore. Many significant changes occurred in Viet Nam's consumer behaviour during the Covid pandemic. The proportion of new online consumers in Viet Nam accounted for 41%, the highest in Southeast Asia, followed by Indonesia and the Philippines with 37% (Table 2). Especially during the epidemic outbreak, consumers invest more time online shopping compared to before (3.1 hours/day), with an average of 4.2 hours/day. In Viet Nam, the present digital population and rising internet penetration provide suitable conditions for e-commerce businesses to grow.

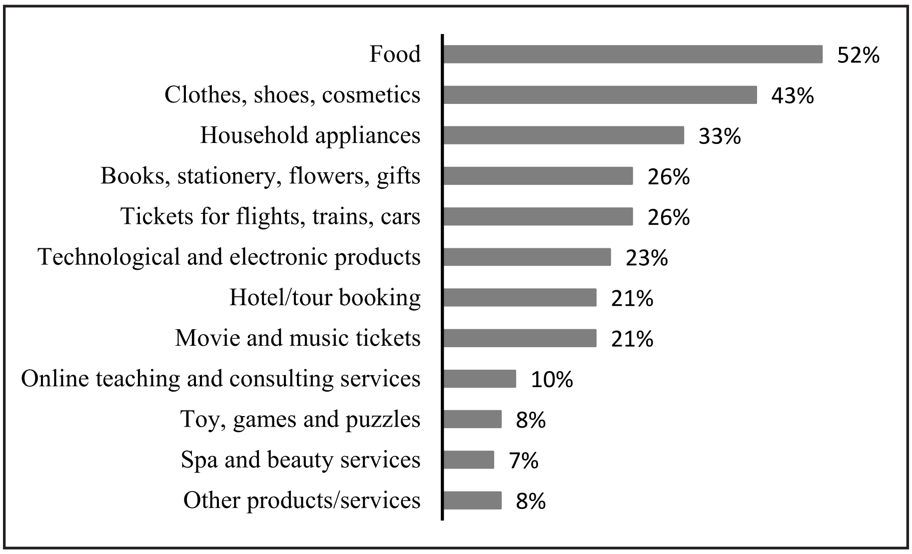
Graph 3 demonstrates that food is the most chosen by consumers whilst online shopping is 52 percent, followed by clothes and cosmetics (37%), household appliances (33%).

Nevertheless, the fundamental success of the value chain will depend on the method and capability of the relationships between the stakeholders (Ilyas et al., 2015). In underdeveloped value chains, trust and coordination are often low. This could be due to a variety of reasons, including lack of management ability, distrust of partners, zero-sum prospects, or simply perceived inequalities in cooperation (McKague and Siddiquee, 2014). In other words, inequality affects a range of actions of parties,

Country	E-commerce market value (Billion Dollar)	The rate of new digital consumers out of total service consumers (%)	The rate of consumers paying with mobile banking apps (%)	Average hours spent online per day (personal use)
Indonesia	44	37	44	4.7
Malaysia	11.4	36	33	4.8
Philippines	7.5	37	53	5.2
Singapore	9	30	17	4.5
Thailand	18	30	5	4.6
Viet Nam	14	41	73	4.2

Source: Google, Temasek, Bain and Company, 2020.

Table 2: Some indicators of E-commerce in Southeast Asia.



Source: Ministry of Industry and Trade, 2021

Graph 3: Main products that were purchased more often shopping online.

through the unequal allocation of risks and benefits, their ability to access, control allocation and use their resources, as well as through knowledge asymmetries. An analysis of 84 publications, orientated in 28 countries and regions, through a system of documents by Hackfort (2021), revealed the existence of five types of structural inequality in the agricultural systems and demonstrate the power of the enterprise, including: 1) in digital technology development; 2) in the distribution of benefits from the use of digital technologies; 3) sovereignty over data, hardware and digital infrastructure; 4) on skills and knowledge ('digital literacy'); and 5) in defining problems and problem-solving capabilities.

The above analysis indicates that Viet Nam is still in the early stages of digital transformation. The high connection and registration rates thanks to affordability, accessibility, and exceptional government support. The employment of e-commerce for agricultural products has achieved considerable success. This presents important opportunities for digital solutions to the following major challenges facing Viet Nam's agriculture:

- Shaping a common vision of digital collaboration and a digital future must become a priority;
- Differences in the perception of the economic impacts values in the digitalization of agriculture by different economic actors;
- Institutional decisions and technology choices to provide participation of small and medium agricultural producers and farmers in digitization processes
- Digital inequalities between urban and rural areas related to Internet access and digital literacy levels of residents;
- Lack of capital to invest in machinery and technology;
- Lack of digitally competent agricultural workforce.

The chances of solving these problems are mostly determined by the institutional decisions of the authorities. For example, developing the sharing economy could become an institutional decision promoting the digitization of small farms. In particular, the sharing of agricultural machinery is actively experienced in developing countries among small groups of farmers with close social ties. Regarding the practice in Northern Thailand, an information-oriented model was chosen to address the IT-related problems affecting the economic agribusiness of small-scale farmers (Raungpaka and Savetpanuvong, 2017). In India, Gold Farm's digital access-based solution can help overcome the financial constraints faced by farmers in accessing expensive agricultural equipment (Sengupta et al., 2019).

Conclusion

According to the United Nations Sustainable Development Goals, digital agriculture has the enviable potential to increase economic contribution through expanding market opportunities, agricultural productivity and cost-effectiveness (Trendov et al., 2019). This study provides a general idea of the potential for digitization in agriculture for a particular country.

The concept of digital agriculture is very useful to identify the current agricultural development subject and help relevant departments to make rational agricultural development planning within the framework of digitalization of agriculture (Klerkx et al., 2019). In this regard, when determining the conditions affecting the viability of digital agricultural transformation, the following issues could be distinguished. These are: forming an institutional framework for digital agricultural development; the need for information infrastructure development; forming digitally comprehensive human resources.

This study has employed the concept of digital agriculture to the problems related to the development of digital agriculture in Viet Nam today. The key findings indicate that Viet Nam is in the early stages of digital transformation in agriculture. Digital technology is gradually spreading in the agricultural field. However, the adoption is hindered by digital inequalities, constraints on human resources, finance and infrastructure, as well as inadequate awareness of existing technologies. In fact, digital transformation is an ongoing process, in which future technological developments and its impacts are highly uncertain and difficult to predict. Development occurs in very different ways and therefore the future outcomes are quite different (Daum, 2021). Hence, for the digital transformation to come into play in a positive way, institutional decisions by regional governments are indispensable to shape the development of digital agriculture. In this context, in-depth studies play an important role in verifying and affirming the authors' empirical conclusions.

Acknowledgments

This research is part of a PhD project, which was funded by the Governments of the Russian Federation and Vietnam (PhD Scholarship under the Agreements). I would like to express my advisor Prof. Inna V. Mitrofanova for her guidance and encouragement to accomplish this work. I also thank the anonymous reviewers for their comments and suggestions that improved the paper.

Corresponding authors
Ph.D. Student Nguyen Thi Ngoc Loi
Faculty of Economics, The University of Danang – Campus in Kontum, 704 Phan Đình Phùng, Quang Trung, Kon Tum, Vietnam
E-mail: ngocloi@gmail.com

References

[1] Banu, S. (2015) "Precision agriculture: tomorrow's technology for today farmer", *Journal of Food Process Technol,* Vol. 6, No. 8, pp. 1-6. ISSN 2157-7110. DOI 10.4172/2157-7110.1000468.

[2] Burra, D., Hildebrand, J., Giles, J., Nguyen, T., Hasiner, E., Schroeder, K., Treguer D., Juergenliemk, A., Horst, A., Jarvis, A. and Kropff, W. (2021) "*Digital Agriculture Profile: Viet Nam*", FAO: Rome (Italy), 22 p. [Online] Available: http://www.fao.org/3/cb3956en/cb3956en.pdf [Accessed: July 23, 2021].

[3] Cable (2020) "*Worldwide broadband speed league 2022*" [Online]. Available: https://www.cable.co.uk/broadband/speed/worldwide-speed-league/. [Accessed: June 3, 2021].

[4] Cameron, A., Pham, T. H., Atherton, J., Nguyen, D. H., Nguyen, T. P., Tran, S. T., Nguyen, T. N., Trinh, H. Y. and Hajkowicz, S. (2019) "Vietnam's Future Digital Economy Towards 2030 and 2045", CSIRO, Brisbane, 172 p.

[5] Daum, T. (2021) "Farm robots: Ecological utopia or dystopia?", *Trends in Ecology & Evolution*, Vol. 36, No. 9, pp. 774-777. DOI 10.1016/j.tree.2021.06.002.

[6] Davnis, V. V., Tinyakova, V. I., Blinov, A. O. and Volodin, Y. V. (2019) "Combined Modeling of Projected Evaluation of the Regional Socio-economic Development", *International Journal of Economics & Business Administration*, Vol. 7, Special. No. 1, pp. 348-354. ISSN 2241-4754. DOI 10.35808/ijeba/278.

[7] Do, K. C. (2018) "Smart Agriculture: Issues and Directions for Research and Training", Vietnam *Journal of Agricultural Science*, Vol. 16, No. 7, pp. 707-718. ISSN 2588-1299. (in Vietnamese).

[8] Duong, D. T. (2020) "Sustainable development for Vietnam agriculture", In *INTERAGROMASH 2020, E2S Web of Conferences, XIII International Scientific and Practical Conference "State and Prospects for the Development of Agribusiness – INTERAGROMASH 2020*", Vol. 175, p. 01015, 9 p. DOI 10.1051/e3sconf/202017501015.

[9] Economist Intelligence Unit (2020) "*The Inclusive Internet Index*" [Online]. Available: https://theinclusiveinternet.eiu.com/explore/countries/performance?year=2020. [Accessed: June 3, 2021]

[10] Education First (2020) "*EF EPI. EF English Proficiency Index*". [Online]. Available: https://www.ef.com/assetscdn/WIBIwq6RdJvcD9bc8RMd/legacy/__/~/media/centralefcom/epi/downloads/full-reports/v10/ef-epi-2020-english.pdf [Accessed: June 15, 2021].

[11] Elijah, O., Rahman, T. A., Orikumhi, I., Leow, C. Y. and Hindia, M. N. (2018) "An Overview of Internet of Things (IoT) and Data Analytics in Agriculture: Benefits and Challenges", *IEEE internet of Things Journal*, Vol. 5, No. 5, pp. 3758-3773. ISSN 1858-2262. DOI 10.1109/JIOT.2018.2844296.

[12] European Parliament (2016) "*Precision agriculture and the future of farming in Europe*", Scientific Foresight Unit. PE 581.892, 42 p. ISBN 978-92-846-0475-3. DOI 10.2861/020809.

[13] Faskhutdinova, M. S., Amirova, E. F, Safiullin, I. N. and Ibragimov, L. G. (2020) "Human resources in the context of digitalization of agriculture", *BIO Web of Conferences, International Scientific-Practical Conference "Agriculture and Food Security: Technology, Innovation, Markets, Human Resources",* (FIES 2020), Vol. 27, p. 00020. pp. 1-6. E-ISSN 2117-4458. DOI 10.1051/bioconf/20202700020.

[14] General Statistics Office of Viet Nam (2020) "*Niên giám thống kê đầy đủ năm 2019*". [Online]. Available: https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2020/09/nien-giam-thong-ke-day-du-nam-2019/. [Accessed: June 10, 2021]. (In Vietnamese).

[15] German Agricultural Society (2018) "*Opportunities. Risk. Acceptance*". [Online] Available: https://www.smart-akis.com/wp-content/uploads/2018/03/Folder_Position_Digitalisierung_e_IT.pdf. [Accessed: June 10, 2021].

[16] Google, Temasek and Bain & Company (2020) "*E-Conomy SEA 2020, at full velocity: Resilient and racing ahead*". [Online] Available: https://nextbn.ggvc.com/wp-content/uploads/2020/11/e-Conomy_SEA_2020_Report.pdf [Accessed: July 15, 2021].

[17] Hackfort, S. (2021) "Patterns of Inequalities in Digital Agriculture: A Systematic Literature Review", *Sustainability*, Vol. 13, p. 12345. E-ISSN 2071-1050. DOI 10.3390/su132212345.

[18] Herlitzius, T. (2017) "Automation and Robotics - the Trend Towards Cyber Physical Systems in Agriculture Business", in *Proceedings of the 9th AVL International Commercial Powertrain Conference 2017*, Helmut-List-Halle, Austria, pp. 1-4. DOI 10.4271/2017-01-1932.

[19] Hoang, X. D. and Do, T. T. T. (2020) "Prospects for Agriculture 4.0 in Developing Countries: Case Studies from Vietnam". In Sakata, Shozo ed. 2020, "*Structural Changes of Agriculture in the CLMTV Countries and their SocioEconomic Impacts*", BRC Research Report No. 57, Bangkok Research Center, JETRO Bangkok / IDE-JETRO, p. 102-116. [Online] Available: https://www.ide.go.jp/library/English/Publish/Reports/Brc/pdf/27_06.pdf [Accessed: 2 August 2, 2021].

[20] IFAD, IPSARD and ADB (2020) "*Impacts of COVID-19 Pandemic on Smallholder Farmers and Vulnerable Rural People in Vietnam*", IFAD, IPSARD and ADB: Ha Noi, Vietnam, 44 p. [Online]. Available: https://nardt.org/images/ACC_1/files/Tai%20lieu/bao%20cao%20dai%20dich%20covit%2019%20TA.pdf [Accessed: 15 June 15, 2021].

[21] Ilyas, R. M., Banwet, D. K. and Shankar, R. (2007) "Value Chain Relationship - A Strategy Matrix", *Supply Chain Forum: An International Journal*, Vol. 8, No. 1, pp. 56-72. ISSN 1624-6039. DOI 10.1080/16258312.2007.11517176.

[22] INSEAD (2019) "*The Global Talent Competitiveness Index 2019*", INSEAD: Fontainebleau, France, 339 p. ISBN 979-10-95870-18-0.

[23] ITU and FAO (2020) "*Status of Digital Agriculture in 18 countries of Europe and Central Asia*", ITU and FAO: Geneva, Switzerland, 102 p. ISBN 978-92-5-132889-7.

[24] Ivanova, I. A., Pulyaeva, V. N., Vlasenko, L. V., Gibadullin, A. A. and Safarov, B. G. (2020) "Collaboration of different generations in the digital environment of the economy", *IOP Conference Series: Earth and Environmental Science*, Vol. 421, No. 3, p. 032039. ISSN 17551307. DOI 10.1088/1755-1315/421/3/032039.

[25] Kitchenham, B. and Charters, B. (2007) "*Guidelines for performing Systematic Literature Reviews in Software Engineering*", Software Engineering Group, School of Computer Science and Mathematics, Keele University, EBSE Technical Report Version 2.3, 65 p. [Online]. Available: https://www.elsevier.com/__data/promis_misc/525444systematicreviewsguide.pdf [Accessed: July, 23, 2021].

[26] Klerkx, L. and Rose, D. (2020) "Dealing with the game-changing technologies of Agriculture 4.0: how do we manage diversity and responsibility in food system transition pathways?", *Global Food Security*, Vol. 24, p. 100347. ISSN 2211-9124. DOI 10.1016/j.gfs.2019.100347.

[27] Klerkx, L., Jakku, E. and Labarthe, P. (2019) "A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda", *NJAS - Wageningen Journal of Life Sciences*, Vol. 90-91, p. 100315. ISSN 1573-5214. DOI 10.1016/j.njas.2019.100315.

[28] Koutsos, T. M., Menexes, G. C. and Dorbas, C. A. (2019) "An efficient framework for conducting systematic literature reviews in agricultural sciences", S*cience of The Total Environment*, Vol. 682, pp. 106-117. ISSN 0048-9697. DOI 10.1016/j.scitotenv.2019.04.354.

[29] Le, T. H., Tran, A.T. and Ta, K. C. (2014) "Study to Propose Some Policy Recommendations for Promoting High-Tech Agriculture to Commercialization in Vietnam", *Journal of Science and Technology Policy Management*, Vol. 3, No. 3, pp. 10-21. ISSN 1859-3801. (in Vietnamese).

[30] Lezoche, M., Hernandez, J., del Mar Alemany Diaz, M., Panetto, H. and Kacprzyk, J. (2020) "Agri-food 4.0: a survey of the supply chains and technologies for the future agriculture", *Computers in Industry*, Vol. 117, p. 103187, 36 p. ISSN 0166-3615. DOI 10.1016/j.compind.2020.103187.

[31] Lioutas, E. D., Charatsari, C., La Rocca, G. and De Rosa, M. (2019) "Key questions on the use of big data in farming: an activity theory approach", *NJAS - Wageningen Journal of Life Sciences*, Vol. 90-91, p. 100297, pp 1-12. ISSN 1573-5214. DOI 10.1016/j.njas.2019.04.003.

[32] Mai, H. and Van, H. (2019) "Current Status and Problems of Vietnamese Agricultural Sector", *The EUrASEANs: Journal on Global Socio-Economic Dynamics*, Vol. 5, No. 18, pp. 23-35. ISSN 2539-5645. DOI 10.35678/2539-5645.5(18).2019.23-35.

[33] McKague, K. and Siddiquee, M. (2014) "Strengthening Value Chain Relationships", In: *Making Markets More Inclusive*. Palgrave Macmillan, New York. ISBN 978-1-349-48028-9. DOI 10.1057/9781137373755_8.

[34] Ministry of Industry and Trade (2021) "*Vietnam E-Commerce White Paper 2020*", Department of Commerce and Digital Economy, Ministry of Industry and Trade: Ha Noi, 96 p. [Online]. Available: https://idea.gov.vn/. [Accessed: July 15, 2021].

[35] Ministry of Information and Communications (2020) "*Information and Communication Technology White Paper*", Information and Communication: Hanoi, 94 p. [Online]. Available: https://www.mic.gov.vn/Upload_Moi/TinTuc/SachTrang2020-Final.pdf. [Accessed: July 15, 2021].

[36] Mirolyubova, T. V., Karlina, T. V. and Nikolaev, R. S. (2020) "Цифровая Экономика: Проблемы Идентификации И Измерений В Региональной Экономике" (Digital Economy: Identification and Measurements Problems), *Economy of Region*, Vol. 16, No. 2, pp. 377-390. ISSN 2072-6414. DOI 10.17059/2020-2-4. (in Russian).

[37] Ngo, D. M., Doan, H. S. and Mai, V. T. (2019) "A Review of Precision Agriculture in Rice Production in Vietnam", *International workshop on ICTs for precision agriculture*, pp. 105-130. [Online]. Available: https://www.fftc.org.tw/upload/files/activities/20190926114217/PROCEEDING_BOOK_FFTC_2019.pdf#page=105 [Accessed: August 2, 2021].

[38] Nguyen T. N. L. and Mitrofanova I. V. (2021) "Фермерская Экономика Вьетнама: Тенденции и Пути Развития в Среднесрочной Перспективе" (Farming Economy of Vietnam: Trends and ways of development in the Mid-Term), *Economics: Yesterday, Today and Tomorrow*, Vol. 11, No. 7A, pp. 22-32. ISSN 2222-9167. (in Russian).

[39] Okenova, A. O. (2019) "Цифровизация сельского хозяйства в Кыргызской Республике" (Digitalization of Agriculture in the Kyrgyz Republic), *Journal of International Economic Affairs*, Vol. 9, No 1, pp. 97-106. ISSN 2587-8921. DOI 10.18334/eo.9.1.39675. (in Russian).

[40] Pham, T. V. H. (2018) "*Overview of IoT Development in Agriculture and Applications in Vietnam*", Technical Report, University of Engineering and Technology, VNU. [Online]. Available: https://eprints.uet.vnu.edu.vn/eprints/id/eprint/3316/1/IoT%20in%20algriculture%20in%20Vietnam.pdf. [Accessed: August 2, 2021].

[41] Rachinger, M., Rauter, R., Müller, C., Vorraber, W. and Schirgi, E. (2019) "Digitalization and its influence on business model innovation", *Journal of Manufacturing Technology Management*, Vol. 30, No. 8, pp. 1143-1160. ISSN 1741-038X. DOI 10.1108/JMTM-01-2018-0020.

[42] Raungpaka, V. and Savetpanuvong, P. (2017) "Information orientation of small-scale farmers' community enterprises in Northern Thailand", *Kasetsart Journal of Social Sciences*, Vol. 38, No. 3, pp. 196-203. ISSN 2452-3151. DOI 10.1016/j.kjss.2016.08.018.

[43] Ryan, M. (2017) "*Taiwan: Home to the Total Supply chain for Agriculture 4.0*". [Online]. Available: https://agfundernews.com/taiwan-home-total-supply-chain-agriculture-4-0.html. [Accessed: August 24, 2021].

[44] Sengupta, T., Narayanamurthy, G., Moser, R. and Hota, P. K. (2019) "Sharing app for farm mechanization: Gold Farm's digitized access based solution for financially constrained farmers", *Computers in Industry*, Vol. 109, pp. 195-203. ISSN 0166-3615. DOI 10.1016/j.compind.2019.04.017.

[45] Snyder, H. (2019) "Literature review as a research methodology: An overview and guidelines", *Journal of Business Research*, Vol. 104, pp. 333-339. ISSN 0148-2963. DOI 10.1016/j.jbusres.2019.07.039.

[46] Sundmaeker, H., Verdouw, C., Wolfert, S. and Pérez Freire, L. (2016) "Internet of food and farm 2020". In: Vermesan, O., Friess P. (Eds.) "*Digitising the Industry - Internet of Things Connecting Physical, Digital and Virtual Worlds*", River Publishers, Gistrup/Delft, pp. 129-151. E-ISBN 978-87-93379-82-4. DOI 10.1079/PAVSNNR201611035.

[47] Trendov, N. M., Varas, S. and Zeng, M. (2019) "*Digital Technologies in Agriculture and Rural Areas*", FAO: Rome, 26 p. ISBN 978-92-5-131546-0.

[48] Union Nations (2020) "*E-Government Survey 2020*", Union Nations: New York, 364 p. [Online]. Available: https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2020-Survey/2020%20UN%20E-Government%20Survey%20(Full%20Report).pdf [Accessed: July 10, 2021].

[49] Vlachopoulou, M., Ziakis, C., Vergidis, K. and Madas M. (2021) "Analyzing AgriFood-Tech e-Business Models", *Sustainability*, Vol. 13, p. 5516. ISSN 2071-1050. DOI 10.3390/su13105516.

[50] Vo, K. S. (2018) "Apply the 4.0 Revolution in Agriculture", *Quang Binh Science and Technology Information Journal*, Vol. 6, pp. 17-21. ISSN 0866-7543. (in Vietnamese).

[51] Wolfert, S., Ge, L., Verdouw, C. and Bogaardt, M. J. (2017) "Big Data in Smart Farming – A Review", *Agriculture Systems*, Vol. 153, pp. 69-80. ISSN 0308-521X. DOI 10.1016/j.agsy.2017.01.023.

[52] World Bank (2019a) "*The Digital Economy in Southeast Asia Strengthening the Foundations for Future Growth*", WB: Washington DC, USA, 128 p. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/31803. [Accessed: July 10, 2021].

[53] World Bank (2019b) "*Future of Food Harnessing Digital Technologies to Improve Food System Outcomes*". WB: Washington, DC. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/31565. [Accessed: July 15, 2021].

[54] XM (2020) "*The Demand for Recruiting Human Resources in the Information Technology Industry is Still Increasing*". [Online]. Available: https://baotintuc.vn/xa-hoi/nhu-cau-tuyen-dung-nhan-luc-nganh-cong-nghe-thong-tin-van-tang-20200911154903397.htm. [Accessed: July 15, 2021]. (in Vietnamese).

Agris on-line Papers in Economics and Informatics

Volume XIV Number 3, 2022

Corporate Transparency, Sustainable Development and SDG 2 and 12 in Agriculture: The Case of Ukraine

Inna Makarenko[1], Alex Plastun[2], Serhiy Kozmenko[3], Olga Kozmenko[4], Artem Rudychenko[5]

[1] School of Business, Prague City University, Czech Republic, and Accounting and Taxation Department, Sumy State University, Ukraine

[2] International Economic Relations Department, Sumy State University, Ukraine

[3] Institute of Market Problems, University of Social Sciences, Lodz, Poland

[4] University of Economics and Innovation in Lublin, Poland; Department of Finance, Kharkiv National University of Economics, Ukraine

[5] Sumy State University, Ukraine

Abstract

This paper explored sustainability transparency and SDGs 2 and 12 disclosure and its influence on their overall efficiency, using data from Ukrainian agricultural companies. To do this Sustainability Transparency Index (STI) methodology is developed and used. The following hypothesis is tested: the higher the STI score is, the better position of the company is among its peers. For these purposes, STI index is calculated for the top100 Ukrainian agriculture companies. Correlation analysis, Granger causality tests and regression analysis provide evidences in favour of high dependence of position in top100 from the STI score: the more efforts companies invest into Sustainability Transparency, the higher the position in ranking is. This is direct evidence that companies' sustainability transparency is an important element of its activity nowadays. Recommendations to improve sustainability transparency based on suitable reporting practices are provided in this paper.

Keywords

Sustainable development goals, transparency, sustainability reporting, Sustainability Transparency Index, agricultural management, resilient agricultural practices.

JEL Classification: Q01; O13; O44.

Makarenko, I., Plastun, A., Kozmenko, S., Kozmenko, O. and Rudychenko, A. (2022) "Corporate Transparency, Sustainable Development and SDG 2 and 12 in Agriculture: The Case of Ukraine", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 57-70. ISSN 1804-1930. DOI 10.7160/aol.2022.140305.

Introduction

According to United Nations, key problems of humanity are health care, climate changes, poverty and gender inequality. In 2015, 17 Sustainable Development Goals (SDGs) and 169 targets were introduced on global and national levels (United Nations, 2015) to solve these problems. SDGs caused serious changes in the behaviour of economic subjects. Companies have paid more attention to sustainable development and become more transparent about these efforts to the world (Androniceanu, 2021).

One of the tools for achieving the SDGs is to strengthen the regulatory requirements for the disclosure of information by companies on environmental (E), social (S) and governance (G) ESG – criteria. Ensuring the transparency of the business environment and reporting on the incorporation of CSR into the activities of companies is the key to effective monitoring of progress in achieving SDGs in the corporate sector.

ESG investing comprises' financial and ethical paradigms is to prioritize investments that positively impact society and the world. ESG investment has become a prominent and influential industry, constituting a significant portion of global equity portfolios and funds (Daugaard, 2020).

On micro level financial performance of companies with social-responsible investment is better than traditional ones (López et al., 2007; Nicolescu et al. 2020). The positive impact can be ensured by different socially responsible activities – both internal and external. Particularly, there are obvious links between investments in human capital, including practices of personnel development, and firm performance (Samoliuk et al., 2021; Urbancová & Vrabcová, 2020). These links are typical for enterprises of different age and size (Bilan et al., 2020; Çera et al., 2020) and first of all responsible practices have impact on financial performance (Myšková and Hájek, 2019; Vo et al., 2020).

According to Statman (2000), ESG-based stocks outperform traditional ones. From the geographical point of view, ESG indices perform better in the European markets than in the US ones (Cortez et al., 2009).

According to the MSCI (Morgan Stanley Capital International) 2021 Global Institutional Investor survey (a survey of 200 asset owner institutions with assets totalling approximately $18 trillion), over three-quarters (77%) of investors increased ESG investments "significantly" or "moderately" in 2020, with this figure rising to 90% for the largest institutions (over $200 billion of assets).

Companies use SDGs and ESG for communication with stakeholders and emphasis its fundamental role in value creation potential, social benefits, risk mitigation (Indahl and Jacobsen, 2019; Androniceanu, 2019).

The last decade has been marked by the dynamic development of regulatory disclosure tools based on ESG criteria and SDGs. More than 300 governmental and non-governmental, mandatory and voluntary instruments have been introduced in the 50 largest countries by GDP (both developed and developing UNPRI, 2016b).

Plastun et al. (2019) showed that the more ESG criteria are used for disclosure regulation, the higher the country's ranking in the Ranking of 50 largest economies. Non-government corporate ESG disclosure has the most significant influence. In Plastun et al. (2020) the linkage between countries SDGs achievement ranking and country's ranking in the Ranking of 50 largest economies was showed additionally. Ukraine's adoption of a national SDGs target system in 2017 unites it with the global community. However, the level of SDGs progress in Ukraine compared to the 50 leading countries in the world is low - 46th out of 149 countries in the 2016 Global SDG Indicators Database (2016). Sukhonos et al. (2019) showed that corporate social responsibility activity in Ukraine is relatively low because of the low perception of sustainability ideology and reporting. Plastun et al. (2021) provide some preliminary explanation of SDGs 2 and 12 disclosure achievements in Ukraine agriculture companies and found that problems in their achieving are similar for these countries.

Agriculture plays a fundamental role in daily life, providing livelihoods for one-third of the global population and enabling food production. The sector accounts for 9.5% of Gross Domestic Product (GDP) across developing countries and 26% of GDP for the world's least-developed countries. In 2018, agriculture added USD 3.3 trillion to the world economy, up 50% from 2008 (USD 2.2 trillion).

Agriculture is not only the key sector of public support (Pronko, 2020) but also one of the key spheres to achieve SDGs, because it deals with food security, hunger, waste-free production and reduction of environmental pollution (Oláh et al., 2021; Popp et al., 2021).

Agriculture provides impact on the multiply SGDs from "No Poverty" (SDG 1) to "Zero Hunger" (SDG 2) and "Sustainable Consumption and Production" (SDG 12).

According to GIIN (Sunderji et al., 2020) the highest affected SGDs are SDG 8 "Decent work and economic growth" (81%), SDG 2 "Zero Hunger" (68%), SDG 5 "Gender equality" (62%) and SDG 1 "No Poverty" (57%).

Despite the evidence that sustainable management practices are important for business, ESG-efforts in agriculture are very limited.

The key guidelines in conducting agribusiness based on sustainable development for companies worldwide are Food and Agriculture Business Principles, developed by the UN Global Compact network. The fundamental principle is "encourage good governance and accountability", which requires companies to be transparent and highlight their influence.

Based on data from Ukrainian agricultural companies, this paper aims to show that sustainability transparency issues is an important element nowadays. To do this Sustainability Transparency Index (STI) methodology is developed and applied to the top100 Ukrainian agriculture companies. Correlation analysis, Granger causality tests and regression analysis showed that the higher the STI score, the better the company's position in the overall ranking of agricultural companies. This is direct evidence that sustainability transparency of the company is vital element of its activity nowadays.

Materials and methods

The samples of the biggest companies were formed to conduct a comparative study of the agricultural companies' transparency in Ukraine and their disclosure about SDG 2 and 12.

To select Ukrainian companies, the website Latifundist, 2021 was used. It presents the top 100 agricultural holdings of Ukraine in terms of the land bank.

Preliminary, for each company, the English-language web-sites and the most recent published sustainability reports were analysed. In case of their absence, sites and reports in Ukrainian were analysed. The study was conducted in March 2021.

The research methodology included the author's questionnaire on the status of disclosure by companies on SDG and CSR, emphasising certain ESG-criteria through content analysis of sites and reports of agricultural companies.

The question list included the following parameters and their options, which describe the sustainability disclosure state by agricultural companies (Table 1).

Parameter	Option
Links to sustainability information	There is no website
	There is the site, information on CSR and sustainable development are not available
	Available
Existence of sustainable development policy	Existent (with type indication)
	No policy
Reporting periods are available	List of periods disclosed in the reporting
The most recent reporting period	The period for which the reporting is analysed through content analysis
Sustainable Development and SDG Report	Information on SDG or CSR is on the site
	Sustainable Development Report
	Non-financial report
	Chapter in the annual report
	Consolidated reporting
	Report of independent auditors
	Corporate governance

Source: Compiled by the authors

Table 1. Basic questionnaire on the state of sustainability disclosure, SDG and CSR by agricultural companies (to be continued).

Parameter	Option
Management report	Available
	Absent
Disclosure according to ESG criteria	Ecological
	Social
	Government (including anti-corruption)
SDG	In terms of some goals
	Absent
Other relevant goals related to CSR and sustainable development	Available
	Absent

Source: Compiled by the authors

Table 1. Basic questionnaire on the state of sustainability disclosure, SDG and CSR by agricultural companies (continuation).

This questionnaire was used for Ukrainian companies to characterize their sustainable development transparency and Goals. Next questionnaire was transformed into binary form. It makes it possible to normalise the values of the studied information parameters and sustainability reports of Ukrainian agricultural holdings and build their Sustainability Transparency Index (STI) (Table 2).

The algorithm of the normalization method of values of sustainability disclosure parameters, CSR and SDG in the reporting of agricultural holdings within the specified limits is the following. First, it is necessary to find the number of parameters for the index, the number of verified criteria and set the maximum evaluation value. Let the maximum index value be from 0 to 100. Similar algorithm was used in Makarenko et al. (2020) They analysed sustainability reporting in Ukraine in ESG disclosure based on The Quality and Compliance Bank Management Reports Index and showed a low level of compliance in the country as well. Then the algorithm consists of the following steps:

1. Finding minimum and maximum number of evaluation criteria [min; max].
2. Finding the number of verified criteria – x.
3. Setting the maximum value for k.
4. Calculation the rating value according to Equation 1.

$$y = \left(\frac{x - min}{\max - min}\right) * k, \text{where } x \neq min; \quad (1)$$

The calculated values of the index are presented on a 100-point scale with a letter rating system. The minimum point is E, then the maximum is

Parameter	Option			0
Links to sustainability information	There is no website			+
	There is the site, information on CSR and sustainable development are not available			+
	Available			
Existence of sustainable development policy	Existent (with type indication)			
	No policy			+
Sustainable Development and SDG Report	There is no information on SDG or CSR on the website (sustainable development report, non-financial report, chapter in the annual report, information in the consolidated financial statements, etc.)			
	Absent			+
Management report	Available			
	Absent			
Disclosure according to ESG criteria	Ecological	Available	+	
		Absent		+
	Social	Available	+	
		Absent		+
	Government	Available	+	
		Absent		+
	Anti-corruption	Available	+	
		Absent		+
Disclosure on SDG	Available			
	Absent			+
Other relevant goals related to SDG and sustainable development	Available			
	Absent			+

Source: Compiled by the authors

Table 2. Modified questionnaire on the state of disclosure on sustainable development, SDG and CSR by Ukrainian agricultural companies.

A. Totally, there are 5 evaluation sets with certain intervals that can be represented as follows:

1. A [80;100]
2. B [60;80]
3. C [40;60]
4. D [20;40]
5. E [0;20]

Below is example of STI calculations for the case of "Kernel" (Ukrainian agricultural company). Out of 25 general evaluation parameters, 11 were verified for "Kernel" (Equation 2):

$$\text{STIkernel} = \left(\frac{11-0}{25-0}\right) * 100 = 52{,}0\ (C) \qquad (2)$$

Results and discussion

The UN Global Compact is a supranational organization that brings together companies that have signed ten principles of socially favourable, environmentally friendly policies that protect human rights, fight against corruption, and actively promote SDGs. The global network includes 13,555 companies from 162 countries, and published 81,808 reports (communications on achieving these principles). In Ukraine, signatories are 107 well-known companies such as agro-industrial holding Astarta-Kyiv, MHP, Kernel.

As a result, we see a lack of involvement of companies from the agricultural sector to communicate on SDG progress in Ukraine. These communications can take place not only in the reports according to the principles of the UN Global Compact but also in the sustainability, compiled according to one of the many standards (SASB, CDP, GRI), etc. The leading codified sustainability reporting system is the GRI system of standards. In total, it presents 15,588 organizations with 63,582 reports.

In Ukraine, 22 companies have published 78 reports during the time of the database existence. The same three agricultural companies are signatories to the UN General Assembly (agro-industrial holding Astarta-Kyiv, MHP, Kernel). These data indicate a small representation of agricultural companies in both countries in the commonly accepted bases for sustainability disclosure.

The extensive research on SDG incorporation into the Ukrainian companies' activities by non-governmental institutions is conducted by the CSR Ukraine and UN Global Compact Network Ukraine. In particular, the latest study in 2020 included an analysis of 116 cases from 64 companies on CSR in 2016-2019 and 97 non-financial reports of companies that are the largest taxpayers in 2015-2019 (Figure 1).

SDG 2 is one of the least mentioned goals by companies. The vast majority of companies are in the Top-100 Ukrainian companies representing the mining, metallurgical and energy sectors.

Regarding SDG 12, primarily Ukrainian companies' contribution is conducting educational activities on separate waste collection and management. However, according to the dynamics of SDG 12 indicators, progress in this area is insufficient.

At the same time, SDGs 2 and 12 are partially integrated into corporate sustainability strategies, investment strategies and CSR practices. The solution to this problem could be to encourage companies to SDG disclosure and implement strict requirements for including the goals in forming the management report and key companies' indicators in terms of SDG.

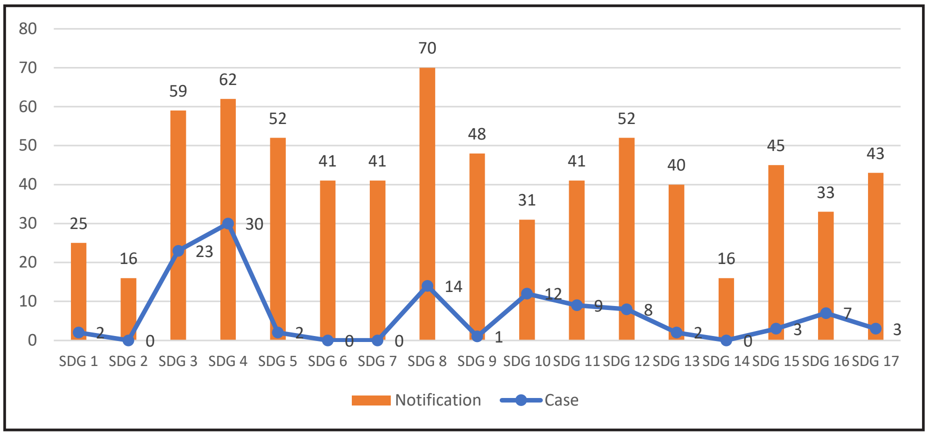
The UN Global Compact Network Ukraine (2021a) provides alternative data on incorporating the SDGs 2 and 12. In particular, in 2020, 1 case on SDG 2 implementation in companies' activities was introduced, and 3 cases related to SDG 12 (Table B.1).

A detailed analysis of the UN Global Compact Network cases in the context of their goals, the solutions aimed to achieve them allowed drawing a foregone conclusion. First of all, the investigated cases do not apply to agro-industrial companies. Metro Cash & Carry Ukraine, Food Bank, Subsidiary with foreign investments Pernod Ricard Ukraine is indirectly involved in the food industry.

Unfortunately, these cases do not contain data on investment in these projects, which is primarily due to insufficient SDG disclosure by Ukrainian companies and the low quality of their communications with stakeholders. 37% of Ukrainian companies do not have their website. It does not allow to conclude their level of transparency in CSR and SDG initiatives. Three Ukrainian companies have non-functioning websites (Svitanok, Freedom Farm, Greenstone).

Half of the analysed Ukrainian agricultural holdings have information on SDG and CSR on their website.

59 out of 100 Ukrainian agricultural holdings do not have a CSR policy published on their website. Meanwhile, such a policy does not correlate with the size of the company's land bank. In particular, five companies from the top 10 agricultural holdings of Ukraine (Agroprosperis, Mriya, Epitsentr Ahro, HarvEast Holding, IMK) do not have sustainability policies, and some companies have their website (Agroprosperis, Mriya, Epitsentr Ahro).

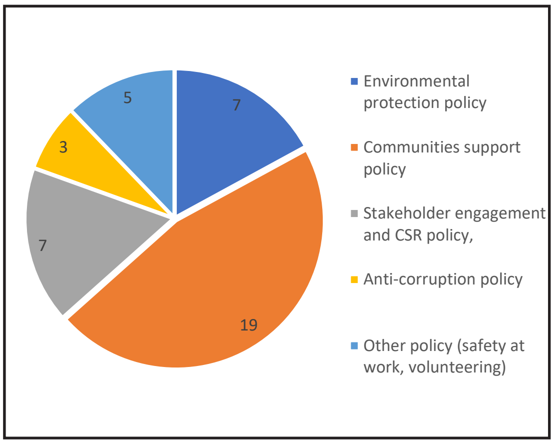


Source: CSR Ukraine (2020), The contribution of Ukrainian business to the implementation of Ukraine's Sustainable Development Goals 2016-2020 (https://csr-ukraine.org/wp-content/uploads/2020/12/Vpliv--biznesu-na-CSR.pdf.)

Figure 1: The condition of SDG incorporation into the activities of Ukrainian companies according to the Center of CSR Ukraine.

Kernel has the largest number of formalized corporate sustainability policies (number one in the Latifundist (2021) rating according to the land bank size). It has a sustainability policy, environmental protection, community cooperation, labour protection, industrial, technical and transport safety. Astarta-Kyiv is the third in the ranking and has a policy on sustainable development, a plan of interaction with stakeholders, a policy to fight against corruption.

19 out of the 41 Ukrainian companies have integrated some fields of accountability, transparency and sustainable development at the policy level into corporate governance. The vast majority have policies to promote rural development, projects and communities (Figure 2). In second place are the general policies on CSR, sustainable development, interaction with stakeholders (7 companies). In the third place is a set of policies that characterize the various areas of corporate volunteering, philanthropic activities and the creation of safe working conditions (5 policies).



Source: compiled by the authors according to companies' sites and sustainability reports

Figure 2: Types of sustainability policies of the top 100 Ukrainian agricultural holdings as of March 2021.

Analysis of the Ukrainian agricultural holdings under the duration of sustainability reporting (according to the list of available reporting periods disclosed in the reporting) shows that most companies cover traditional financial statements for the last 3-5 years.

Only Astarta (8 reports for 2013-2020), MHP and Kernel (6 non-financial reports for 2015-2020) follow the tradition of sustainability reporting.

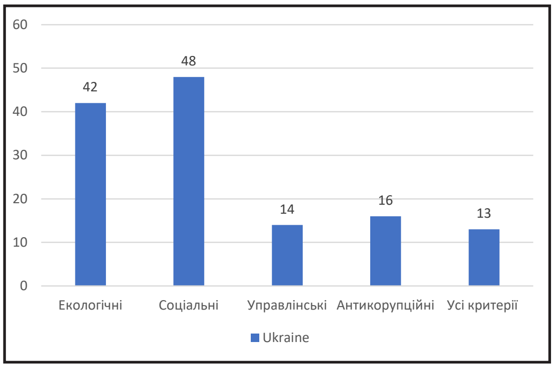
Regarding the sustainability disclosure format and its goals, the transparency of Ukrainian agricultural companies is quite negative. It is by the fact that 50% of companies do not disclose sustainability issues (Figure 2), and do not submit even publicly available financial statements on their websites.

In addition to the two categories of Ukrainian agricultural holdings (50% of those that do not disclose about themselves, and 31% that provide separate sustainability information in the annual financial or consolidated financial statements), there is a group of agricultural holdings led by Kernel. This 8% of the 100 companies have a regular section in the annual report, which describes their progress towards sustainable development and its goals for stakeholders. Non-financial and sustainable development reports are generally published only by MHP and Astarta. Sustainability information and CSR is presented on the corporate pages of APK-Invest, Zelena Dolyna, Kusto Agro and KSG Agro. Other disclosures on sustainable development by Ukrainian companies are sporadic.

An important marker of the transparency of Ukrainian agricultural holdings and their compliance with the legal requirements for non-financial reporting in Ukraine is their accordance (as large and medium-sized companies) with the requirements of the Law "On Accounting and Financial Reporting" to prepare a management report and disclose according to ESG criteria.

Out of 100 surveyed Ukrainian agricultural holdings, only 14% have published management reports covering social, environmental and governance aspects, the company's operating environment strategy (Figure 3). In this aspect, the most successful companies are MHP, Agroprosperis, Astarta, Vitagro, Nibulon, AgroGeneration, Zakhidnyy Buh, Dnipro Agro Group, Ukraine-2001, AGRICULTURAL TECHNOLOGY COMPANY, A.G.R. Group, SAT, Ecoprod, Cygnet Agrocompany, Kischenzi.

Ukrainian agricultural holdings mainly disclose their initiatives regarding environmental and social aspects of sustainable development and their criteria. Also, Ukrainian companies pay attention to anti-corruption and good management practices (16 and 14% of the 100 surveyed Ukrainian agricultural holdings). 13 Ukrainian companies cover environmental, social, governance and anti-corruption initiatives in their activities.



Source: compiled by the authors according to companies' sites and sustainability reports

Figure 3: Level of disclosure according to ESG - criteria by agricultural holdings in Ukraine .

In addition, six companies out of the top 10 Ukrainian agricultural holdings covered all criteria (Kernel took the 1st place, MHP – 2nd, Astarta-Kiev – 4th, Mriya – 5th, HarvEast Holding – 7th, IMK – 8th, Nibulon – 16th, Grain Alliance – 24th (Baryshivska Grain Company), Zakhidnyy Buh – 27th, Agromino – 28th, Ukraine-2001 – 38th, Agricom Group – 49th, Arnica – 79th). The other seven companies are differentiated by several positions of the rating by the size of the land bank. It indirectly confirms the lack of connection between the volume of the company's land bank and its transparency on sustainable development and SDGs.

SDG 2 (7 companies) are the most actively implemented by Ukrainian companies. No companies pay attention to SDG 9. SDG 7, 8, 13 are implemented by 5 companies, and SDG 3 and 12 - by 4 (Figure 4).

The companies' activities in case of progress, targets and investments in SDG 2 are presented in the reporting information by Kernel, MHP, Astarta-Kiev, Nibulon, Agricom Group, Arnica, Goodvalley Ukraine. SDG 12 is highlighted in the reports of Kernel, Astarta-Kiev, Arnica, Goodvalley Ukraine.

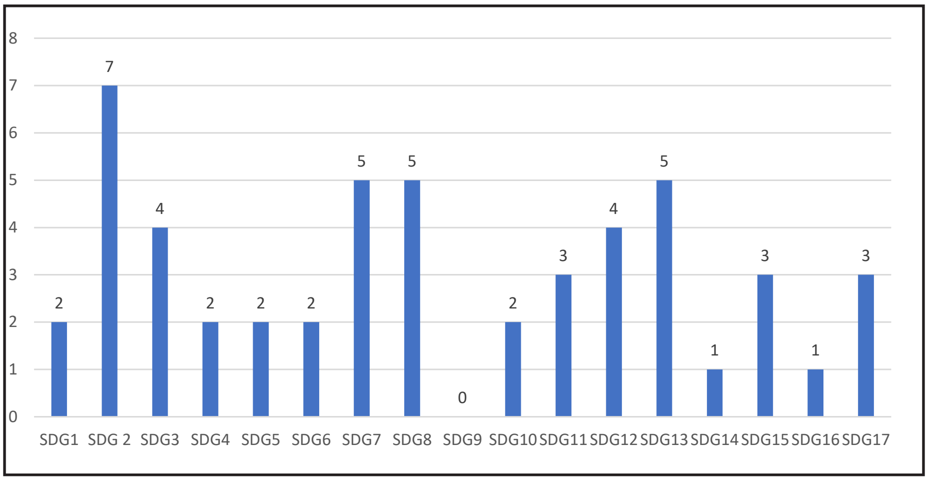
Two Ukrainian companies, in addition to 17 SDGs, mention other relevant goals related to CSR and sustainable development.

For example, as a signatory to the UN Global Compact, Kernel has set an ESG-related goal – to reduce GHG emissions intensity by 5% over a five-year horizon in our oilseed processing business. The general vision of Agricom Group in the context of SDGs sounds like creating the potential of the Ukrainian countryside.

Disclosure of all 17 SDGs set obviously proved the level of agriculture sustainability transparency. But SDG 2 and 12 are the most important for agriculture companies.

It is worth to note that the highest level of SDG 2 disclosure in Ukrainian agriculture companies as a positive benchmark, created only by the largest companies with high level of STI values. As well as SDG 12 is not disclosed properly. Possible explanations of these situation is linked with initial stage of sustainable production technologies introduction by Ukrainian agroholdings as well as usage of extensive technologies in food security provision. The SDG 2 and especially SDG 12 disclosure in agriculture companies sustainability reporting should be promoted.

According to the results of the STI calculation (Appendix A), we obtained the following results (Table 3).



Source: compiled by the authors according to companies' sites and sustainability reports

Figure 4: Level of disclosure by Ukrainian companies in terms of SDGs for March 2021.

Intervals	Number of companies	Average point	Companies
A [80;100]	1	92. 0	Astarta-Kiev
B [60;80]	1	68. 0	Agricom Group
C [40;60]	5	44.8	Kernel, MHP, Nibulon, Goodvalley Ukraine, Arnica
D [20;40]	27	23.4	Clever Agro, Grain Alliance Baryshivska Grain Company), Agromino, Ukraine-2001, Fozzy Group
E [0;20]	66	4.7	Agroton, AgroGeneration, Ecoprod, Agricultural product, Avis Ukragro

Source: Compiled by the authors based on own calculations

Table 3: Grouping of Ukrainian agricultural holdings by STI index value.

The average value of the index for all 100 companies is 46.58 points. However, there is a significant variation of these values (maximum 92 points stand for Astarta, and minimum 0 is present in 29 companies).

There is a relationship between the company reporting and its ownership: if the company has foreign management, it is a guarantee that it is doing well with reporting. The only exception is Prometey. As for agricultural holdings with Ukrainian management, such dependence was not found. Moreover, the large size and turnover of the company do not guarantee that it will have better reporting (if at all) than a company with a poor land bank.

Correlation analysis (correlation coefficient = -0.25) provides preliminary evidence that between Rank and STI there is a reversal relationship: the higher the STI is – the better position in the ranking the company has (or vice versa: the better the position of the company in the ranking – the higher STI has).

To find the answer to the question who is the driver: STI or Rank Granger Causality tests are performed. Results are presented in Table 4. As can be seen, the driving factor is STI. This means the more efforts companies invest into Sustainability Transparency, the higher the position in ranking is.

	F	p-value
Granger Causality Test: Y(Rank) = f (STI)	7.75	0.01
Granger Causality Test: Y(STI) = f(Rank)	1.24	0.27

Source: Compiled by the authors based on own calculations

Table 4: Granger Causality Test: Rank vs STI.

Based on these results, a simple linear regression Y(Rank) = f (STI) is estimated to quantify the parameters of relationship; the results are reported in Table 5.

Parameter	Value
Mean Rank (a_0)	59.24 (0.00)
Slope for the STI (a_1)	-0.47 (0.01)
F-test	6.21 (0.01)
Multiple R	0.25

Note: P-values are in parentheses

Source: Compiled by the authors based on own calculations

Table 5: Regression analysis results: case of *Y(Rank) = f (STI).*

Results imply that the Rank can be described by the following equation:

$$Rank_i = 59.24 - 0.47 \times STIi \quad (3)$$

i.e., there is a negative relationship between the Rank and the STI score. It means the higher the STI score is the better position of the company in the ranking.

We also estimate a regression with dummy variables for *Y(Rank) = f(A;B;C;D;E)*; the results are shown in Table 6.

Parameter	Value
Mean Rank (a_0)	51.00 (0.08)
Slope for the A (a_1)	-46 (0.27)
Slope for the B (a_2)	0 (-)
Slope for the C (a_3)	-13.6 (-)
Slope for the D (a_4)	0.04 (0.99)
Slope for the E (a_5)	4.70 (0.87)
F-test	1.18 (0.32)
Multiple R	0.22
Multiple R	0.25

Note: P-values are in parentheses

Source: Compiled by the authors based on own calculations

Table 6: Regression analysis results: case of *Y(Rank) = f(A;B;C;D;E)*

As can be seen, the Rank would be higher than the average for the companies from A, B, C groups. Affiliation to groups D and E means the company would be ranked below average. This is evidence in favour of rank dependence from STI score and thus transparency of the company.

To conclude, the sustainability transparency of the company is an important element nowadays. As a result, appropriate reporting practices are required.

Conclusion

This paper explored sustainability transparency among agricultural companies in Ukraine.

Agriculture is key sphere for promotion progress in SDG 2 and 12. Despite the evidence that sustainability agriculture practices are important for business, ESG-efforts in agriculture are very limited. One of the reasons of such state of art is not sufficient sustainability transparency and disclosure by agriculture companies.

Nevertheless, the Food and Agriculture Business Principles (UN Global Compact (2021b) fundamental principle is "encourage good governance and accountability", which stressed the huge role of transparent agriculture practice in achievement SDGs.

Authors proved that high-quality and verified sustainability reports, long history of reporting by international standards, participation in CSR and sustainable development networks and disclosure on SDGs (including 2 and 12) is key characteristics of agriculture companies transparency and effective stakeholder (investor) engagement.

The samples of the biggest 100 agriculture companies were formed to conduct a comparative study of the agricultural companies' transparency in Ukraine and their disclosure about SDG 2 and 12.

The following hypothesis was tested (H1): the higher the transparency, the better the company's position is among its peers. To do this Sustainability Transparency Index (STI) methodology is developed. To test H1 STI index is calculated for the top100 Ukrainian agriculture companies.

Preliminary stage of hypothesis testing was comparative analysis of the sustainability transparency of Ukrainian agricultural holdings according to the basic questionnaire and construction STI as well as benchmarking analysis of these companies progress towards SDGs 2 and 12 and CSR practice.

Benchmarking analysis shows that according to UN Global Compact, GRI SDD, CSR Ukraine a small representation of agricultural companies in both countries in the commonly accepted bases for sustainability and SDGs disclosure.

Basic questionnaire on the state of sustainability disclosure, SDG and CSR by agricultural companies includes links to sustainability information on the company's websites, existence of sustainability policy, available reporting period, SDG Reporting, Management report, disclosure according to ESG criteria.

The algorithm of the normalization method of sustainability CSR and SDG disclosure parameters of agricultural holdings within the specified limits was used for STI constructing.

Correlation analysis, Granger causality tests and regression analysis provide evidence in favour of high dependence of position in top 100 from the STI score.

Results of study means that sustainability transparency in agriculture companies is an important element of its activity nowadays. Recommendations to improve sustainability transparency based on suitable reporting practices are provided in this paper.

Main areas for improvement includes:

- verification of analytics sustainability transparency in agriculture, development of methodologies for formulating the sustainability indicator in agriculture companies reporting, verification procedures by auditors in the framework of building a CSR and SDGs (esp. SDG 2 and 12) strategy in the agriculture;
- development the requirements for reliability of the financial and sustainability reporting for agriculture companies in both countries and its mandatory audit;
- taking into account approaches to the mandatory audit of public interest companies, the promotion of good faith in the market of accounting services and agriculture market.
- promoting obligatory and voluntary incentives for the more comprehensive SDG 2 and more special SDG 12 disclosure by agriculture companies in both countries.

Acknowledgments

Alex Plastun gratefully acknowledges financial support from the Ministry of Education and Science of Ukraine (0121U100473).

Inna Makarenko and Artem Rudychenko are grateful to the Czech government for the support provided by the Ministry of Foreign Affairs of the Czech Republic, which allowed this scientific cooperation to start within the project "AgriSciences Platform for Scientific Enhancement of HEIs in Ukraine".

Corresponding authors
Inna Makarenko, Doctor of Economics, Associate Professor,
School of Business, Prague City University, Polská 10, 120 00 Praha 2 - Vinohrady, Czech Republic,
and Accounting and Taxation Department, Sumy State University, 2, Rymskogo-Korsakova st., 40007 Sumy, Ukraine
Phone: +380 669 356 016 , E-mail: i.makarenko@uabs.sumdu.edu.ua

References

[1] Androniceanu, A. (2019) "Social Responsibility, an Essential Strategic Option for a Sustainable Development in the Field of Bio-Economy", *Amfiteatru Economic*, Vol. 21, No. 52, pp. 503-519. ISSN 2247-9104. DOI 10.24818/EA/2019/52/503.

[2] Androniceanu, A. (2021) "Transparency In Public Administration As A Challenge For A Good Democratic Governance", *Administratie si Management Public*, Vol. 36, pp. 149-164. ISSN 1583-9583. DOI 10.24818/amp/2021.36-09.

[3] Bilan, Y., Mishchuk, H., Samoliuk, N. and Mishchuk, V. (2020) "Gender discrimination and its links with compensations and benefits practices in enterprises", *Entrepreneurial Business and Economics Review*, Vol. 8, No. 3, pp.189-204. ISSN 2353-8821. DOI 10.15678/EBER.2020.080311.

[4] Çera, G., Belas, J., Marousek, J. and Çera, E. (2020) "Do size and age of small and medium-sized enterprises matter in corporate social responsibility?", *Economics and Sociology*, Vol. 13, No. 2, pp. 86-99. ISSN 2306-3459. DOI 10.14254/2071-789X.2020/13-2/6.

[5] Cortez, M., Silva, F. and Areal, N. (2009) "Socially Responsible Investing in the Global Market: The Performance of US and European Funds", *International Journal of Finance & Economics*, Vol. 17, No 3, pp. 254-271. ISSN 10769307. DOI 10.2139/ssrn.1342469.

[6] Daugaard, D. (2020) "Emerging new themes in environmental, social and governance investing: a systematic literature review", *Accounting & Finance*, Vol. 60, No 2, pp. 1501-1530. ISSN 0810-5391. DOI 10.1111/acfi.12479.

[7] Indahl, R. and Jacobsen, H. (2019) "Private Equity 4.0: Using ESG to Create More Value with Less Risk Summa Equity", *Journal of Applied Corporate Finance*, Vol. 31, No 2, pp. 34-42. ISSN 1078-1196. DOI 10.1111/jacf.12344.

[8] Latifundist (2021) "*Ukrainian agro companies*". [Online]. Available: https://latifundist.com/rating/top100#315 [Accessed: 10 Dec. 10, 2021].

[9] López, M. V., Garcia, A. and Rodriguez, L. (2007) "Sustainable development and corporate performance: A study based on the Dow Jones Sustainability Index", *Journal of Business Ethics*, Vol. 75, pp. 285-300. ISSN 0167-4544. DOI 10.1007/s10551-006-9253-8.

[10] Makarenko, I. Sukhonos, V., Zhuravlyova, I., Legenchuk, S. and Szołno, O. (2020) "Sustainability reporting assessment for quality and compliance: the case of Ukrainian banks' management reports", *Banks and Bank Systems*, Vol. 15, No 2, pp. 117-129. ISSN 1816-7403. DOI 10.21511/bbs.15(2).2020.11.

[11] MSCI (2021) " *Investment Insights 2021*", Global Institutional Investor Survey. [Online]. Available: https://www.msci.com/zh/our-clients/asset-owners/investment-insights-report [Accessed: Dec. 10, 2021].

[12] Myšková, R. and Hájek, P. (2019) "Relationship between corporate social responsibility in corporate annual reports and financial performance of the US companies", *Journal of International Studies*, Vol. 12, No. 1, pp. 269-282. ISSN 2306-3483. DOI 10.14254/2071-8330.2019/12-1/18.

[13] Nicolescu, L., Tudorache, F. G. and Androniceanu, A. (2020) "Performance risk analysis on mutual funds versus stock exchanges in young financial markets", *Journal of International Studies*, Vol. 13, No. 1, pp. 279-294. ISSN 2306-3483. DOI 10.14254/2071-8330.2020/13-1/18.

[14] Oláh, J., Popp, J., Duleba, S., Kiss, A. and Lakner, Z. (2021) "Positioning Bio-Based Energy Systems in a Hypercomplex Decision Space - A Case Study", *Energies*, Vol. 14, No. 14, pp. 1-17. ISSN 1996-1073. DOI 10.3390/su13169157.

[15] Plastun, A., Makarenko I., Kravchenko O., Ovcharova N. and Oleksich Z. (2019) "ESG disclosure regulation: in search of a relationship with the countries' competitiveness", *Problems and Perspectives in Management*, Vol. 17, No. 3, pp. 76-88. ISSN 1727-7051. DOI 10.21511/ppm.17(3).2019.06.

[16] Plastun, A., Makarenko I., Khomutenko L., Osetrova O. and Shcherbakov, P. (2020) "SDGs and ESG disclosure regulation: is there an impact? Evidence from Top-50 world economies", *Problems and Perspectives in Management*, Vol. 18, No 2, pp. 231-245. ISSN 1727-7051. DOI 10.21511/ppm.18(2).2020.20.

[17] Plastun, A., Makarenko I., Grabovska T., Situmeang, R. and Bashlai, S. (2021) "Sustainable Development Goals in agriculture and responsible investment: A comparative study of the Czech Republic and Ukraine", *Problems and Perspectives in Management*, Vol. 19, No 2, pp. 65-76. ISSN 1727-7051. DOI 10.21511/ppm.19(2).2021.06.

[18] Popp, J., Kovács, S., Oláh, J., Divéki, Z. and Balázs, E. (2021) "Bioeconomy: Biomass and biomass-based energy supply and demand", *New Biotechnology*, Vol. 60, pp. 76-84. ISSN 1871-6784. DOI 10.1016/j.nbt.2020.10.004.

[19] Pronko L., Furman I., Kucher A. and Gontaruk Y. (2020) "Formation of a state support program for agricultural producers in Ukraine considering world experience", *European Journal of Sustainable Development*, Vol. 9, No. 1, pp. 364-379. ISSN 2239-6101. DOI 10.14207/ejsd.2020.v9n1p364.

[20] Samoliuk, N., Bilan, Y. and Mishchuk, H. (2021) "Vocational training costs and economic benefits: exploring the interactions", *Journal of Business Economics and Management*, Vol. 22, No. 6, pp. 1476-1491. ISSN 1611-1699. DOI 10.3846/jbem.2021.15571.

[21] Statman, M. (2000) "Socially Responsible Mutual Funds", *Financial Analysts Journal*, Vol. 563, pp. 30-39. ISSN 1938-3312. DOI 10.2469/faj.v56.n3.2358.

[22] Sukhonos, V., Makarenko I., Serpeninova, Y., Drebot, O. and Okabe, Y. (2019) "Patterns of corporate social responsibility of Ukrainian companies: clustering and improvement strategies for responsible activities", *Problems and Perspectives in Management*, Vol. 17, No. 2, pp. 365-375. ISSN 1727-7051. DOI 10.21511/ppm.17(2).2019.28.

[23] Sunderji, S., Bass, R., Hand, D. and Nova, N. (2020) "*Understanding Impact Performance: Agriculture Investments*", Global Impact Investing Network / The GIIN [Online]. Available: https: //thegiin.org/assets/Understanding%20Impact%20Performance_Agriculture%20Investments_webfile.pdf [Accessed: 10 Dec. 2021].

[24] UN Global Compact (2021a) "*UN Global Compact Participants*" [Online]. Available: https: //www.unglobalcompact.org/what-is-gc/participants/ [Accessed: Dec. 10, 2021].

[25] UN Global Compact (2021b) "Food and Agriculture Business Principles", Global Compact. [Online]. Available: https://d306pr3pise04h.cloudfront.net/docs/issues_doc%2Fagriculture_and_food%2FFABPs_Flyer.pdf [Accessed: Dec. 10, 2021].

[26] United Nations (2015) "*Resolution adopted by the General Assembly on 25 September 2015*". [Online]. Available: https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf [Accessed: Dec. 10, 2021].

[27] Urbancová, H. and Vrabcová, P. (2020) "Factors influencing the setting of educational processes in the context of age management and CSR", *Economics and Sociology*, Vol. 13, No 3, pp. 218-229. ISSN 2306-3459. DOI 10.14254/2071-789X.2020/13-3/13.

[28] Vo, H. D., Van, T. H. L., Dinh, T. H. L. and Ho, M. C. (2020) "Financial inclusion, corporate social responsibility and customer loyalty in the banking sector in Vietnam", *Journal of International Studies*, Vol. 13, No. 4, pp. 9-23. ISSN 2306-3483. DOI 10.14254/2071-8330.2020/13-4/1.

Appendix A

Company	Astarta-Kiev	Agricom Group	Kernel	MHP	Nibulon	Goodvalley Ukraine	Arnica	Clever Agro	Grain Alliance (Baryshivka grain company)	Agromino
Sustainability information	1	1	1	1	1	1	1	1	1	1
Existence of sustainable development policy	1	1	1	1	1	1	1	1	1	1
Sustainable Development Report	1	1	1	1	1	0	0	0	1	1
E	1	1	1	1	1	1	1	1	1	1
S	1	1	1	1	1	1	1	1	1	1
G	1	1	1	1	1	0	1	1	1	1
C	1	1	1	1	1	1	1	0	1	1
SDG 1	1	1	0	0	0	0	0	0	0	0
SDG 2	1	1	1	1	1	1	1	0	0	0
SDG 3	1	1	0	0	0	1	0	0	0	0
SDG 4	1	1	0	0	0	0	0	0	0	0
SDG 5	1	1	0	0	0	0	0	0	0	0
SDG 6	1	1	0	0	0	0	0	0	0	0
SDG 7	1	1	1	0	0	1	0	0	0	0
SDG 8	1	1	1	0	0	0	1	1	0	0
SDG 9	1	1	0	0	1	0	1	1	0	0
SDG 10	1	1	0	0	0	0	0	0	0	0
SDG 11	1	0	0	1	0	1	0	0	0	0
SDG 12	1	0	1	0	0	1	1	0	0	0
SDG 13	1	0	1	1	0	1	0	0	0	0
SDG 14	1	0	0	0	0	0	0	0	0	0
SDG 15	1	0	1	0	0	0	0	1	0	0
SDG 16	0	0	0	0	1	0	0	0	0	0
SDG 17	1	0	0	1	1	0	0	0	0	0
Other goals	0	1	1	0	0	0	0	0	0	0
Verified parameters	23	17	13	11	11	11	10	8	7	7
STI	92	68	52	44	44	44	40	32	28	28
Group	A	B	C	C	C	C	C	D	D	D

Source: Compiled by authors

Table A.1: Top-10 agricultural companies in Ukraine by STI index value.

Appendix B

Parameter	Case 1	Case 2	Case 3	Case 4
Project	"You can – Metro will help": waste management and hunger-fighting initiative	Public station for waste sorting «No waste recycling station»	The entrenchment of the practice of industrial waste minimization through their reuse	Boosting corporate energy efficiency in enterprises
SDG	2	12	12	12
Criteria	Social	Social	Environmental	Environmental, Governance
Company	Metro cash & carry Ukraine, Kyiv city charity foundation "Food Bank"	Subsidiary with foreign investments Pernod Ricard Ukraine	Ukrenergo	GIZ, Ministry of economic development and trade of Ukraine
Number of partners	Over 90	2	-	Over 10
Area	18 regions where METRO is present in Ukraine	Kyiv	Regions where the companies are present	70 enterprises from 4 industries (machine building, production of building materials, dairy industry, bread and bakery products)
Duration	2011 – currently	June 2018 - currently	2019	2018 – currently
Goals	Reduce the amount of waste in the food industry and fight against hunger by donating food and non-food products to people in need – children, people with disabilities, pensioners, people in need.	Improve the environment by involving the community in the waste sorting; encourage authorities to accelerate the adoption of necessary legislation for building the waste sorting and recycling infrastructure; change the attitudes of young people to waste management; reduce the amount of waste disposed in the landfills	To achieve environmentally sound use of all waste types throughout their life cycle by minimizing the amount of industrial waste and ensuring the possibility of their reuse; to ensure sound management of natural resources	To upgrade the quality and degree of technological sophistication and innovation of Ukrainian industries. Energy modernization of Ukrainian enterprises, taking into consideration the reduction of greenhouse gas emissions
Solution	Cooperation with food bank organization; implementation of the regular charitable initiative: "METRO Mykolay", "Share Easter breakfast", "Collect a school bag", aimed at collecting food and non-food goods for charitable and non-profitable organizations in all cities of METRO Stores operation in Ukraine.	Waste sorting by the station's professional team, providing practical training for schoolchildren regarding the importance of waste sorting and processing.	The identification of the state-of-the-art methodologies of industrial waste reuse. The transfer of industrial waste (in particular porcelain insulators) to companies engaged in manufacturing construction mixtures in production processes. The reuse of industrial waste (in particular porcelain insulators) during constructions at the company's substations. The extension of the use period of porcelain insulators, which would have to be disposed of, uses them for substations' decorations.	Based on the open competition results, there were selected enterprises for pilot energy audits and pilot projects to increase energy efficiency. Advice and support are provided to companies by local service organizations who have been trained by international experts and are receiving further support and back-up from them.
Results	The donations have already received more than 90 organizations. Among the recipients – orphans, families in need, people with disabilities, refugees, pensioners. The company conducted "You can – METRO will help" social program	No Waste Recycling Station helps to reduce the amount of waste disposed in the landfills in Kyiv.	Various methods of reuse of industrial waste are defined. The use of natural resources is reduced. Further researches on scientifically sound methods of reusing industrial waste are being conducted	The Training Networks for Energy Efficiency (LEEN stands for "Learning Energy Efficiency Networks") were introduced. In such networks, companies work together on a partnership basis to learn from each other and achieve agreed energy-saving goals. There were formed the Network of energy efficiency bakers and the Network of Manufacturers of Energy Efficient Building Materials
Impact	More than 1 million units of various food, non-food goods and basic needs products have been donated since the project implementation	470 tons of recyclables collected and sent for recycling; 200 lectures and 100 tours were provided	The utilization of industrial waste amounting to UAH 750,000 was avoided.	11 different enterprises from the region plan for 18 months to save 6330 Mwt of energy and reduce CO_2 emissions by 4,210 tons

Source: compiled by the authors on the basis of UN Global Compact Network Ukraine (2020), Voluntary business progress review of achieving sustainable development goals in Ukraine

Table B.1: Examples of real companies' cases in achieving SDG 2 and 12 in Ukraine.

Volume XIV Number 3, 2022

Agricultural Development Around Protected Areas in Vietnam: Agroecology Perspective

Nguyen Thi Trang Nhung[1], Tran Huu Cuong[1], Nguyen Van Phuong[2], Thomas Dogot[3], Philippe Burny[3], Ho Thi Minh Hop[3], Philippe Lebailly[3]

[1] Faculty of Accounting and Business Management, Vietnam National University of Agriculture, Ha Noi, Vietnam

[2] VNU University of Economics and Business, Vietnam National University, Hanoi, Vietnam

[3] Agro-Bio Tech, Liege University, Gembloux, Belgium

Abstract

Agricultural development nearby protected areas is required to minimize negative impacts from uses of off-farm resources as well as improper activities on the ecosystem and ensure livelihood for local farming communities. This research aims at assessing agricultural management practices and outcomes toward agroecology of rice cultivation in the buffer zone of Xuan Thuy National Park. Data were gathered from ecosystem managers, communal authorities and 96 rice cultivators living in 14 villages adjacently to the park in 2017-2018. “Traffic light” approach developed by FAO was used as an analytical technique to evaluate and visualize the environmental sustainability of rice cultivation with three levels of desirable, acceptable and unsustainable. The assessment reveals that none of the environmental indicators achieved at sustainable including fertilizer management, soil fertility, pesticide management, biodiversity preservation, and water conservation. Therefore, agricultural development in this area is required to be scrutinized for improvements especially the overdependency on nitrogen fertilizers, improper application of pesticides, limited adoption of biodiversity-friendly practices as well as other environmentally-friendly practices. The research highlights the need of implementing agroecological approach and special regime for protected area buffer zone to strengthen environmental preservation.

Keywords

Xuan Thuy National Park, buffer zone, agroecology, agricultural development.

Nhung, N. T. T., Cuong, T. H., Phuong, N. V., Dogot, T., Burny, P., Hop, H. T. M. and Lebailly, P. (2022) "Agricultural Development Around Protected Areas in Vietnam: Agroecology Perspective, *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 71-84. ISSN 1804-1930. DOI 10.7160/aol.2022.140306.

Introduction

The integration of agricultural production in protected area buffer zones in Vietnam has been associated with simultaneous beneficial and detrimental consequences. Many issues related to environmental problems from agriculture have been profound. The conversion of wetland mangroves to other land-use forms of aquaculture raising has led to fragmentation of ecosystems and natural habitat degradation (Khai and Yabe, 2014). The expansion of farming to new areas has resulted in wide encroachment into protected areas and drainage of natural wetlands. Agricultural developments with improper practices have destroyed biodiversity and habitats, driven wild species to extinction, accelerated the loss of environmental services, and eroded agricultural genetic resources. Farms discharge large quantities of agrochemicals, organic matter, drug residues, and sediment into water bodies. The resultant water pollution posed demonstrated risks to aquatic ecosystems, human health, and productive activities (Pedersen, 1996; Buckton, 1999; Gilmour and Van San, 1999; Haneji et al., 2014; Khai and Yabe, 2014; Kamoshita et al., 2018). The question is how the residents living adjacent to the protected site use land and other natural resources for their livelihood in a way that does not impair the long-term viability of environmental assets of the areas? Or how the agricultural production systems around the conservation sites are designed and managed to enhance the positive impacts of conservation on protected areas and reduce the negative impacts of farming activities on the environment? Whether buffer communities should be treated differently from outer ones? How can communities and agencies involve more in conservation activities? Many challenges and constraints continue to pose problems to the sustainable development of agriculture nearby protected areas that aim to conserve the natural environment while providing the basis for the economic development of local residents. The protected area practitioners should be equipped with the valuable information to achieve effective management as a basis for creating improved futures for species, ecosystems, and maintaining healthy environments. Due to diverse obstacles, policies should be translated into development and conservation activities in and around protected areas, and efforts to address the environmental problems associated with agricultural activities should focus on technical improvements in management practices with more rigorous monitoring and regulations. These measures have largely sought to control the environment in which agriculture takes place.

Xuan Thuy National Park plays an important ecological function in preventing damages of storms and tidal surges, supporting fisheries, birds and mangroves, absorbing waste and replacing sediment, maintaining biodiversity. The park also contributes greatly to economic values for people including reducing natural disaster losses, providing commercial values of fisheries and non-timber forest products, improve outcomes from farmed/harvested species (Hai and Nhan, 2015). Policymakers and governors recognize this park as a place to balance socioeconomic development and environmental protection (Leslie et al., 2018). The livelihood of most people living near the park relies on agriculture (cropping, livestock and aquaculture account for over 90% of the total labor force). Farmland expansion and agricultural intensification for food demand of growing population around the park cause depletion of water quality, mangrove fragmentation and destruction, wetland biodiversity deterioration, and increasingly vulnerable levels (Beland, 2006; Nhuan et al., 2009; Nhan, 2014; Haneji et al., 2014; Hai and Nhan, 2015; Kamoshita et al., 2018). Rice farming system dominate the buffer zone and provide main income sources for local people. Current farming practices in the buffer zone have created many problematic issues such as a similarly high rate of fertilizers and pesticides as compared with non-buffer zones (Kamoshita et al., 2018), water conflicting due to pollution from farms (Nguyen et al., 2019); higher concentration of pesticides and herbicides than allowed ranges (Mai and Nguyen, 2003).

In the light of the above, this research seeks to assess the current situation of agricultural production around protected areas under the context of environmental protection for foreseeable agroecology, take Xuan Thuy National Park as a case analysis.

Materials and methods

Case study selection: Rice cultivation around Xuan Thuy National Park

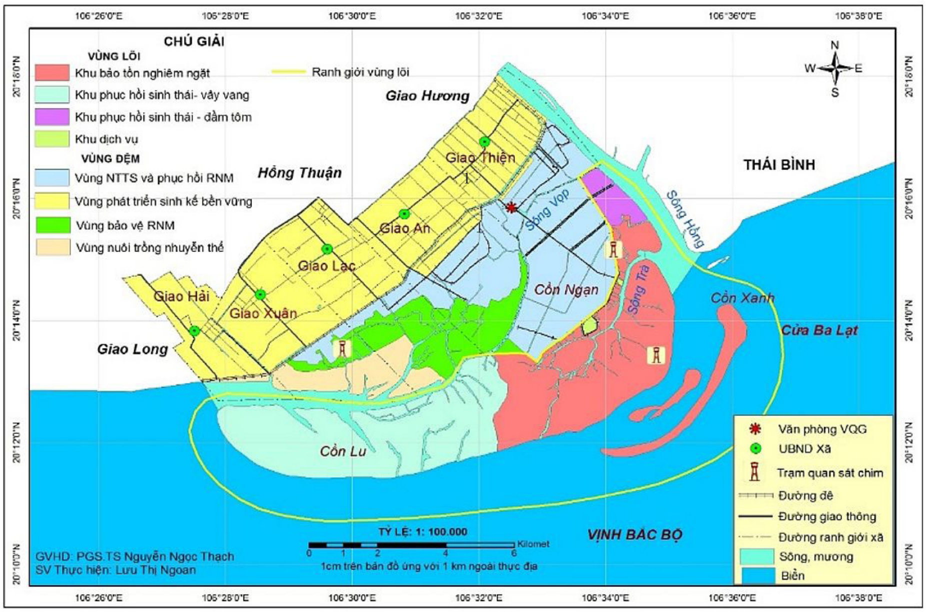
Xuan Thuy National Park (XTNP) situates in Giao Thuy district, Nam Dinh province, Vietnam. It covers a total area of 7,100 ha extending from latitude 20°10’ to 20°15’ North and longitude 106°20’ to 106°32’ East (VAF, 2017). The park is under the authority of Nam Dinh People’s Committee. The 8,000 ha buffer zone locates adjacently the park. The buffer communes are under the administrative management of Giao Thuy district People’s Committee. Agricultural production in the buffer zone is under the expertise instruction of the Division of Agricultural and Rural Development (DARD) and the Center of Agricultural Services of Giao Thuy district People’s Committee (Figure 1).

The case study taken is XTNP including its buffer zone due to several criteria as follow:

- The park has conservation and development functions:

  XTNP has particular environmental and economic significance because it has rich biodiversity and coastal protection role. Main functions of XTNP are ecological function for the region and economic function for local communities which is based on the Decision 01/QD/TTg/2003 by the Vietnamese Prime Minister. There are six specific functions (Hai and Nhan, 2015):

  - Conserving wetland with mangroves and wetland without mangroves;
  - Preserving migratory and local birds;
  - Sustainable using and preserving aquatic habitats;
  - Adapting and minimizing vulnerability from climate change;
  - Increasing benefits from ecosystem services for local communities; and



Note: (1) Signifies rice fields
Source: Hai and Nhan, 2015

Figure 1: Map of Xuan Thuy National Park and the buffer zone.

- Contributing to socio-economic development for the region.

- XTNP is place for balancing socio-economic development and environmental protection.

Policymakers and governors recognize this park is a place to balance socioeconomic development and environmental protection (Leslie et al., 2018). The park plays an important ecological function in protecting coasts against typhoons, storms, and tidal surges, providing sources of fisheries, mangroves, and replacing sediment. The park also contributes greatly to economic values for people including reducing natural disaster losses, providing commercial values of fisheries and non-timber forest products, improve outcomes from farmed/harvested species.

- Local communities continue to rely on XTNP's ecosystem for rice-related livelihoods.

Rice farming system has been cultivating largely with almost all households around XTNP since the 1960s. Rice is grown by two mono-crops per year. The winter-spring crop starts from the middle to the end of January when rice varieties are sown or transplanted then harvested at the end of May. The land is dried for about two weeks before starting the second crop (summer-autumn) in the middle of June then harvested around the end of October. Rice straw is mainly burned in fields. After the second crop, local cultivators dry and fallow land for about eight weeks then starts preparing land with plow by machines for the next crop. There are two varieties including pure-line and high-yielding. This production is a low-intensive technological application. Only machines are used to plow land and harvest grains. Various inorganic fertilizers and pesticides are widely utilized in rice plots. Our further results reveal that there is no special training or different farm management skills for rice farmers in the buffer communes of XTNP in comparison with outer communes. The guidelines for rice cultivation have been disseminated similarly for all communes of Giao Thuy district.

Data collection and analysis

Data collection

Fieldwork is carried out from 2017 to 2018 with a total of 96 respondents. A sample size of the household survey was calculated by the Toro Yamane equation:

$$n = \frac{N}{1 + N(e)^2}$$

where n = sample size; N = total households practicing each farming system (2,737 households); *e* = level of precision (e = 0.1). For this parameters, *n* = 96 respondents. Then, Fish Bowl Draw sampling (simple random sampling) was used to choose interviewers in 14 village of Giao Thien buffer commune. All aspects of rice cultivation were interviewed including farming knowledge and practices, production management, farm performances, economic and environmental issues incorporated with the production

Moreover, this research also approached Xuan Thuy National Park managers, headers of the Giao Thien commune to investigate their roles in disseminating advisory services for rice growers.

Data analysis

This research uses core indicators of agroecological outcomes with links to the development and conservation aims. Table 1 presents indicators used if farms are utilizing agroecological principles in their design and management:

Indicators	Sources
Yields	Buck et al., 2006, Trabelsi et al., (2016); D'Annolfo et al (2017); FAO (2018); Trabelsi et al. (2019).
Net farm income	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Soil fertility	SOCLA & TWL (2015); Trabelsi et al., (2016); FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Pesticides management	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Fertilizer management	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019)
Biodiversity	Trabelsi et al., (2016); D'Annolfo et al (2017), FAO (2018); Trabelsi et al. (2019); Mottet et al (2020).
Water preservation	FAO (2018); Trabelsi et al. (2019)

Source: Mottet et al., 2020; Trabelsi et al., 2019; FAO, 2018; D'Annolfo et al., 2017; Trabelso et al., 2016; Buck et al., 2006.

Table 1: Core indicators of agroecology with links to sustainable livelihood and sustainable agriculture.

◦ *Net farm income:* Income from agroecological production enables the economic viability of farms. Incomes of farms ensure households gain profits. Net farm income is calculated by the formula: Revenue from animals/plants/other farm activities (quantity of crops/animals/other activities sold multiplied by the gate price) + Income in kind – Total operating expenses after rebate (input costs + depreciation of equipment and machinery + taxes + hired labor costs + interests + cost land rent + veterinary service costs) + subsidies (FAO, 2018; Mottet et al. 2020).

◦ *Use of biodiversity-friendly practices*: According to Mottet et al., (2020), the biodiversity of agroecological farming is evaluated through the method of FAO (2018). FAO (2018) uses elaborated methods of biodiversity-friendly practices to appraise environmental outcomes of crop or livestock production: (1) leaving at least 10% of the total area for natural or various vegetation; (2) non-pesticides and antimicrobials application; (3) at least two of the following contribute to the production: crop/pasture; trees; animal products; fish (each of them account at least 10% value of the holding production); (4) applying crop rotation at least 3 crops on at least 80% of farm area over 3 years; (5) using at least two different varieties for above 2 ha farmland; applying monoculture for below 2 ha farmland; (6) at least 50% of livestock population use local breeds. The sustainability of biodiversity are calculated as follow:

* Desirable: farmers use at least four measures.
* Acceptable: farmers use 2-3 measures.
* Unsustainable: farmers use fewer than 2 measures.

◦ *Pesticide management:* Improper use of pesticides causes harm to people and the environment. Good practices can reduce the associated risks. Agroecology provides various methods to reduce the need for pesticides (Mottet et al., 2020). Pesticide management assessments of agroecology are proposed based on the methods of FAO (2018): FAO (2018) uses three measures for protecting health: (1) adherence to label recommendations; (2) cleansing equipment after use; (3) safe disposal of waste. FAO (2018) uses eight measures for protecting the environment: (1) following label recommendations; (2) applying good agricultural practices (crop rotation, mixed cropping, inter-cropping, crop spacing, etc.); (3) adopting biological pest control or bio-pesticides; (4) Adopting pasture rotation to suppress livestock post population; (5) applying pest resistant/ tolerant rice varieties/disease resistant/certified seeds;

(6) removing rice plant attacked by pest and disease; (7) cleansing equipment after use; (8) using less than two times for each pesticide in a season to restraint pesticide resistance. The sustainability levels of pesticide utilization are:

* Desirable: farms do not use pesticides or use slightly: farmers follow three measures of health protection and at least four measures of environmental protection.
* Acceptable: farm applies at least two measures of health protection and at least two measures of environmental protection.
* Unsustainable: farm applies fewer than two measures of each above list.

◦ *Soil fertility:* Fertility refers to the capacity of a soil to provide crops with nutrients with stability over the years. Soil fertility or soil health underpins farmed outputs and ecosystem functioning. It is a core element of sustainable agroecology (Trabelsi et al., 2016; FAO, 2018; Trabelsi et al., 2019; Mottet et al., 2020). A range of agroecological activities can improve soil fertility such as crop residue protection, animal manure or cover crop, etc. (Mottet et al., 2017). The assessment of soil fertility is proposed based on the approach of FAO (2018): four threats are used to capture farmers' knowledge about the state of their soil: soil erosion; reduction of soil fertility; salinization or irrigated land; and waterlogging. The sustainability of soil fertility is conducted by FAO (2018):

* Desirable: less than 10% of the farmland is affected by any of the four threats.
* Acceptable: 10-50% of the land is affected by any of the four threats.
* Unsustainable: above 50% of the land is affected by any of the four threats.

◦ *Fertilizer management:* Fertilizer management assessment of agroecology is proposed based on the methods of FAO (2018) that fertilizers must be managed sustainably: (1) not exceed dosages; (2) use organic nutrient sources; (3) use leguminous plants to reduce chemical fertilizers; (4) distribute fertilizers in several times over the growing period; (5) consider soils and climate conditions; (6) use soil sampling at lease every five years to calculate nutrient budget; (7) apply precision farming; (8) use buffer strips along with watercourses. The sustainability levels of fertilizer utilization are:

* Desirable: farms do not use fertilizers or use fertilizers and apply at least four above measures.
* Acceptable: farms do not use fertilizers or use fertilizers and apply at least two above measures.
* Unsustainable: farms use fertilizers and apply non-above measures to mitigate environmental risks.

◦ *Water preservation:* Agriculture causes unsustainable use of water sources. Trabelsi et al., (2019) use techniques of wastewater or effluent treatment as an indicator to assess the water pollution indicator of agroecology. FAO (2018) conducts a farm survey that gathers information on farmers' awareness concerning water use: whether farmers use water to irrigate the cultivation, how they perceive water scarcity and how irrigation agents work effectively. These data provide alternative sources to assess official statistics on water resource use. FAO (2018) evaluates the sustainability of water preservation in crop cultivation are:

* Desirable: farmers use irrigated water below 11% of farmland
* Acceptable: farmers use irrigated water above 10% of farmland, or farmers do not know whether water stable in years; or farmers experience a shortage of water but irrigation agents allocate water effectively.
* Unsustainable: others.

Data analysis was conducted through the use of SPSS program version 22.0. A Mann-Whitney U test was used to analyze the difference-of-means of fertilizer doses according to different rice varieties and different cropping seasons.

Results and discussion

Agricultural development toward agroecology around Xuan Thuy National Park

Knowledge and application of agroecological practices

Based on the guidelines of FAO for Best Farm Management Practices of irrigated lowland rice cultivation in Asia which are presented by Joint

(2018), we have asked farmers for their knowledge and the application of eco-friendly practices in previous cropping seasons. Our results reveal the low percentage of farmers knowing different methods of agroecology as well as limited application (Table 2).

Our further results reveal diverse reasons for the limited application of agroecological-based practices as follow:

- Soil fertility management methods: Farmers have limits on their own energy and time. Soil fertility management methods require for more labour and time consuming as compared with conventional ones. If they use hired labour, it could reduce their profitability. Poor economic situation of local farmers as well as and high incentive for profits are barriers to the adoption of environmental friendly practices.
- Site specific integrated nutrient management: Farmers face unavailability as well as inaccessibility of conservation equipment to test soil fertility. There are no public and private shops or other places to sell and provide the tools for farmers.
- Integrated pest management:
    - First, integrated pest management practices need longer time between treatment and effect than chemical pesticides. However, farmers lack understanding of long-term benefits of these methods. In this area, there are no demonstration farms to convince farmers to follow the good practices.
    - Second, ongoing habits limit the involvement of farmers in good practices. Farmers feel convenient with things that their parents and neighbors do. New things become unfamiliar for farmers. Farmers also perceive complexity when changing current activities.

Third, lack of institutional supports for sustainable

Methods	Percent of farmers know	Percent of farmers applied
1. Soil fertility management		
- Incorporate residues from previous crops into the soil during land preparation	100.0	30.2
- Incorporate organic manure and compost with chemical fertilizers	100.0	32.3
2.Site specific integrated nutrient management		
- Use leaf color chart as a mean to assist farmers to use proper dose of N fertilizer in different plots	17.7	0.0
3. Integrated pest management		
3.1 Agronomic tactics		
- Crop rotation/mixed crop/intercropping/ trap crops	81.2	0.0
3.2 Mechanical tactics		
- Collecting eggs of harmful pests by screens/barriers	100.0	25.0
- Trapping insects by suction devices (light, nets, etc.)	93.8	24.0
- Removing affected rice plants to prevent spread of diseases	42.7	30.2
3.3 Biological tactics		
- Conservation of natural enemies	45.8	25.0
- Do not use preventive insecticides	52.1	27.1
- Do not use early preventive spraying (before the first 40 days after transplanting)	20.0	20.0
- Growing legumes or broad leaf weeds on rice field bunds for natural enemies	17.7	0.0
- Growing grass and other vegetation near rice fields for natural enemies	0.0	0.0
- Conserve insect predator frog, toad, birds by preventing their capture from rice fields	0.0	0.0
3.4 Chemical tactics		
- Used chemical pesticides as the last methods when all of non-chemical methods are fail to control	19.8	16.7

Source: Survey, 2018

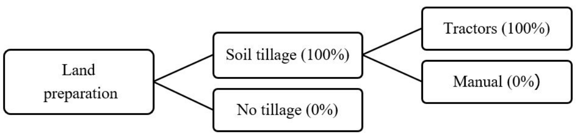
Table 2: Knowledge of farmers and the application of agroecological practices in RB.

practices: Shortage of environmentally friendly programs as well as agricultural advisors restrains to learning process and application of farmers. Farmers wonder the practices will work in their soil/farms without reduction of yield?

Current practices

Land preparation

Farmers apply two mono-crops annually. The first crop starts from the middle to the end of January to the end of May. Land is dried for several weeks before starting the second crop in the middle of June to the end of October. This production is a low-intensive technological application. Farmer use machines in two production stages (plow land and harvest grain) and animals are no longer used in the production (Figure 2). Four-wheel motorized tractors or hand-pulled tractors are used in soil tillage by all of the respondents. A small number of residues from previous crops and organic manure are incorporated in the plowing. Soil is plowed to become puddle and levelled. Farmers do not apply the non-tillage method.

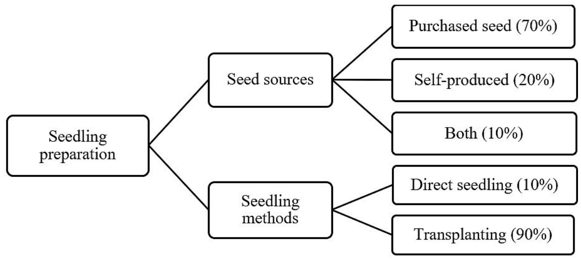


Surrvey, 2018

Figure 2: Land preparation.

Seedling preparation and transplanting

Rice seedlings were transplanted (90% respondents) or direct seeded (sa lua) (10% respondents) with plentiful varieties including pure-line and high-yielding. The majority of farmers (70%) bought seeds from communal agricultural cooperatives and local traders in villages, while a small number of respondents used self-produced varieties (Figure 3). Farmers carried rice seedlings from the nursery into fields and transplant by manual with the density of 2-3 seedling/hills. Seedlings were grown at a 1-2 cm depth. The distance from hill to hill was ranged from 20 x 20 cm to 25 x 25 cm. In this stage, no machines were used.

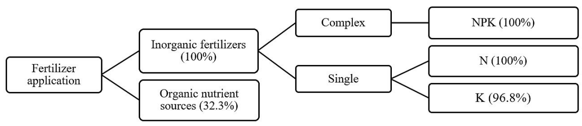


Surrvey, 2018

Figure 3: Seedling preparation.

Fertilizer application

Figure 4 shows the utilization of fertilizers during the growth of rice. Farmers in the buffer zone of XTNP combined blend NPK (nitrogen – phosphorus – potassium) with single N (nitrogen) and K (potassium) for grain yield improvement. All of the surveyed rice farms were cultivated with compound NPK (100% respondents), N (100% respondents) and K (96.8% respondents), whilst only 32.3% of farmers still used organic sources (compost and manure).



Surrvey, 2018

Figure 4: Fertilizer application.

There were diverse kinds of NPK fertilizers with different ratios of pure N-P-K were used in this area such as NPK (16-16-8), NPK (5-10-3) or NPK (5-12-3), etc. However, most farmers were unable to understand the meanings of the ratios. Tables 3 presents the amount of N, P and K used in rice after authors' conversion from farmers' uses.

Based on demographical characteristics, the Division of Agriculture and Rural Development of Giao Thuy district recommended farmers to apply less fertilizers in the 2nd season than 1st season for both kinds of varieties because the 2nd season has better favorable weather with more rain and shorter

Fertilizers	Inbred varieties		High-yielding varieties	
(kg/sao/season)	1st season	2nd season	1st season	2nd season
N	15.74[a]	15.65[a]	14.17[a]	14.0[a]
P	9.27[a]	9.36[a]	9.13[a]	7.11[a]
K	4.85[a]	4.86[a]	4.22[a]	3.31[a]

Note: The same alphabet characters after mean denote the similarity between two seasons ($p > 0.05$) from the Mann-Whitney U test. Significance at 1%. 1 sao is equivalent to 360 m^2.
(Source: survey, 2018)

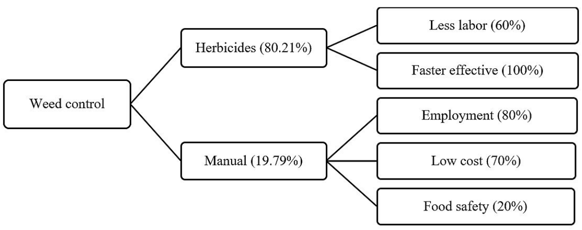
Table 3: Fertilizer rates according to different varieties in different seasons.

growth duration (12-20 days) (DARD, 2017). The instructions were informed to farmers through agricultural extension personnel of communal agricultural board and communal agricultural cooperative. However, the Mann-Whitney U tests demonstrate the similarity in fertilizers employed between two seasons according to different varieties

Results also highlight the overloading of N. Farmers applied at the average of 14.0 kg/sao/season for high-yielding rice (equivalent 388.9 kg/ha) and 15.7 kg/sao/season (434.8 kg/ha) for inbred. The rate is higher than local standards suggested by the Division of Agriculture and Rural Development (maximum 12 kg/sao/season or 333.36 kg/ha/season) (DARD, 2017) and other tropical regions such as China (360 kg/ha) (Xiaowei et al., 2016) and in Philippines (from 60 to 120 kg N/ha) (Shaobing et al., 2004).

Weed, pest and disease control

Weeds are one of the most serious constraints to rice cultivation in this area because weed competes with rice for light, water, nutrients, and space. Figure 5 shows two methods of weeding in XTNP's buffer zone including chemical weed control (herbicides) (80.21% of our respondents) and manual weeding (19.79% of our respondents). Farmers preferred herbicides because this method requests less labor and has faster effectiveness.

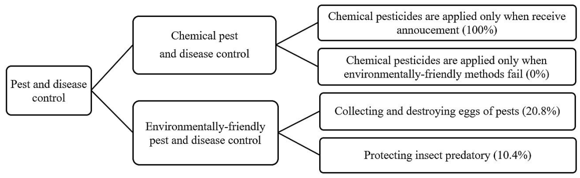


Surrvey, 2018

Figure 5: Weed control.

A small percentage of farmers recognized the negative impacts of herbicides for grain quality, they applied hand weeding. They removed weed manually after about 20-25 days since transplanting time or about 30-35 days after direct seedlings. They repeated weeding the second time or more. Hand weeding also provided employment and lower cost especially poor farmers.

There were 100% of our respondents often applied chemical methods to eliminate pests, snails or funguses when receiving announcements of communal authorities instead of basing on field observation. They did not consider environmentally-friendly methods before spraying chemical pesticides (Figure 6). Besides chemical inputs, a moderate proportion of farmers adopted ecosystem management-based methods such as destroying eggs of caterpillars and snails (20.8%) or protecting insect predators such as toads and birds (10.4%).

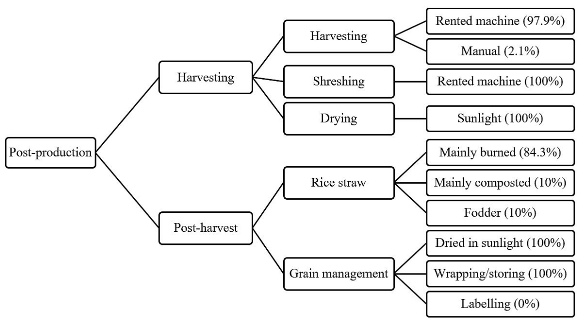


Surrvey, 2018

Figure 6: Pest and disease control.

Post-production

Post-production includes harvesting, bundling, hauling, threshing, drying, cleaning, storage, milling and grading of rice. Farmers harvested grain when the majority of them became mature. There were 97.9% of farmers hired machines to harvest rice and 2.1% of them harvested grains by hand. Then farmers quickly shreshed rice grain by machines (100% of respondents) on the fields to prevent the attacks of rats, insects or pathogenic fungi. Rice grains were dried in open sunlight to remove moisture content. When the moisture rate was low, farmers removed unfilled grains by fan winnowing. At the following stage, farmers stored grains and seeds in woven plastic sacks or airtight containers to prevent absorbing moisture from outside and damages by rats during months. Rice straw was mainly burned (84.3% of respondents) in fields or composted with other household wastes (6.2% of farmers) or carried home to use as fodder for animals (9.5% of farmers) (Figure 7).



Surrvey, 2018

Figure 7: Post-production.

Outcomes

From economic perspective, farm yields measure the physical productivity of land in crops or aquaculture farming. It is an indicator of agricultural productivity expressed as the amount of farm outputs given a certain area and during a certain period. Rice yield was 6,22 kg/ha/crop, which was much higher than the Vietnam national average (5,54 kg/ha) (FAO, 2017). High yield and net farm income are considered a top incentive of local farmers and communal authorities (Table 4).

Indicators	Value	Percent (%)
1. Total cost (mil.VND/ha/year)	104.31	
1.1. Purchased input costs	103.20	
Family labor	58.34	55.93
Hired machinery	16.50	15.82
Seedlings	3.15	3.02
Chemical fertilizers	15.68	15.03
Pesticides	6.21	5.95
Hired labor	3.32	3.18
1.2. Fixed costs		
Land charge	1.11	1.07
2. Yield (ton/ha/crop)	6.22	
3. Product price (mil.VND/kg)	0.006	
4. Gross output (mil.VND/ha/year)	124.79	
5. Net farm income (mil.VND/ha/year)	20.48	

Note: VND: Vietnam Dong. Exchange rate: 1 USD = 23,300 VND on October 13rd 2021
Source: Survey, 2018

Table 4: Net farm income of rice production.

From environmental perspective, rice cultivation creates many problematic issues in this area. Our results reveal none of the environmental indicators gain desirable or sustainable (Table 5).

We highlight that the utilization of synthetic fertilizers in rice fields was mainly unsustainable (67.7% of respondents) because they apply none of the measures to restraint the environmental risks. Only 32.3% of respondents applied two measurements to reduce associated environmental consequences (use organic nutrient sources and distribute fertilizers several times over the growing period). Due to inordinate practices, the sustainability of soil fertility was mainly undesirable (88.54% of respondents).

The adoption of chemical pesticides was assessed at acceptable but interviews with farmers and locals reveal the growing doses of pesticides incorporated with the dramatic reduction of biodiversity in paddy fields, frequent disease occurrence, and serious outbreak of exotic snails (Pomacea canaliculata). However, very few eco-friendly practices of pest and disease control are introduced and applied. Most farmers consider pesticides as a preventive resort rather than disease treatment.

The practices of agrobiodiversity conservation are also evaluated as unsustainable levels (100%

Indicators	Percent (%)	Levels of sustainability
1. Fertilizer usage		
No fertilizers/acquire at least four measures to reduce fertilizer-related risks	0.00	
Use fertilizers and acquire at least two measures to reduce fertilizer-related risks	32.30	Acceptable
Use fertilizers and do not apply measures to reduce fertilizer-related risks	67.70	Unsustainable
2. Soil fertility		
Below 10% farm area get affected	0.00	
10%-50% farm area gets affected	11.45	Acceptable
Above 50% of farm area get affected	88.54	Unsustainable
3. Pesticide management		
No pesticides, follow three health-related measures and at least four environmental-related measures	0.00	
Use pesticides, follow at least two health-related measures and at least two environmental-related measures	100.00	Acceptable
Use pesticides without applying any health-related and environmental-related measures	0.00	
4. Biodiversity-friendly practices		
Above 3 measures	0.00	
From 2-3 measures	0.00	
Below 2 measures	100.00	Unsustainable
5. Water preservation		
Use irrigated water below 11% of area	0.00	
Use irrigated water above 10% of area/water availability reduction experienced	100.00	Acceptable
None of above cases	0.00	

Source: Survey, 2018

Table 5: Environmental issues of rice production.

of respondents) because farmers applied only one measurement of biodiversity conservation (growing several kinds of varieties including inbred and hybrid).

Rice cultivation in this area relies mainly on irrigation. Water is managed by private limited companies. Irrigation calendars for farming were informed to locals. Farmers were accessible to intake water and their farms were not waterlogging, so the irrigation in rice was acceptable. Nonetheless, none of the respondents apply methods for water-saving or low volume such as drip. There are no limits for access to irrigation water such as pricing, quotas, priority usage, etc. Large volumes of irrigated water used for an intensive rice system might leach more chemicals into nearby ecosystems.

Discusion

Agricultural operation adjacent protected areas needs to meet plentiful goals of increasing farm outputs and reducing costs through raising the quality of habitats and ecosystem services (Sara and Jefferey, 2008). This helps to satisfy the demands of foods and ecosystem services of communities in environmentally sensitive sites such as flood control or climate change adaptation. According to Sara and Jefferey (2008), agroecology manages landscapes for both production and conservation purposes including: (1) ensuring sustainable livelihood for farmers, (2) benefiting agriculture through ecosystem services such as pest control, soil fertility, water quality, and pollination, etc., (3) conserving outside landscape such as flood protection and carbon sequestration, etc.

Even though being a buffer zone of international and national importance site, this zone lacks agriculture conservation-related programs. At the commune level, buffer communal authorities (communal agricultural board and communal agricultural cooperative) focus mainly on food security and income improvement through grain yield enhancement. They sell materials (fertilizers, pesticides, and rice varieties), and disseminate knowledge on stages of production (land preparation, irrigation, plant protection, fertilizing, etc.) for farmers. While XTNP management board is in charge of ensuring environment conservation within the park (core zone-7,100 ha). The park only approaches local communities to educate and propagate them to preserve the living environments, such as garbage managing, bird conservation, and growing trees. Currently, farmers have no interaction with XTNP's staff for rice cultivation. This research recommends that the park should have more political authority to restraint the farming activities that harm the environment and promote decisions in eco-friendly cultivation. The park should have the political power to maintain environmentally-friendly production. The park should have key roles to monitor environmental assessment of agriculture, work with farmers to suggest alternative and more natural-friendly activities and techniques.

Thus, special regimes for agricultural development nearby the protected area need to be issued to restraint the risk of agrochemical pollution. Nam Dinh PPC must establish specific laws and regulations for XTNP's buffer zone which ensure that agricultural production nearby the park should be a mean to continue protecting soil, water sources and biodiversity. To ensure biodiversity conservation and landscape improvement, Nam Dinh PPC must integrate ecological outcomes of agricultural production. These programs require to safeguard wild habitats through the restriction of synthetic fertilizers, chemical pesticides and other drugs. The government might allow farmers to continue farming activities but without fertilizers, pesticides, and other hazardous chemicals and subsidy for the loss of income. There is a need for economic incentives from the government for local farmers. Economic instruments require regulations on paying farmers directly or creating markets for those whose practices for minimizing environmental impacts and provision of ecosystem services for the region, reward farmers and communities for their conservative activities in cultivation or participate in the protection of the landscape.

Without some forms of intervention, short-term financial incentives lead to the intensive use of agrochemicals, while conservative measures were not adopted around the sensitive site. Current practices need to be modified if they cause potential impacts on the environment. Agricultural production in this area is required to be scrutinized for improvements to ensure that agriculture would remain viable in the future. A major focus of activities needs to be targeted on individuals and groups of farmers that still make the greatest use of natural resources adjacent to the conservation site:

One indication that farmers overused chemical fertilizers than local suggested standards. Even though the imbalance fertilization has long been existed, farmers and local authorities face difficulty in matching crop needs with existing soil fertility due to the lack of equipment, capacity and budget.

As warned by Lin and Jayant (2003), the overuse for these inputs can lead to leaching fertilizers and expanding nitrate contents into soil, groundwaters, crops and human health. Therefore, this research recommends that a reduction in nitrogen dosage and precise fertilizing can help reduce the input costs and improve soil health. Precision fertilizing knowledge is urgent to be transferred for farmers through communal extension personnel and XTNP's staff to tackle the abuse of N. Applying leaf color chart (Singh et al., 2007; Singh et al., 2014) can help farmers to determine the volume of N for different rice varieties in different seasons. This is a simple farming equipment for judging the dosage of N based on plant demand and soil variability, it, therefore, helps cultivators to manage farms with greater precision and cost-saving. Growing legumes and adding them with farm residues to the soil is an effective way to improve lowland rice yield and reduce the overloading of N which was pointed out earlier by Ladha and Reddy (2003). In addition, integrated mechanical, biological and botanical methods of pest and disease control should be enhanced in this area to improve the efficiency simultaneously reduce threats to wildlife including collecting and destroying eggs of pests; removing affected rice plants to prevent the spread of diseases; allowing grasses and vegetation adjacent to rice fields to conserve natural enemies; conserving as much as possible insect predators (birds, frogs, and toads, etc.) to stimulate rice insect pests; and maximizing the use of local resources through extracting oil and powdering seeds from locally available plants (papaya, custard apple, lemongrass, etc.). Rewarding farmers for their eco-friendly efforts would be considered to encourage more people to protect the environment.

Lack of awareness on the long-term benefits of agroecological production of provincial and lower authorities remains high-yielding orientation. Thus, there is also a dramatic need for education creating and/or improving awareness and willingness of managers, environmentalists, agriculturists, and farmers to participate in ecological agriculture programs.

Conclusion

The small-scale rice cropping system has been cultivated largely by households in the XTNP's buffer zone. Farmers grow rice in two mono-crops per year and synthetic fertilizers play essential roles for rice growth. Farmers preferred to combine diverse kinds of compound NPK with single N and K. There was a small proportion of households that used organic nutrient sources but they overused N. Pest and disease were controlled widely by chemical pesticides, whilst farmers applied limited requirements of health and environmental-related risk mitigation.

The research highlights the limited knowledge and application of agroecological-based practices in rice cultivation. The range of environmental indicators was evaluated. The application of biodiversity-friendly methods was critically unsustainable. Pesticides and water use were evaluated at acceptable but they are required to adjust. Soil fertility and fertilizer-related risks are concerned as unsustainable. In general, most of the environmental indicators are not sustainable.

Agriculture adjacent to protected areas needs to ensure dual goals of development and conservation or in other words, satisfy economic viability for people and environmental soundness for the ecosystem. Agroecology approach is highly recommended in this research to (1) improve economic resilience at farm level through effective cost strategies incorporate with eco-friendly farming practice, and (2) strengthen collective actions between XTNP and local authorities. The researchers suggest that XTNP should become a major agency to lead nearby communities to move forward conservation agriculture. The park needs to work with buffer communes to assist farmers with integrated nutrient management for crop yield enhancement while maintaining soil health. The coordination between XTNP and buffer communes in agricultural programs or assigning technicians of the park to work with buffer communes can ensure conservative goals and environmental performances are integrated into agricultural developments.

Corresponding authors
Nguyen Thi Trang Nhung
Faculty of Accounting and Business Management, Vietnam National University of Agriculture
100000 Ha Noi, Vietnam
E-mail: nttnhung@vnua.edu.vn

References

[1] Beland, M., Goita, K., Bonn, F. and Pham, T. (2006) "Assessment of land-cover changes related to shrimp aquaculture using remote sensing data: a case study in the Giao Thuy District, Vietnam", *International Journal of Remote Sensing*, Vol. 27, pp. 1491-1510. ISSN 0143-1161. DOI 10.1080/01431160500406888.

[2] Buck, L. E., Milder, J. C., Gavin, T. A. and Mukherjee, I. (2006) "Understanding ecoagriculture: a framework for measuring landscape performance", Ecoagriculture Discussion Paper No. 2, Department of Natural Resources, Cornell University, Ithaca, USA.

[3] Buckton, S. T., Cu, N., Tu, N. D. (1999) "The conservation of key wetland sites in the Mekong delta", BirdLife International Vietnam Programme Conservation Report No. 12., BirdLife International Vietnam Programme, Hanoi, Vietnam.

[4] DARD (Department of Agriculture and Rural Development of Giaothuy District). (2017) "Guidelines for rice cultivation adapting climate change", Department of Agriculture and Rural Development of Giaothuy District: Namdinh, Vietnam.

[5] D'Annolfo, R., Gemmill-Herren, B., Graeub, B. and Garibaldi, L. A. (2017) "A review of social and economic performance of agroecology", *International Journal of Agricultural Sustainability*, Vol. 15, No. 6, pp. 632-644. ISSN 1473-5903. DOI 10.1080/14735903.2017.1398123.

[6] FAO (2017) "*Statistics of Rice and Paddy Production*". [Online]. Available: http://www.fao.org/faostat/en/#data/QC/visualize [Accessed: Sept. 30, 2021].

[7] FAO (2018) "*Proportion of agricultural area under productive and sustainable agriculture. SDG Indicator 2.4.1. Methodological note*". [Online]. Available: http://www.fao.org/3/ca7154en/ca7154en.pdf [Accessed: Sept. 30, 2021].

[8] Gilmour, D. A. and Van San, N. (1999) "*Buffer zone management in Vietnam*", IUCN and the Forest Protection Department, Hanoi.

[9] Hai, H. T. and Nhan, H. T. T. (2015) "Hiện trạng đa dạng sinh học của Vườn quốc gia Xuân Thủy" Current situation of Xuan Thuy National Park), Hong Duc Publishing House, 65 Trang Thi, Hoan Kiem, Ha Noi. (in Vietnamese).

[10] Haneji, C., Amemiya, T., Itoh, K., Mochida, Y., Hoang, N. T. T. and Van Pham, C. (2014) "Analysis of environmental stressors on ecosystems of Xuan Thuy National Park, Vietnam", *Journal of Vietnamese Environment*, Vol. 5, No. 1, pp. 12-21. ISSN 2193-6471. DOI 10.13141/jve.vol5.no1.pp12-21.

[11] Joint, F. (2018) "*Rice Production Guidelines: Best Farm Management Practices and the Role of Isotopic Techniques*", Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, No. 184. ISBN 978-92-0-103418-2.

[12] Kamoshita, A., Nguyen, Y. T. B. and Dinh, V. T. H. (2018) "Preliminary assessment of rice production in coastal part of Red River Delta surrounding Xuan Thuy National Park, Vietnam, for improving resilience", In *Resilient Asia*, pp. 7-38, Springer, Tokyo. DOI 10.1007/978-4-431-56597-0_2.

[13] Khai, H. V. and Yabe, M. (2014) "Choice modeling: assessing the non-market environmental values of the biodiversity conservation of swamp forest in Vietnam", *International Journal of Energy and Environmental Engineering*, Vol. 5, No. 1, pp. 1-8. ISSN 2008-9163. DOI10.1007/s40095-014-0077-5.

[14] Ladha, J. K. and Reddy, P. M. (2003) "Nitrogen fixation in rice systems: State of knowledge and future prospects", *Plant and Soil*, Vol. 252, Vol. 1, pp. 151-167. ISSN 0032-079X. DOI 10.1023/A:1024175307238.

[15] Leslie, M., Nguyen, S. T., Nguyen, T. K. D., Pham, T. T., Cao, T. T. N., Le, T. Q. and Chris, Y. (2018) "Bringing social and cultural considerations into environmental management for vulnerable coastal communities: Responses to environmental change in Xuan Thuy National Park, Nam Dinh Province, Vietnam", *Ocean & Coastal Management*, Vol. 158, pp. 32-44. ISSN 0964-5691. DOI 10.1016/j.ocecoaman.2018.03.022.

[16] Lin, Z. and Routray, J. K. (2003) "Operational indicators for measuring agricultural sustainablity in developing countries", *Environmental Management*, Vol. 32, No. 1, pp. 34-46. ISSN 0301-4797.

[17] Mai, T. N. and Nguyen, T. M. N. (2003) "Geochemical sedimentary evolution features of the processes of formation, development and degradation of mangrove forests in Namdinh coastal region", Vietnam. Annual Report of FY 2001, The Core University Program between Japan Society for the Promotion of Science (JSPS) and National Centre for Natural Science and Technology (NCST), pp. 137-148.

[18] Mottet, A., Bicksler, A., Lucantoni, D., De Rosa, F., Scherf, B., Scopel, E., López-Ridaura, S., Gemmil-Herren, B., Kerr, R. B., Sourisseau, J.-M., Petersen, P., Chotte, JH.-L., Loconto, A. and Tittonell, P. (2020) "Assessing transitions to sustainable agricultural and food systems: a Tool for Agroecology Performance Evaluation (TAPE)", *Frontiers in Sustainable Food Systems*, Vol. 4, No. 252. ISSN 2571-581X. DOI 10.3389/fsufs.2020.579154.

[19] Nhan, H. T. T. (2014) "Research on Indicators of Biodiversity of Wetland: Study in Xuan Thuy National Park", Ph.D. Thesis, Ha Noi National University, Ha Noi, Vietnam.

[20] Nhuan, M. T., Ngoc, N. T. M., Huong, N. Q., Hue, N. T. H., Tue, N. T. and Ngoc, P. B. (2009) "Assessment of Vietnam coastal wetland vulnerability for sustainable use (Case study in Xuanthuy Ramsar Site, Vietnam)", *Journal of Wetlands Ecology*, Vol. 2, No. 1, pp. 1-16. E-ISSN 2091-0363. DOI 10.3126/jowe.v2i1.1850.

[21] Nguyen, T. T. N., Tran, H. C., Ho, T. M. H., Burny, P. and Lebailly, P. (2019) "Dynamics of farming systems under the context of coastal zone development: the case of Xuan Thuy National Park, Vietnam", *Agriculture*, Vol. 9, No. 7, 138. ISSN 2077-0472. ISSN 2077-0472. DOI 10.3390/agriculture9070138.

[22] Pedersen, A., Thang, N. H., Dung, V. V. and Hoang, T. T. (1996) "The conservation of key coastal wetland sites in the Red River Delta", Hanoi: BirdLife International Vietnam Programme.

[23] Sara, J. S. and Jefferey, A. M. (2008) "Biodiversity conservation and agricultural sustainability: towards a new paradigm of ecoagriculture landscapes", *Philosophical Transactions of the Royal Society*, pp. 477- 494. ISSN 0962-8436. DOI 10.1098/rstb.2007.2165.

[24] Shaobing, P., Jianliang, H., John, E. S., Rebecca, C. L., Romeo, M. V, Xuhua, Z, Grace, S. C., Gurdev, S. K. and Kenneth, G. C. (2004) "Rice yields decline with higher night temperature from global warming", *Proceedings of the National Academy of Science (PNAS)*, Vol. 101, No. 27, pp. 9971-9975. E-ISSN ISSN 1091-6490. DOI 10.1073/pnas.0403720101.

[25] Singh, V., Singh, B., Thind, H. S., Singh, Y., Gupta, R. K., Singh, S., Singh, M., Kaur, S., Singh, M., Brar, J. S., Singh, A., Singh, J., Kumar, A., Singh, S., Kaur, A. and Balasubramanian, V. (2014) "Evaluation of leaf colour chart for need-based nitrogen management in rice, maize and wheat in north-western India", *Journal of Research Punjab Agricultural University*, Vol. 51, No. 3-4, pp. 239-245. E- ISSN 2277-1271.

[26] Singh, Y., Bijay, S., Jagish, K. L., Jaswinder, S. B., Raj, K. G., Jagmohan, S. and Vethaya, B. (2007) "On-farm evaluation of leaf colour chart for need-based nitrogen management in irrigated transplanted rice in north-western India", *Nutrient Cycling in Agroecosystem*, Vol. 78, No. 2, pp. 167-176. ISSN 1385-1314. DOI 10.1007/s10705-006-9082-2.

[27] Trabelsi, M., Mandart, E., Le Grusse, P. and Bord, J. P. (2019) "ESSIMAGE: a tool for the assessment of the agroecological performance of agricultural production systems", *Environmental Science and Pollution Research*, Vol. 26, No. 9, pp. 9257-9280. ISSN 0944-1344. DOI 10.1007/s11356-019-04387-9.

[28] Trabelsi, M., Mandart, E., Le Grusse, P. and Bord, J. P. (2016) "How to measure the agroecological performance of farming in order to assist with the transition process", *Environmental Science and Pollution Research*, Vol. 23, No. 1, pp. 139-156. ISSN 0944-1344. DOI 10.1007/s11356-015-5680-3.

[29] VAF (Vietnam Administration of Forestry) (2017) "National Parks of Vietnam", Ha Noi: Vietnam Association of National Park and Nature Reserve.

[30] Xiaowei L., Huoyan, W., Jianmin, Z., Fengqin, H., Dejin, Z., Zhaoming, C. and Yongzhe, L. (2016). "Effect of N Fertilization pattern on rice yield, N Use efficiency and fertilizer-N Fate in the Yangtze river basin, China", *PLoS One*, Vol. 11, No. 11, pp. 1-20. E-ISSN 1932-6203. DOI 10.1371/journal.pone.0166002.

Volume XIV Number 3, 2022

Financing Gap of Agro-food Firms and the Role of Policies

Ján Pokrivčák[1, 2], Marián Tóth[2]

[1] Institute of Economic Policy and Finance, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Slovakia

[2] Department of Economics and Quantitative Methods, Faculty of Economics, University of West Bohemia in Pilsen, Czech Republic

Abstract

The objective of this paper is to evaluate the position and financing needs of agri-food industry in Slovakia. There is a growth of agri-food sector which is reflected in growing demand for finance. Despite current favourable conditions on the financial market in Slovakia, some viable firms still face a credit constraint. Financing gap exists due to relatively high interest rates for some firms and due to their lack of sufficient collateral.

Based on the survey results and focus group meetings we estimate the financing gap. Results show that there is potential for a further expansion of the financing market, with a financing gap estimated at EUR 36.8 mil. Small firms suffer the most from the financing gap and they constitute 77.4% of the gap.

Financing gap and financing needs will be growing in the future. Firms need to increase investment to stay competitive on the market and need to adopt to changes in consumer preferences. This requires further investment into new technology and equipment. Tougher environmental requirements make firms invest into more environmentally friendly production processes. Furthermore, the sector is expected to be growing in the future. Financial instruments in the form of loan guarantees and interest rate subsidies would partly eliminate the existing financing gap. Small firms would benefit from simple and flexible financial instruments serving as guarantees for loans. Large firms would benefit from long-term loans supported by financial instruments. Policy-makers should place special attention on the use of financial instruments in agri-food sub-sectors with potential high value added and high employment.

Keywords

Agri-food, demand for finance, finance providers, financing gap.

Pokrivčák, J. and Tóth, M. (2022) "Financing Gap of Agro-food Firms and the Role of Policies", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 85-96. ISSN 1804-1930. DOI 10.7160/aol.2022.140307.

Introduction

Many viable firms suffer from lack of investment funds both in developing and developed countries (Ciaian et al., 2012; Lee and Chambers, 1986; Färe et al., 1990; Bhattacharyya and Kumbhakar 1996; Heltberg, 1998; Blancard et al., 2006; Rizov et al., 2013). In the EU context, credit constraint problems tend to be more pronounced in Central and East European Countries where financial markets are less developed and firms operate in less stable economic environment than in the old EU-15 member states (Swinnen – Gow 1999; OECD, 1999, 2001; Fidrmuc et al., 2013; Dries – Swinnen, 2004).

The investment theory derives credit constraints on investment from information asymmetries on the capital market which drive a wedge between the costs of internal and external funds (Greenwald et al., 1984; Jensen and Meckling, 1976; Myers and Majluf, 1984). It includes rejected applicants as well as discouraged borrowers defined as firms that need external finance but do not apply for a bank loan because they fear their application will be rejected (Jappelli, 1990). Credit constraints result in financing gap defined as the unmet credit demand due to constrained or missing access to financing.

Credit constraint firms invest less and have lower allocative and technical efficiency (Feder, 1985; Feder et al., 1990; and more recently Blancard et al., 2006; Kumbhakar and Bokusheva, 2009;

Huttel et al., 2010). Empirical research agrees that improving access to credit is crucial in helping firms to deal with liquidity constraints and thus improve resource allocation in the economy (Love, 2003; Wurgler, 2000). Access to finance also enables firms to exploit growth and investment opportunities (Beck, Demirguc-Kunt and Maksimovic, 1999).

Literature identifies several impacts of credit constraints. Credit constraint firms have limited access to short-term finance or long-term finance. Short-term loans are not linked to investments and improve the cash-flow of the firm. Firms use long-term credit to purchase fixed assets and equipment and short-term credit to finance working capital. In the absence of long-term finance, a firm tends to favor investment in technologies with immediate payoff rather than adopting more productive technologies with delayed returns, due to fear of liquidation (Léon, 2020). Firms face a risk of a lack of liquidity when they finance long-term investment with short-term debt because creditors may refuse to roll over their credits (Diamond, 1991). Short investment horizon may have negative effect on firm performance, especially for small and young firms, which are credit rationed for long-term debt due to their inability to produce hard information (adequate records and accounts) and their limited relationship with banks (Demirguç-Kunt and Maksimovic, 1999: World Bank, 2016). Constrained firms planned, on average, more severe cuts in technology expenditures, capital expenditures, marketing expenditures and employment than unconstrained firms during the global financial crisis of 2008 (Campello et al., 2010). Study of Fabiani et al. (2015), based on data for 9 European countries in 2007–2009, shows that credit-constrained firms have bigger likelihood of cutting permanent and temporary jobs. In this regard, the financial stability of firms became an essential factor of employer value proposition evaluation in times of crisis (Egerová et al., 2021; Samoliuk et al., 2022), fostering enterprises to seek new responses to growing financial and personnel risks (Cepel et al., 2020). Constrained firms seek for alternative funding and Carbó-Valverde et al. (2016) found an increased share of trade credit for bank-constrained firms in Spain during the 2008 financial crisis.

There are several determinants of credit constraints. Generally, credit constrained firms are small, have poor rating and low collateral (Campello et al., 2010). Based on survey covering 8,387 firms in 20 European countries, credit constrained firms in Eastern Europe have several common determinants with credit constrained firms in Western Europe. Small and financially opaque firms as well as firms with alternative financing sources are less likely to apply for credit. In Eastern Europe a higher fraction of non-applicants seems to be discouraged by lending conditions, that is, high interest rates and tough collateral requirements, while in Western Europe more firms simply do not need loans (Brown et al., 2011). Based on analysis of loans to agri-food firms in Slovakia, small and medium sized enterprises operating in agri-food industry do not exhibit a higher default rate than other sectors. But highly indebted firms are more likely to default on their loan than other firms (Fidrmuc et al., 2013). Major credit constraints determinants of farmers in developing countries are distance to the formal credit sources, lending procedure, time lag, and interest rate as major constraints whereas land ownership reduces the constraints to access formal credit (Chandio and Jiang, 2018).

To deal with the problem of credit constraint Common Agricultural Policy of the European Union traditionally allows Member States to use investment grants to support specifically small and medium farms and food processing firms. In total 7,041 bil. EUR were spent on investment grants from CAP budget in programming period 2014 – 2020. In Slovakia investment support for food processing amounted to 202 mil. EUR including national co-financing (APA, 2021). The support was equally distributed between farms and agri-food firms.

The literature asserts a positive relationship between investment grants and productivity of credit constraint firms (Ciaian et al., 2012). For these firms, investment grants may provide an additional source of finance either directly by increasing firms' financial resources or indirectly through the improved access to formal credit.

European Commission attempts to deal with credit constraint with the use of Financial Instruments financed by European Agricultural Fund for Rural Development (EAFRD). Financial instruments are European Union measures of financial support provided on a complementary basis from the budget to address specific policy objectives of the Union. Such instruments may take the form of equity or quasi-equity investments, loans or guarantees, or other risk-sharing instruments, and may, where appropriate, be combined with grants. The financial instruments financed by EAFRD were introduced in 2013. In 2014 - 2020 only 7 countries implemented financial instruments in their CAP policies.

It is therefore interesting and useful for policy makers and analysts to learn the extent of credit constraint in both primary agriculture as well as food processing industry to optimize the budget for investment grants to cope with the problem. The goal of this paper is to evaluate the extent of the credit constraint in the Slovak agri-food sector (food processing industry). In the paper we use data from a representative survey conducted by the EIB in 2019. The paper also provides information for policy makers and analysts on the types of financial instruments to be used to efficiently support agri-food firms. The paper is organized as follows. First section provides a short literature review, which is followed by session on methodology, data description and current state of the Slovak food processing sector, while the last part provides results, summarizes, and concludes.

Materials and methods

In the paper we estimate the extent of the credit constraint in the Slovak agri-food sector based on a representative EU 24 wide survey conducted by the EIB in 2019. Data to calculate financing gap were obtained by a EIB telephone interviewing survey (EC, 2020). The questionnaire was divided into enterprise information part and financing part. In the enterprise information part respondents were asked for main business activities, location, size of the firm and legal status. In the financing part a maximum of 20 questions was asked depending on respondent's situation and experience with loan applications. Questions in the questionnaire had a form of both closed and open questions. The sample consisted of 50 agri-food firms in Slovakia and was a part of EU-wide survey of 2200 EU agri-food firms. The survey was designed to be statistically representative at national level. To confirm the survey results in 2019 we organized focus-group meetings with relevant food associations and commercial banks: Slovak Milk Union, Slovak Agricultural Chamber, Slovak Agricultural and Food Chamber, Slovak Poultry Union, Tatra Bank, VÚB bank, ČSOB bank

To analyse the financing gap, we first analyse the demand and the supply for finance of the agri-food industry.

Financing gap is the unmet credit demand due to constrained or missing access to financing. This definition includes:

- Rejected credit applications by banks.
- Discouraged credit applications, i.e., credit applications not submitted by the firm due to fear of rejection.

The calculation of financing gap is linked only to viable firms defined as firms with stable or growing turnover or firms not facing cost increase in 2018. The share of viable firms is based on the representative survey results performed in 2019 in Slovakia.

We compute financing gap for four types of loans and three types of firms. We consider following loan types: short-term loans, medium-term loans, tong-term loans, and credit lines. Based on Eurostat data we divide firms into small, medium, and large firms.

Calculation of financing gap can be divided into 4 parts:

1. Unmet credit demand share

It is a sum of a) the share of viable firms with rejected credit applications and b) the share of viable firms with discouraged credit application in the sample data.

$$\textit{Unmet credit demand share} = \textit{Rejection share} + \textit{Discouraged Share} \quad (1)$$

a) Share of viable firms with rejected credit applications.

$$\textit{Rejection share} = \frac{\textit{Number of Viable Firm with rejected credit applications}}{\textit{Total survey population}} \quad (2)$$

b) Share of viable firms with discouraged credit applications

$$\textit{Discouraged share} = \frac{\textit{Number of Viable Firm with Discouraged credit applications}}{\textit{Total survey population}} \quad (3)$$

2. Total number of firms with unmet demand

To calculate the total number of firms with unmet demand we multiply rejection share plus discouraged share with the total number of agri-food firms in Slovakia according to Eurostat in year 2017.

$$\textit{Total no. of firms with unmet demand} = (\textit{Unmet credit demand share}) \times (\textit{Total no.of firms}) \quad (4)$$

3. Loan size

An average loan size is estimated from the EU 24 wide survey results. The loan size is calculated separately for small, medium, and large agri-food firms for short-term, medium-term, long-term loans as well as for credit lines. To adjust the average size of loan in the EU to Slovakia, the purchasing power parity index is applied.

4. Financing gap

The financing gap for each type of loan is calculated by multiplying total number of firms with unmet demand by loan size.

Financing gap = (Total no.of firms with unmet demand) x (Loan size) (5)

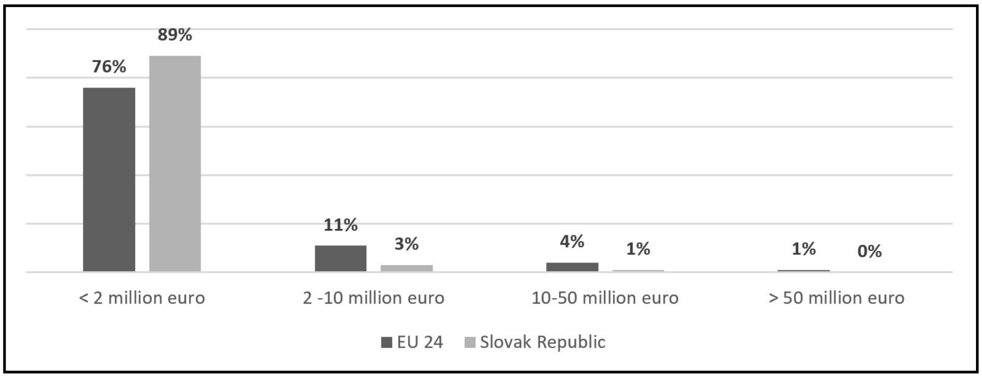
Results and discussion

Slovak agri-food companies are smaller than the EU average when measured by sales. 89% of all respondents in the survey had sales below EUR 2 mil. per year and almost none had annual sales above EUR 10 mil. (Figure 1). In the EU 76% of surveyed companies had sales below EUR 2 mil. and 5% of all surveyed companies had higher annual sales than EUR 10 mil.

Average sales of the Slovak agri-food industry either remained unchanged or increased in 2018 year, which was a better result than in the rest of the EU. Sales in Slovakia increased due to rising prices. Selling prices of agri-food industry increased for higher proportion of Slovak firms than for the EU firms (Figure 2).

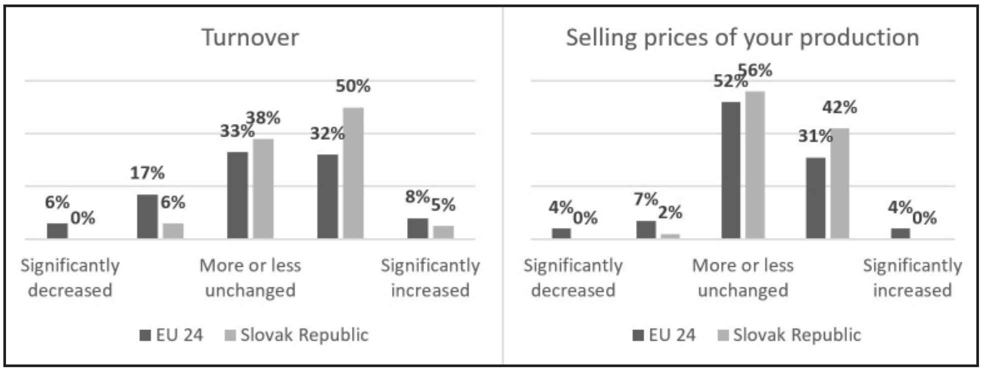
Survey results show that all requests for all types of loans by maturity were either satisfied by the banks or applications are still in the evaluation process. Some loans were declined by the applicants as not necessary (Figure 3). The situation in Slovakia is better than in the EU in this respect.

In Slovakia, 21% of agri-food firms applied for credit which is a smaller share than that in the EU (46%). Significantly smaller share of firms applied for all types of credit in Slovakia than in the EU (Figure 4).



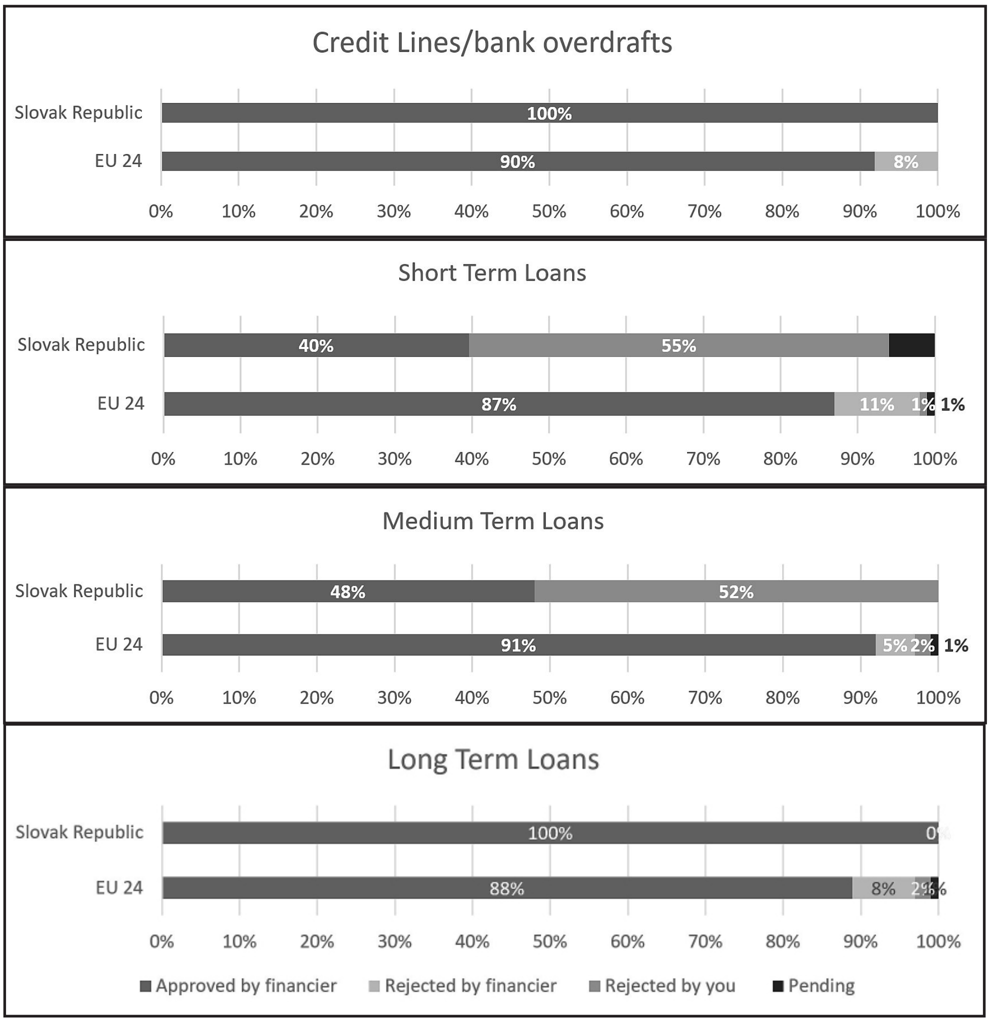
Source: agri-food survey, own calculations

Figure 1: What was the turnover (sales) of the company in 2018? (as % of respondents).



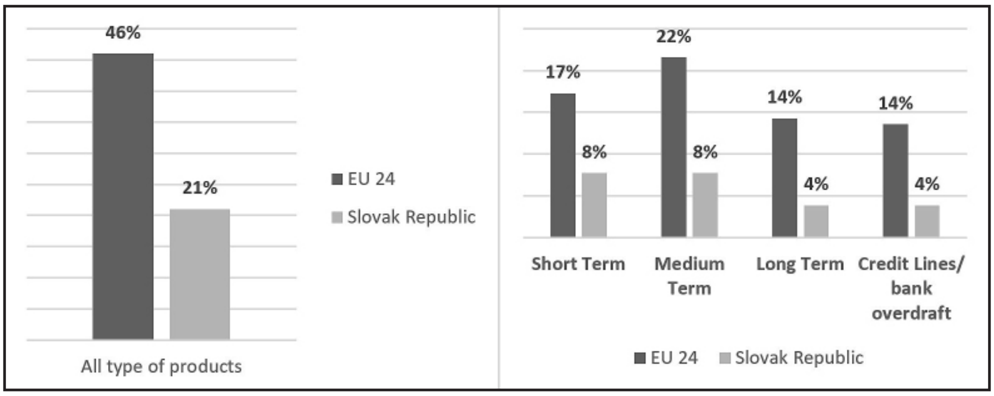
Source: agri-food survey, own calculations

Figure 2: Changes in company's key indicators (as % of respondents).



Source: agri-food survey, own calculations

Figure 3: Results of the application (as % of total applicants).

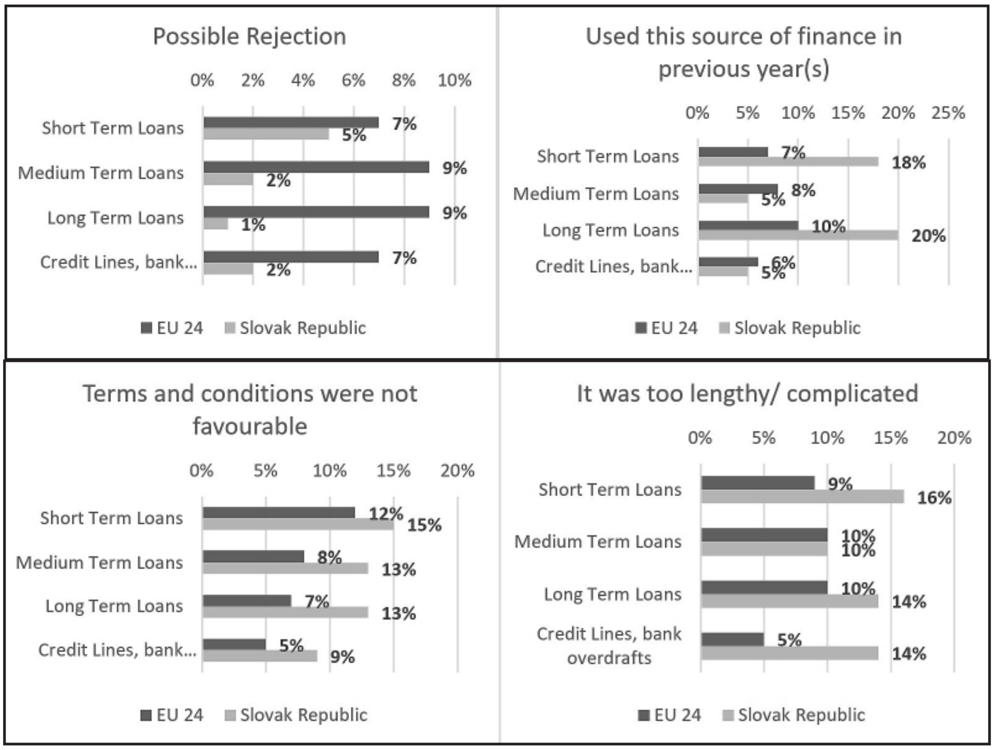


Source: agri-food survey, own calculations

Figure 4: Firms applying for finance in the last year and by maturity (as % of respondents).

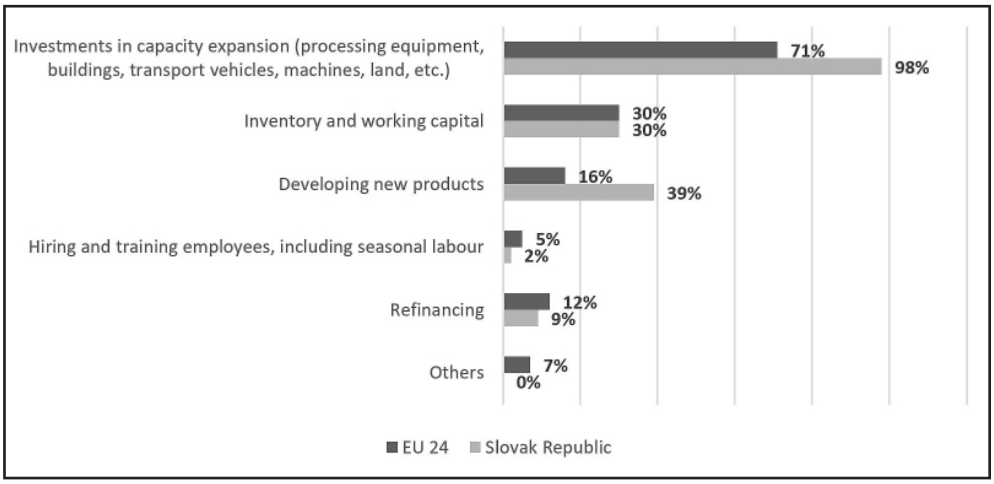
Between 1 and 5% of firms (depending on the type of loans) have not applied for a loan because of the fear of rejection. In the EU about 7% of agri-food firms have not applied due to the reason of the fear of rejection, which is significantly higher number than in Slovakia (Figure 5).

However, in Slovakia higher percentage of firms than in the EU did not apply for loans because they used funds from previous year, due



Source: agri-food survey, own calculations

Figure 5: Reason of no application (as % of non-applicants).



Source: agri-food survey, own calculations

Figure 6: For what purpose(s) did your enterprise need the finance? (as % of total applicants).

to non-favourable conditions or due to lengthy and complicated procedures. Up to 15% of firms did not apply for loans in Slovakia due to non-favourable conditions and up to 16% due to lengthy and complicated procedures.

Up to 98% of all applicants in Slovakia used loans to expand capacity, while 39% of applicants applied for a loan to develop new product and 30% to obtain working capital (Figure 6).

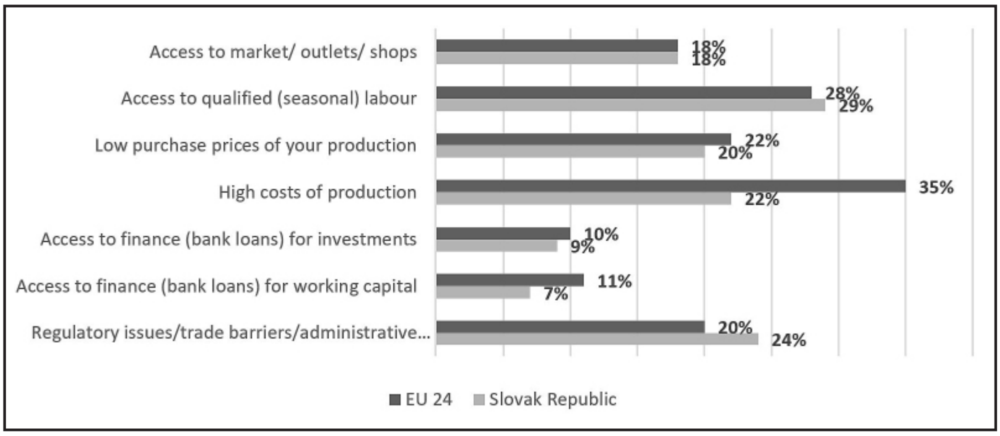
In addition to the problem of access to finance, which was experienced by 9% of Slovak firms in agri-food industry, there were other problems the sector was facing: 29% of firms in Slovakia (28% in the EU) had problems with the access to qualified labour, 24% of firms in Slovakia (20% in the EU) struggled with regulatory and administrative constraints, 18% of firms both in Slovakia and the EU had difficulties to access the market, and 22% of firms in Slovakia (35% in the EU) had to deal with high production costs (Figure 7).

In Slovakia 33% of agri-food firms while 43% of those in the EU would have their financing problems alleviated by lower interest rates, 28% in Slovakia and 32% of firms in the EU stated that financing problems would be reduced by guarantees provided by the government and for 24% of Slovak firms (26% of EU firms) affordable equity funding is important for dealing with financing problems (Figure 8). Respondents also state other reasons that would improve their access to finance: loans with longer maturity, loans with flexible repayments or insurance products.

There are 27 banks in Slovakia and food processing sector is financed by all of them. Currently the banks have a sufficient liquidity. Financing of agri-food is only constrained by credit and risk limits.

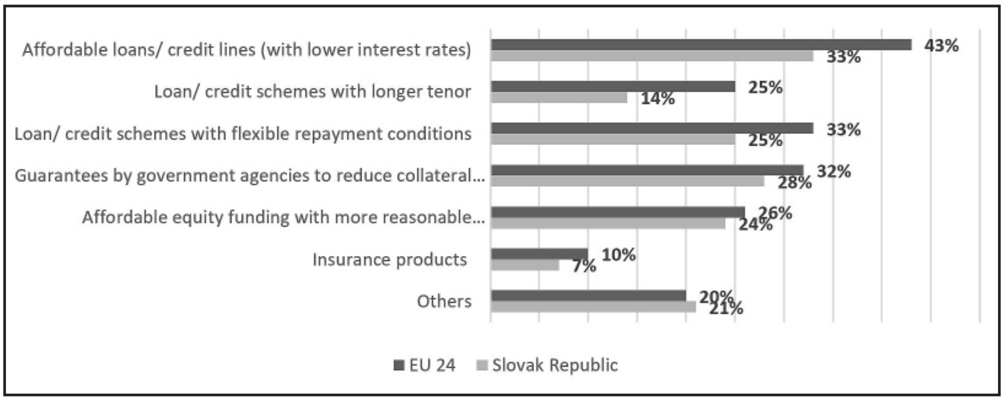
Total outstanding bank loans and leasing in the agri-food sector amounted to EUR 668 mil. in 2018. The National Bank of Slovakia does not report specifically agri-food and therefore we use a database of the Ministry of Agriculture (POTRAV). In 2018, the volume of loans in the food processing industry reached EUR 649 m, which was 4.8% increase from the previous year. Short term loans amounted to EUR 339 mil. which is 52.2% of total loans. Loans with maturity over 1 year make 47.8% of all loans in food processing industry.

Leasing companies play a minor role when compared to the banks in providing of finance to firms in Slovakia. In 2018, the volume of leasing offered to agri-food for machinery and equipment amounted to EUR 18.7 m, which is about 5% of financing of the agri-food sector. Leasing is used by food processing companies to finance highly specific machinery. Slovak Guarantee and Development Bank offers loans to agri-food sector too in form of subsidized loans for small and medium size enterprises.



Source: agri-food survey, own calculations

Figure 7: Did your company experience any of these difficulties in the last year (2018)? (as % of respondents).



Source: agri-food survey, own calculations

Figure 8: Drivers reducing difficulty for your company to access finance (as % of respondents).

After stagnation of loans in the post crisis period, in 2016 loan volume started to increase in Slovakia. In 2018 loans to industry grew annually by 5%, which is above the median growth rate in the EU. Last years, long-term loans started to decline which was partially compensated by higher growth of short-term loans

In Slovakia, the share of debt is relatively high (53% in 2018). It is significantly higher than the median in the region of Central and East Europe and higher than the median of all EU member states. Debt to equity ratio, however, declined in 2018 as in the other member states. High financial leverage exposes firms to higher risk when economic growth turns negative. However, rising revenues affected positively development of other financial indicators of firms. In Slovakia, the share of failed loans is declining reaching 3,59 % of all loans, which is the lowest level in the post crisis period. This reflects stable macroeconomic environment in Slovakia. Out of EU countries, Slovakia, Czech Republic and Poland reported the highest growth of loans to firms.

Additionally, agri-food sector benefits from Common Agricultural Policy Pillar II. Measure 4.2. The budget for the measure was in the period 2015-2018 EUR 162.5 mil. There has been only one call in this period and in total 387 agri-food firms were supported. Maximum grant volume was EUR 2 mil. per beneficiary and EUR 10 mil. in case of collective projects. However, 109 firms which did fulfil criteria of the call with total demand EUR 45 mil. were not supported due to limited budget.

The financing gap and its drivers

Table 1 shows the results of financing gap calculations according to equations 1 – 5 described in Materials and Methods.

The financing gap for the Slovak agri-food sector is estimated at EUR 36.8 mil. (Table 2). On average it is EUR 10,600 per firm. However, unmet financing needs are concentrated in specific segments of the sector. The financing gap mainly concerns small firms. The type of loans for which the gap is the largest are short term and long-term loans. The financing gap as estimated from the survey represents approximately 5.5% of the total outstanding loan volume to the sector.

Financing gap exists for some firms due to relatively high interest rates, while other firms suffer from the lack of sufficient guarantees and of less diverse supply of financing instruments. According to a survey validated by focus group of experts from agri-food and banking sectors, 33% of firms in Slovakia while 43% of those in the EU would have their financing problems alleviated by lower interest rates, 28% in Slovakia and 32% of firms in the EU stated that financing problems would be reduced by guarantees provided by the government and for 24% of Slovak firms (26% of EU firms) affordable equity funding is important for dealing with financing problems. Respondents also state other reasons that would

		Short-term Loans	Medium-term Loans	Long-term Loans	Credit lines/ bank overdraft
1. Unmet credit demand share	Share of rejected credit applications	0.65%	0.65%	0.00%	0.00%
	Share of discouraged credit applications	9.79%	0.65%	18.14%	4.90%
	Sum of shares of rejected and discouraged applications	10.44%	1.30%	18.14%	4.90%
2. Total number of firms with unmet demand	Small firms	161	20	180	76
	Medium firms	13	2	22	6
	Large firms	5	1	8	2
3. Loan size	Small firms	€ 103,469	€ 141,645	€ 401,753	€ 116,828
	Medium firms	€ 822,021	€ 774,055	€ 2,153,277	€ 625,438
	Large firms	€ 810,592	€ 1,355,713	€ 3,805,692	€ 1,272,000

Source: survey results, own calculation

Table 1: Financing gap calculation in the agri-food sector.

Size Category	Loan Maturity	Financing gap
Financial gap for SMALL firms	Short-term	9 452 409
	Medium-term	5 685 752
	Long-term	9 453 583
	Credit Line	3 881 009
TOTAL Small-scale Firms		**28 472 754**
Financial gap for MEDIUM firms	Short-term	2 762 036
	Medium-term	1 142 805
	Long-term	1 863 594
	Credit Line	764 184
TOTAL Medium-scale Firms		**6 532 620**
Financial gap for LARGE firms	Short-term	513 472
	Medium-term	377 343
	Long-term	620 945
	Credit Line	293 001
TOTAL Large-scale Firms		1 804 760
TOTAL FINANCING GAP		36 810 134

Source: survey results, own calculation

Table 2: Total financing gap in Slovak agriculture (EUR).

improve their access to finance: loans with longer maturity, loans with flexible repayments or insurance products.

In Slovakia, financing gap is also driven by non-favourable conditions of loans as well as by lengthy and complicated procedures of loan application. Higher percentage of firms than in the EU did not apply for loans because they used funds from previous year, due to non-favourable conditions or due to lengthy and complicated procedures. Up to 15% of firms did not apply for loans in Slovakia due to non-favourable conditions and up to 16% due to lengthy and complicated procedures.

According to focus group, financing needs as well as financing gap will increase in the future due to rising investment demand caused by enhanced environmental concerns that require investments due to changing consumer preferences as well as due to growing international competition.

Conclusion

Viable firms in agri-food sector in Slovakia experience credit constraint. Out of financing gap of EUR 36.8 mil. long term loans make EUR 11.9 mil., medium-term loans EUR 7.2 mil. and the rest (EUR 17.7 mil.) is linked to short-term loans and credit lines. Small firms with number of employees up to 49 have the highest financing gap (77.4% of the total financing gap).

Financial instruments proposed by the European Commission are intended to cope with the credit constraint of agri-food firms to increase investment and competitiveness of agri-2014 – 2020 financial instruments were not implemented in Slovakia. New Common Agricultural Policy of the European Union for years 2023 – 2027 expects from member states to offer financial instruments for farms.

Small firms will specifically benefit from guarantees while interest rate subsidies might improve access to finance and higher investments for both small as well as medium and large firms.

Financial instruments might provide agri-food firms with greater flexibility and lower administrative cost compared to current investment grant system existing within Rural Development Programme. The current system suffers from low frequency of calls for proposals, high administrative burden. Time-consuming evaluation and monitoring create significant costs that could be partially eliminated by the system of support via financial instruments (Pokrivcak et al., 2020).

There is a growth of agri-food sector which is reflected in growing demand for finance. Despite current favourable conditions on the financial market in Slovakia, some viable firms still face credit constraints. Financing gap exists due to relatively high interest rates for some firms and due to their lack of sufficient guarantees. It is expected that financing gap and financing needs will be growing. Firms need to increase investment to stay competitive on the market. Changes in consumer preferences require firms to invest into new technology and equipment. Tougher environmental requirements make firms invest into more environmentally friendly production processes. Furthermore, the sector is expected to be growing in the future.

Acknowledgments

This paper was supported by the Czech Science Foundation (GACR) under project 19-18080S, by the Operational Program Integrated Infrastructure within the project: Demand-driven Research for the Sustainable and Innovative Food, Drive4SIFood 313011V336, co-financed by the European Regional Development Fund and project VEGA number 1/0768/20 with the title Evaluation of the impacts of the Rural Development Program on the Slovak economy.

Corresponding authors
doc. Ing. Marián Tóth, PhD.
Department of finances, Faculty of Economics and Management, Slovak University of Agriculture in Nitra
Tr. A. Hlinku 2, 949 76 Nitra, Slovakia
Phone: +421 905 808 957, E-mail: marian.toth.fem@gmail.com

References

[1] APA (2021) "*Program Implementation 2021*". [Online]. Available: https://www.apa.sk/sumarne-prehlady-1 [Accessed: May 10, 2021].

[2] Beck, T., Demirguc-Kunt, A. and Maksimovic, V. (2005) "Financial and Legal Constraints to Growth: Does Firm Size Matter?", *Journal of Finance*, Vol. 60, No. 1, pp. 137-177. ISSN 1540-6261. DOI 10.1111/j.1540-6261.2005.00727.x.

[3] Bhattacharyya, A. and Kumbhakar, S. (1996) "Governmental Interventions, Market Imperfections, and Technical Inefficiency in a Mixed Economy: A Case Study of Indian Agriculture", *Journal of Comparative Economics*, Vol. 22, No. 3, pp. 219-241. ISSN 1095-7227. DOI 10.1006/jcec.1996.0028.

[4] Blancard, S., Boussemart, J. P., Briec, W. and Kerstens, K. (2006) "Short- and Long-run Credit Constraints in French Agriculture: A Directional Distance Function Framework Using Expenditure-constrained Profit Functions", *American Journal of Agricultural Economics*, Vol. 88, No. 2, pp.351-364. ISSN 0002-9092. DOI 10.1111/j.1467-8276.2006.00863.x.

[5] Brown, M., Ongena, S., Popov, A. and Yeşin, P. (2011) "Who needs credit and who gets credit in Eastern Europe?", *Economic Policy*, Vol. 26, No. 65, pp. 93-130. ISSN 0266-4658. DOI 10.1111/j.1468-0327.2010.00259.x.

[6] Campello, M., Graham, J. R. and Harvey, C. R. (2010) "The real effects of financial constraints: evidence from a financial crisis", *Journal of Financial Economics*, Vol. 97, No. 3, pp. 470-487. ISSN 0304-405X. DOI 10.1016/j.jfineco.2010.02.009.

[7] Carbó-Valverde, S., Rodríguez-Fernández, F. and Udell, G. F. (2016) "Trade credit, the financial crisis, and SME access to finance", *Journal of Money, Credit and Banking*, Vol. 48, No. 1, pp. 113-143. ISSN 1538-4616. DOI 10.1111/jmcb.12292.

[8] Ciaian, P., Falkowski, J. and Kancs, D. (2012) "Productivity and Credit Constraints: A Firm Level Propensity Score Evidence from Agricultural Farms in Central and East European Countries", *Acta Oeconomica*, Vol. 62, No. 4, pp. 459-487. ISSN 1588-2659. DOI 10.1556/AOecon.62.2012.4.3.

[9] Cepel, M., Gavurova, B., Dvorsky, J. and Belas, J. (2020) "The impact of the COVID-19 crisis on the perception of business risk in the SME segment, *Journal of International Studies*, Vol. 13, No. 3, pp. 248-263. E-ISSN 2306-3483, ISSN 2071-8330. DOI 10.14254/2071-8330.2020/13-3/16.

[10] Chandio, A. A and Jiang, Y. (2018) "Determinants of credit constraints: evidence from Sindh, Pakistan", *Emerging Markets Finance and Trade*, Vol. 54, No. 15, pp. 1-10. ISSN 1540-496X. DOI 10.1080/1540496X.2018.1481743.

[11] Demirguc-Kunt, A. and Maksimovic, A. (1999) "Institutions, financial markets, and firm debt maturity", *Journal of Financial Economics*, Vol. 54, No. 3, pp. 295-336. ISSN 0304-405X. DOI 10.1016/S0304-405X(99)00039-2.

[12] Diamond, D. W. (1991) "Debt maturity structure and liquidity risk", *Quarterly Journal of Economics*, Vol. 106, No. 3, pp. 709-737. ISSN 1531-4650. DOI 10.1016/S0304-405X(99)00039-2.

[13] Dries, L. and Swinnen, J. F. M. (2004) "Foreign Direct Investment, Vertical Integration and Local Suppliers: Evidence from the Polish Dairy Sector", *World Development*, Vol. 32, No. 9, pp. 1525-1544. ISSN 0305-750X. DOI 10.1016/j.worlddev.2004.05.004.

[14] Egerová, D., Kutlák, J. and Eger, L. (2021) "Millennial job seekers' expectations: How do companies respond?", *Economics and Sociology*, Vol. 14, No. 1, pp. 46-60. DOI 10.14254/2071-789X.2021/14-1/3

[15] European Commission (2020) "*Financial needs in the agriculture and agri-food sectors in the European Union*", [Online]. Available: https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_eu_summary.pdf [Accessed: Apr. 1, 2021].

[16] Fabiani, S., Lamo, A., Messina, J. and Rõõm, T. (2015) "European firm adjustment during times of economic crisis", *IZA Journal of Labor Polic*y, Vol. 24, No. 4, pp. 1-28. ISSN 2193-9004. DOI 10.1186/s40173-015-0048-3.

[17] Färe, R., Grosskopf, S. and Lee, H. (1990) "A Nonparametric Approach to Expenditure-constrained Profit Maximisation", *American Journal of Agricultural Economics*, Vol. 72, No. 3, pp. 574-581. ISSN 1467-8276. DOI 10.2307/1243026.

[18] Feder, G. (1985) "The relation between farm size and farm productivity: The role of family labour, supervision and credit constraints", *Journal of Development Economics*, Vol. 18 No. 3-4, pp. 297-313. ISSN 0304-3878. DOI 10.1016/0304-3878(85)90059-8.

[19] Feder, G., Lau, L., Lin, J. and Luo, X. (1990) "The relationship between credit and productivity in Chinese agriculture: A microeconomic model of disequilibrium", *American Journal of Agricultural Economics*, Vol. 72, No. 5, pp. 1151-1157. ISSN 1467-8276. DOI 10.2307/1242524.

[20] Fidrmuc, J., Ciaian, P, Kancs, D. and Pokrivcak, J. (2013) "Credit Constraints, Heterogeneous Firms and Loan Defaults", *Annals of Economics and Finance*, Vol. 14, No. 1, pp. 53-68. ISSN 1529-7373. DOI 10.1186/s40100-017-0078-9.

[21] Greenwald, B., Stiglitz, J. E. and Weiss, A. (1984) "Informational imperfections in the capital market and macroeconomic fluctuations", *The American Economic Review*, Vol. 74, No. 2, pp. 194-199. ISSN 00028282. DOI 10.3386/w1335.

[22] Heltberg, R. (1998) "Rural Market Imperfections and the Farm Size-productivity Relationship: Evidence from Pakistan", *World Development*, Vol. 26, No. 26, pp. 1807-1826. ISSN 0305-750X. DOI 10.1016/S0305-750X(98)00084-9.

[23] Huttel, S., Mubhoff, O. and Odening, M. (2010) "Investment reluctance: Irreversibility or imperfect capital markets?", *European Review of Agricultural Economics*, Vol. 37, No. 1, pp. 51-76. ISSN 1464-3618. DOI 10.1093/erae/jbp046.

[24] Jappelli, T. (1990) "Who is Credit Constrained in the U. S. Economy?", *The Quarterly Journal of Economics*, Vol. 105, No. 1, pp. 219-234. ISSN 1531-4650. DOI 10.2307/2937826.

[25] Jensen, M. C., and Meckling, W. H. (1976) "Theory of the firm: Managerial behavior, agency costs, and ownership structure", *Journal of Financial Economics*, Vol. 3, No. 4, pp. 305-360. ISSN 0304-405X. DOI 10.1016/0304-405X(76)90026-X.

[26] Lee, H. and Chambers, R. G. (1986) "Expenditure Constraints and Profit Maximisation in US Agriculture", *American Journal of Agricultural Economics*, Vol. 68, No. 4, pp. 857-865. ISSN 00029092. DOI 10.2307/1242132.

[27] Léon, F. (2020) "The provision of long-term credit and firm growth in developing countries", *Economic Modelling,* Vol. 90, No. 52, pp. 66-78. ISSN 0264-9993. DOI 10.1016/j.econmod.2020.04.023.

[28] Love, I. (2003) "Financial Development and Financing Constraints: International Evidence from the Structural Investment Model", *Review of Financial Studies*, Vol. 16, No. 3, pp. 765-791. ISSN 0893-9454. DOI 10.1093/rfs/hhg013.

[29] Kumbhakar, S. and Bokusheva, R. (2009) "Modelling Farm Production Decisions Under an Expenditure Constraint", *European Review of Agricultural Economics*, Vol. 36, No. 3, pp. 343-367, ISSN 1464-3618. DOI 10.1093/erae/jbp031.

[30] Myers, S. C., Majluf, N. S. (1984) "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics*, Vol. 13, No. 2, pp. 187-221. ISSN 0304-405X. DOI 10.1016/0304-405X(84)90023-0.

[31] OECD (1999) "Agricultural Finance and Credit Infrastructure in Transition Economies", *Proceedings of OECD Expert Meeting*, OECD Center for Co-operation with Non-members, Moscow, February 1999. 387 p. ISBN 9264170693. DOI 10.1787/9789264173811-en.

[32] OECD (2001) "Agricultural Finance and Credit Infrastructure in Transition Economies: Focus on South Eastern Europe", *Proceedings of OECD Expert Meetin*g, OECD Center for Co-operation with Non-members, Portoroz, Slovenia, May 2001. 332 p. ISBN 9789264195646. DOI 10.1787/9789264195646-en.

[33] Pokrivcak, J., Tóth, M., Ciaian, P., Bušík, M. and Svorenčík, A. (2020) "Why Cannot Direct Payments Be Capped in Slovakia? A Political Economy Perspective", *Prague Economic Papers*, Vol. 29, No. 26, pp. 625-648. ISSN 2336-730X. DOI 10.18267/j.pep.753.

[34] Rizov, M., Pokrivcak, J. and Ciaian, P. (2013) "CAP Subsidies and Productivity of the EU Farms", *Journal of Agricultural Economics*, Vol. 64, No 3, pp. 537-557. ISSN1477-9552. DOI 10.1111/1477-9552.12030.

[35] Samoliuk, N., Bilan, Y., Mishchuk, H. and Mishchuk, V. (2022) "Employer brand: key values influencing the intention to join a company", *Management & Marketing*, Challenges for the Knowledge Society, Vol. 17, No. 1, pp. 61-72. E-SSN 2069-8887. DOI 10.2478/mmcks-2022-0004.

[36] Swinnen, J. F. M. and Gow, H. (1999) "Agricultural Credit Problems and Policies during the Transition to a Market Economy in Central and Eastern Europe", *Food Policy*, Vol. 24, No. 1, pp. 21-47. ISSN 0306-9192. DOI 10.1016/S0306-9192(98)00067-0.

[37] World Bank (2016) "*Global Financial Development Report 2015-2016: Long-Term Financ*e", World Bank Group Technical report. E-ISBN 978-1-4648-0471-7, ISBN 978-1-4648-0472-4. DOI 10.1596/978-1-4648-0472-4.

[38] Wurgler, J. (2000) "Financial markets and the allocation of capital", *Journal of Financial Economics*, Vol. 58, No. 1-2, pp. 87-214. ISSN 0304-405X. DOI 10.1016/S0304-405X(00)00070-2.

Volume XIV Number 3, 2022

The Relationship between Working Capital and Profitability of Companies Operating in the Food Industry in the Czech Republic

Markéta Šeligová, Ivana Koštuříková

School of Business Administration in Karvina, Silesian University in Opava, Czech Republic

Abstract

The aim of this article is to determine the relationship between working capital and profitability of companies operating in the food industry in the Czech Republic and then find out how working capital affects the profitability of these companies from 2009 to 2019. In the first part of the research we estimate the links between working capital measured by variables such as cash conversion cycle, current assets ratio, current liabilities ratio, working capital ratio and corporate profitability measured by return on sales. In the next part of the research, we estimate the effect of working capital measured by variables such as cash conversion cycle, current assets ratio, current liabilities ratio, working capital ratio on corporate profitability measured by return on sales. Correlation analysis and the GMM method will be used to determine the relationship between working capital and the profitability of companies and how working capital affects the profitability of these companies. The results of the correlation analysis showed statistically significant links between return on sales and variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio. The results of the GMM method showed a statistically significant effect of variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio on the profitability of companies measured by the return on sales indicator. All mitigated effects have been demonstrated for companies operating in the food industry as a whole, as well as in the production of food products and beverages.

Keywords

Cash conversion cycle, current assets ratio, current liabilities ratio, profitability, working capital.

Šeligová, M. and Koštuříková, I. (2022) "The Relationship between Working Capital and Profitability of Companies Operating in the Food Industry in the Czech Republic", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 97-110. ISSN 1804-1930. DOI 10.7160/aol.2022.140308.

Introduction

The manufacturing industry can include metallurgy, engineering, but also the chemical, wood, textile and many others. The manufacturing industry makes a significant contribution to the creation of the Czech Republic's gross domestic product and its production is also a significant component of Czech exports (Ministry of Industry and Trade, 2019). The main branches of the Czech manufacturing industry include the production of food products, including the production of beverages. The sector is strategic in order to feed the population.

The Czech Republic is characterized by high quality food production, with emphasis on health and food safety in the first place. The production of food products is linked to agriculture, but also cooperates with other branches of the processing industry. The majority of production is realized mainly through retail chains. Wide demand and strong competition in the food market puts strong pressure on innovation, resulting in a diverse range of fresh and durable foods for different categories of consumers.

As far as the production of beverages is concerned, it is not a food supplement, but a separate production, sales and consumption segment, which represents an economically smaller dimension within the processing industry. Drinks, like food, must meet strict health criteria, and some drinks, such as mineral waters from spas, provide certain health benefits. However, beverages also to some extent complete the lifestyle of most consumers, with beer dominating in this respect. It is known that the Czech Republic is characterized by high consumption of this beverage, not only produced by large breweries, but also mini-breweries, which before 2020, together with wineries, expanded the business sector in the field of beverage production. Unlike beer, however, the decisive volume of wine is imported mainly from wine-growing countries such as France and Italy. However, government measures related to the covid-19 pandemic in 2020, especially in the gastronomy and tourism sector, significantly slowed down the production and sale of the main commodity, ie beer on the domestic and foreign markets. As for the consumption and production of soft drinks and mineral waters, it is significantly dependent on the weather, but also on other factors such as marketing, etc. If dry and warm periods prevail during the year, consumption increases and thus production, which then reflected in higher capacity utilization. Despite certain fluctuations, beverages generally maintain efficiency and competitiveness even in the differentiation between productions and companies (Institute of Agricultural Economics and Information, 2020). Companies in the food sector belong to the processing industry, where inventory and working capital management is very important. Companies thus have a significant part of the funds stored in inventories, receivables, which can affect their performance or profitability. It is therefore very interesting to find out the links between working capital and the profitability of companies operating in the food industry in the Czech Republic.

Many authors have concluded in their studies that the elements of managerial decision making and capital structuring are two areas that have an impact on business performance. Some authors have examined the relationship between business profitability and working capital management (inventories, receivables, payables). According to Deloof (2003), working capital management has a significant impact on business performance.

According to Howorth and Westhead (2003), some research has shown that cash management firms are larger firms dealing with lower cash sales and cash problems. While smaller businesses focused more on inventory management, less profitable businesses focused on managing their loans. It can be seen from the above that there is a strong relationship between the money transfer cycle in the company and its profitability. The three different components of the cash conversion cycle (liabilities, receivables and inventories) can be managed in a variety of ways to maximize business profitability or to increase company growth.

Lazaridis and Tryfonidis (2006) investigate the relationship of corporate profitability and working capital management from 2001 to 2004. The authors tried to establish using correlation analysis and regression analysis a relationship that is significant between profitability, the cash conversion cycle and its components. The results of research showed that there is statistical significance between profitability, measured through gross operating profit, and the cash conversion cycle. Authors found a negative relationship between profitability (measured through gross operating profit) and the cash conversion cycle which was used as a measure of working capital management efficacy. Authors also found that lower gross operating profit is associated with an increase in the number days of accounts payables. The above could lead to the conclusion that less profitable firms wait longer to pay their bills taking advantage of credit period granted by their suppliers. The negative relationship between accounts receivables and firms' profitability suggests that less profitable firms will pursue a decrease of their accounts receivables in an attempt to reduce their cash gap in the cash conversion cycle. Likewise the negative relationship between number of days in inventory and corporate profitability suggests that in the case of a sudden drop in sales accompanied with a mismanagement of inventory will lead to tying up excess capital at the expense of profitable operations. The authors believe that for this reason managers can create profits for their companies by handling correctly the cash conversion cycle and keeping each different component (accounts receivables, accounts payables, inventory) to an optimum level.

Padachi (2006) claims that working capital management will contribute positively to creating a company's value. In his study, he examined the impact of working capital management on corporate performance across industries over the period 1998 to 2003 using a panel regression analysis. Key variables used in the analysis were inventories days, accounts receivables days, accounts payable days and cash conversion cycle. The regression results show that high investment in inventories and receivables is associated with lower profitability.

Anojan et al., (2010) examined the effect of working capital management on the profitability of manufacturing companies over the period 2003-2007 using correlation analysis and regression analysis. He examined working capital management using the cash conversion cycle (CCC). It was found that cash conversion cycle (CCC) and return on assets (ROA) are negatively correlated. It means that the growth of a cash conversion cycle reduces the profitability of companies measured by return on assets (ROA). Furthermore, the growth of inventory conversion period (ICP) was found to increase return on asset companies. The results suggest that managers can increase the profitability of companies by reducing the number of day inventories and number of day´s accounts receivable. Working capital and its management plays a significant role in improved profitability of companies. Firms can achieve optimal management of working capital by making the trade-off between profitability and liquidity.

Chary et al., (2011), who believe that, working capital decision affects both liquidity and profitability, have also come up with this idea. Excess of investment in working capital may result in low profitability and lower investment may result in poor liquidity. Management need to trade-off between liquidity and profitability to maximize shareholders wealth. For this reason, in their study, they investigated the companies operating in the pharmaceutical industry for the period from 2003 to 2008 through correlation analysis, regression analysis, and Chi-square test. Furthermore, they also showed that the growth of inventories reduces the profitability of companies.

Baveld (2012) investigated how public listed firms in The Netherlands manage their working capital. A sample of 37 firms is used, which are among the fifty largest companies in The Netherlands. The working capital policies during the non-crisis period of 2004-2006 and during the Financial Crisis of 2008 and 2009 are compared. This comparison investigates whether companies have to change their non-crisis working capital policies when the economy is into a recession. The results of this study indicate that, in crisis periods, firms don't need to change their working capital policy concerning accounts payables and inventory, if their goal is to enhance profit. For the working capital policy managing accounts receivables this is not the case. This is because during a crisis accounts receivables have a positive effect on a firm's profitability of the next year. These results are on short-term basis. On the long-term, benefits of aiding customers during crisis periods are likely to grow, because future sales will still be there. Also the risks taken by these aiding firms are relatively low and for large reputable firms it is also relatively cheap.

Huynh (2012) examined the impact of working capital management on the liquidity and profitability of non-financial corporations in the Netherlands. The research was conducted on 62 companies operating in the manufacturing and services sectors for the period 2006 to 2010. Pearson's correlation analysis and regression method (OLS method) were used to determine the relationship between working capital management and company profitability. Fixed Effect regressions indicate that company profitability in both sectors is all negatively influenced by number of day accounts receivable. In the meantime, regresion analysis result in positive impacts of firm size and sales growth on company profitability. In addition, some other results are found specifically to each sector. Number of day inventory and cash conversion cycle are shown to negatively affect the profitability of companies operating in the manufacturing area that they have positive influences on profitability of service companies. In addition, manufacturing and service sectors respectively witness negative influences of number of day accounts payable and aggressive financing policy on their company profitability.

Rehn (2012) concluded that the efficiency of working capital management can be determined by the cash conversion cycle and the net trade cycle. It was found that Finnish and Swedish corporations can increase their gross operating profit by reducing the cash conversion cycle and net trade cycle. There is significant evidence that by effectively managing each portion of working capital, a company can increase its net present value (cash flows, thereby increasing shareholder value).

Golaś et al., (2013) examined the relationship between working capital and profitability of companies in Poland for the years 2005 to 2009. The effectiveness of working capital management were evaluated using a cycles of inventories, receivables, liabilities and cash conversion cycle. Profitability was further measured by the return on assets. Study have shown that in industries where these cycles are the shortest companies achieved the highest rate of return. The beneficial effect of shortening the cycle of working capital on profitability was verified by using regression analysis.

Motlíček et al. (2014) believed that working capital management significantly affects the performance of companies. In their view, this idea varies depending on the sector being monitored and the size of the companies. The authors tried to identify the links between net labor and company costs within medium-sized companies producing machinery and equipment in the Czech Republic. The authors demonstrated the low impact of net working capital components on financial costs. They believe that receivables can affect the financial costs of their financing and the transaction costs associated with their collection. According to the authors, the influence of stocks is a very important and important factor. Inventories correlate strongly with the growth of short-term debts, especially trade payables.

The above studies are published mainly abroad. There are very few studies in the Czech Republic that deal with the issue of working capital. It is therefore very difficult to find such studies. On the other hand, a proctor opens here to expand publications on this topic.

The above literature review shows that there is a relationship between working capital and corporate profitability across different sectors. However, it is not clear what is the relationship between working capital and profitability in the food industry in the Czech Republic. For this reason, the aim of this article is to determine the relationship between working capital and profitability of companies operating in the food industry in the Czech Republic and then to find out how working capital affects the profitability of these companies from 2009 to 2019. In order to meet the goal.

- What is the relationship between working capital and profitability of companies operating in the food industry in the Czech Republic from 2009 to 2019?
- How does working capital affect the profitability of companies operating in the food industry in the Czech Republic from 2009 to 2019?

This article is divided into 4 parts. The first part is devoted to the introduction, where the aim of the article, the overview of relevant literature, including research questions based on the aforementioned literature review. The next part will focus on materials and methods, which will describe selected methods needed to meet the goal of the article, including the characteristics of the data used. The third part of the article will be devoted to the results and discussion, where the results of the research will be presented, including a discussion of the results. The last part will concern the conclusion, which will summarize the most important results or conclusions of the research, including the determination of further steps for future research in this area.

Materials and methods

Financial data from the Orbis database were used to fulfill the aim of the article. This database includes data from the annual reports of individual companies operating worldwide. The Orbis database is thus a source of company data and allows companies to be compared internationally. The annual financial data for the period 2009 to 2019 are used in this research. The data sample includes 3,000 companies operating according to the CZ-NACE classification in the manufacturing industry, specifically in the food industry, of which 2,000 companies operate in the food production industry and 1,000 companies operates in the beverage industry. These data are the basis for the use of correlation analysis and GMM method, which can be used to determine the relationship between working capital and profitability of companies operating in the food industry in the Czech Republic and then find out how working capital affects the profitability of these companies. All links and relationships are determined using the econometric software EViews. Other data, which are drawn from the Ministry of Industry and Trade of the Czech Republic from 2009 to 2019, are also used in the description of the development of selected variables.

Table 1 presents the characteristics and description of the variables used, based primarily on the above literature review and studies.

Making a profit is one of the main goals of running a business. Profit can be measured in absolute terms or in relative terms using ratios. Company managers monitor various profitability indicators. A very important indicator in manufacturing companies and trading companies is especially the indicator of profitability of sales. Profitability of sales represents the ability to achieve income or profit on the basis of invested funds. This indicator can be used to determine the efficiency of the company. This indicator is often referred to as profit margin. The profitability of sales must be properly assessed in the context of the company's turnover and varies greatly between companies in different industries. A low or high value of the indicator does not necessarily mean that the company is successful or not. The low value of this indicator can be caused by a rapid inventory turnover with a high volume of sales. This is typical, for example, of shops and trading companies.

Abbreviation	Variables	Calculation	Expected relationship
ROS	Return on Sales	Operating Profit divided by Total Sales	
CCC	Cash Conversion Cycle	(Number of Days Inventory + Number of Days Accounts Receivables – Number of Days Account Payables)	+/-
CAR	Current Assets Ratio	Current Assets divided by Total Assets	+/-
CLR	Current Liabilities Ratio	Current Liabilities divided by Total Assets	+/-
WCR	Working Capital Ratio	Current Assets divided by Current Liabilities	+/-

Source: own proceeding

Table 1: Description and calculation of used variables.

On the other hand, a high value of sales profitability can be caused by slow inventory turnover and at the same time low sales volume. This can happen, for example, in manufacturing companies.

Cash conversion cycle show how many days you need to sell inventory and then how many days you need to collect debts and how many days the company needs to pay on average payables. To put it simply, cash conversion cycle means the time needed to convert short-term assets into cash and pay short-term liabilities. In a cash flow management context, the more the longer the cash conversion cycle is, the more resources are needed to finance short-term assets, and as a rule, funding is more expensive and vice versa. If the cash conversion cycle is positive, it means that the conversion cycle is greater than the maturity of payables. A positive cash conversion cycle expresses the time period in which the firm has to finance operating activities from sources other than personal liabilities (working capital, other short-term liabilities). If the cash conversion cycle is balanced, it means that the conversion cycle equals the maturity of payables. A balanced cash conversion cycle occurs when the maturity of liabilities is equal to the conversion cycle. If the cash conversion cycle is negative, it means that the conversion cycle is less than the maturity of payables. A negative cash conversion cycle expresses the condition when the maturity of liabilities is shorter than the conversion cycle. A negative cash conversion cycle often arises when a company finances negative working capital, or problematic short-term assets, etc. trade payables.

Current assets are mainly used to settle liabilities. They are constantly in motion, one form passes into another. The money is used to buy material, which is in the process of production from it to create finished products after delivery to customers, receivables arise and after their payment we have money again). Current assets turnover is in the order of days (in the store) to weeks (in production). The faster current assets turn under the same conditions, the greater the profit. Therefore, the speed of its turnover is an important indicator of the use of current assets. Current assets represent the working capital of the company. Working capital consists of inventories, receivables and financial assets. If we deduct short-term liabilities from current assets, we get net working capital.

Current liabilities represent short-term capital due within one year. No organization can do without short-term commitments. They naturally result from the normal operation of the organization and repeated business dealings. Typically, they finance current assets or other operating needs. Short-term debt means all liabilities (debts) that the organization has to repay to third parties, but for some reason has not yet done so. This is not a bad thing, short-term liabilities are a natural phenomenon. These are, for example, unpaid invoices, short-term bank loans, unpaid wages or unpaid taxes. Current assets are used to settle liabilities, primarily money. If the company does not have money, it must also use other current assets. The volume of short-term capital affects the volume of working capital (current assets minus current liabilities) and current liquidity.

The working capital ratio determines whether the company has enough short-term external resources to cover short-term assets. The working capital ratio is used by the company's management, eg in working capital management. The financial manager manages the individual working capital maids, defines its optimal amount with regard to the volume and nature of sales, monitors the recoverability of receivables, and evaluates its individual components. From his position, the financial manager cannot influence individual items of working capital, his role is to encourage others to look for better solutions. If we subtract current liabilities from current assets, we get the value of net working capital. This signals how much operating funds will remain available to us when we pay all our short-term liabilities. Net working capital should ideally be a low positive number. Zero or very low working capital means that the company has nothing to pay for the goods or services taken and, on the other hand, it does not receive any money on account from its customers, because the money received will result in an increase in the indicator to positive values. In this case, the company does not have sufficient capital for its operation. On the other hand, the higher the positive number, the more the company's operations are financed from long-term external sources or from own resources. It is therefore necessary to keep the level of net working capital at a level that ensures the smooth running of the company and at the same time does not mean unnecessarily high costs of financing from long-term or own resources. Optimal value of net working capital.

The above variables and their time series were the basis for the creation of panel data, which are further used in the correlation analysis and GMM method. According to Cohen (2014), the correlation analysis is a suitable method for the initial identification (estimation) of the functional relationship between a particular explanatory and explanatory variable. The correlation relationship can be expressed using the Pearson correlation coefficient, which may take the following form:

$$P = \frac{\Sigma(x_i-\bar{x})(y_i-\bar{y})}{(n-1)s_x s_y} = \frac{\Sigma(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\Sigma(x_i-\bar{x})^2\Sigma(y_i-\bar{y})^2}} \quad (1)$$

Where *X* represents the mean value of the enterprise solvency matrix represented by the selected enterprise liquidity indicator, *Y* is the mean of the matrix of the values of the individual financial indicators related to the structure of the sources of financing (explanatory variables) and n the number of observations. Pearson's correlation coefficient is based on the calculation by entering the covariance of the variables *X* and *Y* into the numerator, and then into the denominator the product of the standard deviations of the variables *X* and *Y*, which is defined as the root of the variance of the random variables *X* and *Y*. According to Evans (1996), the values of the correlation coefficient in different ranges signal different strengths of correlation (degree, level) or correlation relationship. Table 2 presents the range of values of the correlation coefficient and the strength of the correlation (degree, level) or correlation relationship.

Range of values of the correlation coefficient	Correlation strength within a correlation relationship
0 to 0.19	very weak correlation
0.2 to 0.39	weak correlation
0.4 to 0.59	middle correlation
0.6 to 0.79	strong correlation
0.8 to 1	very strong correlation

Source: own proceeding

Table 2: Correlation strength within a correlation relationship.

The statistical significance of the correlation coefficient, which can be tested at 1%, 5% and 10% significance, plays an important role in determining the relationship between variables. Using correlation analysis and the correlation coefficient, the relationship between the variables, including their resulting direction, ie whether they are positive, negative or zero correlations, can be determined. However, it is not possible to determine which variable affects another variable.

For this reason, a generalized method of moments (GMM method) will be used to determine the causal relationship between the variables and to determine the dependence of the endogenous variable on the exogenous variables. According to Prucha (2014), the problem of panel data is mainly when individual panel data are part of a shorter time series and are unsuitable for the use of least squares in terms of panel regression. According to him, the Generalized Method of Moments (GMM method) is a suitable method for examining the functional relationships between variables that are organized into such panel data. On the other hand, the disadvantage is the fact that it is not possible to test the given data within the basic assumptions of the smallest square method, ie heteroskedasticity, autocorrelation, normality and multi-collinearity and stationarity.

In order to ensure sufficient reporting ability, all variables will be tested for their statistical significance (for significance levels of 1%, 5% and 10%). In addition, the robustness of the model will be verified using Sargan / Hansen J-test, which determines to what extent the method is capable of delivering the same results even under load by slight parameter changes. The model is robust in this regard if the results of the Sargan / Hansen test are greater than 0.05. How working capital affects the profitability of companies operating in the food industry can be expressed using the equation below.

$$P_{it} = \alpha_1 + \beta_1 * \Delta P_{it\text{-}1} + \beta_2 * X_{1it} + \beta_3 * X_{2it} + ... \\ ... + \beta_n * X_{nit} + \varepsilon_{it}, \quad (2)$$

Where P_{it} shows the dependent variable (profitability of the company), which is represented by the indicator of gross operating profit (or other indicators capturing the profitability of companies), which captures the profitability of individual business performance of the i-th company in the Czech Republic over time *t*, $\Delta P_{it\text{-}1}$ is an explanatory variable that represents the delayed value of *P* from the previous year, X_{nit} includes explanatory variables that are considered to be elements of working capital that may have an impact on corporate profitability. These are mainly inventories, receivables, payables, inventory turnover time, receivables turnover time, liability turnover time and the cash cycle. The characters α_1 and ε_{it} represent the model constant and the residual component of the model within the generalized moment method (GMM method).

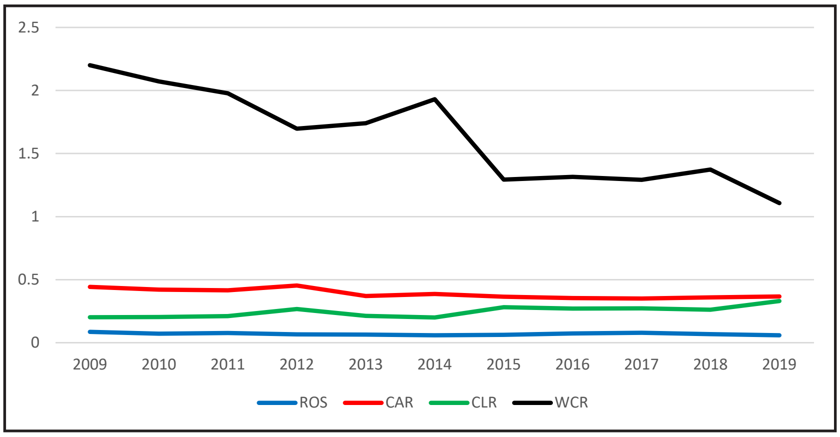
Results and discussion

This part of the article will first show the development of the analyzed variables over time for the period 2009 to 2019. Subsequently, the relationship between working capital and profitability of companies operating in the food industry will be determined using correlation analysis. The GMM method will be used to determine how working capital affects the profitability of the above companies.

Figure 1 shows the development of variables such as return on sales, current assets ratio, current liabilities ratio and working capital ratio for the period 2009 to 2019 within the food industry.

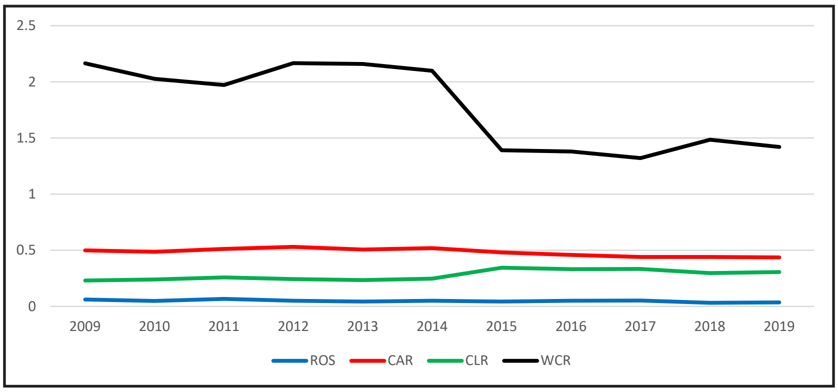
Figure 1 shows that variables such as return on sales, current assets ratio and current liabilities ratio showed a similar development trend throughout the analyzed period. There were no significant fluctuations in these variables throughout the period analyzed. However, a completely opposite development trend was found for variables such as working capital ratio. We see that this indicator showed an alternating development trend. In 2012, the value of the working capital ratio decreased due to the growth of current assets and current liabilities. On the contrary, in 2014 this indicator increased due to an increase in current assets and a decrease in current liabilities. After this year, however, the value of this indicator decreased due to a decrease in current assets and an increase in current liabilities. It can be stated that the development of the return on sales indicator corresponds to the development of indicators such as the current assets ratio and the current liabilities ratio. On the contrary, a completely inconsistent development was recorded for the return on sales indicator and the working capital ratio indicator. It is clear that companies operating in the food sector have a higher volume of current assets than current liabilities. In other words, current assets are higher than current liabilities of these companies. The development of these indicators of companies operating in the whole food sector was outlined within the method of comparison. However, for more detailed analyzes and conclusions, it is necessary to find out the development of these indicators also within individual food sub-sectors.

For this reason, Figure 2 represents the development



Sources: own processing from Orbis database and Ministry of Industry and Trade of the Czech Republic

Figure 1: Development of working capital indicators and profitability of companies in the food industry in the Czech Republic from 2009 to 2019.



Sources: own processing from Orbis database and Ministry of Industry and Trade of the Czech Republic

Figure 2: Development of working capital indicators and profitability of companies in the production of food products in the Czech Republic from 2009 to 2019.

of variables such as return on sales, current assets ratio, current liabilities ratio and working capital ratio for the period 2009 to 2019 only in the production of food products.

It can be stated that variables such as return on sales, current assets ratio and current liabilities ratio show a similar development trend, when the values of the return on sales indicator and the current assets ratio indicator develop almost evenly. A slight fluctuation was recorded in the current liabilities ratio, when the value of this indicator has increased since 2015. This was due to a decrease in current liabilities and an increase in total assets. As in the whole food sector, there was a non-corresponding development between the return on sales indicator and the working capital ratio in the production of food products. The values of the working capital ratio show an alternating uneven trend. A significant fluctuation in this indicator was recorded after 2014, when the assessment of this indicator decreased due to a decrease in current assets and an increase in current liabilities. Based on the comparison of Figure 1 and Figure 2, it can be stated that the above-analyzed variables develop in a completely similar way both within the whole food industry and within the production of food products. In Figure 3, it is possible to decipher the development of the analyzed variables in the production of beverages, which is part of the food industry as a whole.

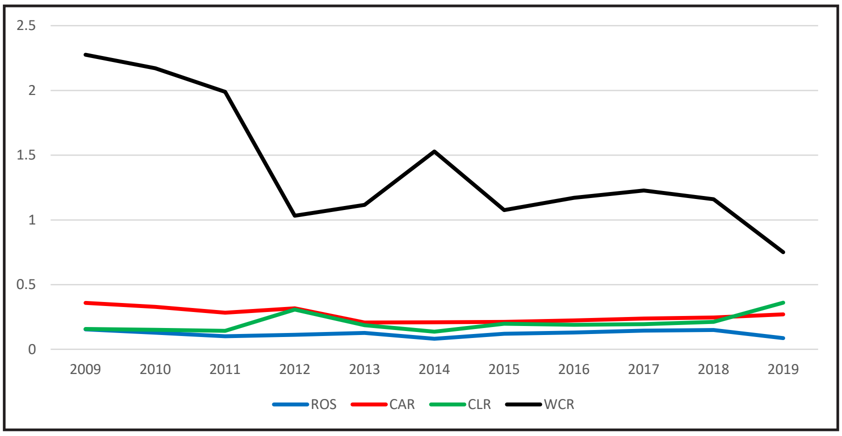
Figure 3 shows the development of variables such as return on sales, current assets ratio, current liabilities ratio and working capital ratio for the period 2009 to 2019 only in the production of beverages.

From figure number 3 it can be stated that within the production of beverages the values of the above variables differ slightly. Return on sales and current assets ratio show a steady trend, but current liabilities ratio fluctuated slightly around 2012 due to an increase in total assets. As for the working capital ratio, this indicator shows an alternating trend, as in the whole food sector and in the sector engaged only in the production of food products. In 2012, the value of this indicator decreased significantly due to the growth of current liabilities and the decrease in total assets. After this year, this indicator increased again due to an increase in total assets. After 2014, the value of the working capital ratio decreased again due to the growth of current liabilities.

In general, it can be stated that the only beverage industry shows a slightly different development trend than the food industry as a whole and the only food industry. It can be stated that the development of the current assets ratio and current libilities ratio corresponds to the development of the return on sales indicator. On the contrary, the development of the working capital ratio does not correspond to the development of the return on sales indicator. These claims apply both to the food industry as a whole and to the food or beverage industry alone.

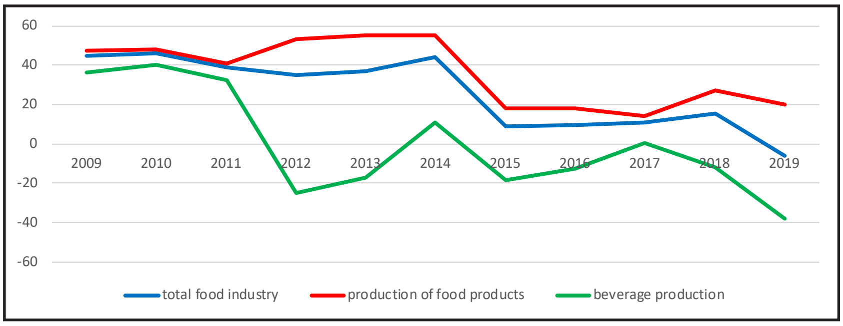
Figure 4 shows the development of the cash conversion cycle (CCC) in days for the whole food industry, for the production of food products and for the production of beverages for the period 2009 to 2019.

As far as the whole food sector is concerned, it can be stated that the value of the cash conversion cycle showed an alternating development trend.



Sources: own processing from Orbis database and Ministry of Industry and Trade of the Czech Republic

Figure 3: Development of working capital indicators and profitability of companies in the production of beverages in the Czech Republic from 2009 to 2019.



Sources: own processing from Orbis database and Ministry of Industry and Trade of the Czech Republic

Figure 4: Development of cash conversion cycle in the food industry in the Czech Republic from 2009 to 2019 (in days)

For almost the entire period analyzed, this indicator reached positive values, which means that the company must finance its operating activities from sources other than trade payables during this period. Only in 2019 did the value of the cash conversion cycle reach negative values. This means that after this year, companies operating in the food sector finance their negative working capital or problematic short-term assets from trade payables. This indicator reached its highest values in 2014 due to a decrease in the turnover time of liabilities and an increase in the turnover time of receivables. After this year, there was the most significant decrease due to a decrease in the turnover time of receivables and a significant increase in the turnover time of liabilities. If we look in more detail at the partial part of the whole food industry, specifically at the industry dealing only with the production of food products, we see that the value of the cash conversion cycle shows a fluctuating trend throughout the analyzed period. Throughout the analyzed period, the value of this indicator reached positive values. The most significant fluctuation occurred in 2015, when the value of the cash conversion cycle decreased significantly due to a decrease in the turnover time of receivables and an increase in the turnover time of liabilities. Regarding the beverage industry, it can be stated that the development of this indicator shows the most significant alternating or fluctuating trend of all 3 analyzed industries. The value of this indicator reaches negative values for almost the entire analyzed period. In 2012 and 2015, this indicator decreased mainly due to an increase in the turnover time of liabilities. In 2014 and 2017, on the other hand, the cash conversion cycle indicator increased. After 2017, the value of the cash conversion cycle decreased due to a decrease in the turnover time of liabilities and an increase in the turnover time of receivables. Table 3 presents the results of the correlation analysis for the whole food industry.

	CCC	CAR	CLR	WCR
ROS	-0.335*	-0.1853*	-0.3616*	+0.4651*

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 3: The results of the correlation analysis for the whole food industry.

	CCC	CAR	CLR	WCR
ROS	-0.1695**	-0.2402*	-0.2185*	-0.0424***

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 4: The results of correlation analysis for the production of food products.

	CCC	CAR	CLR	WCR
ROS	-0.2764*	-0.0684***	-0.6822*	-0.0671**

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 5: The results of the correlation analysis for beverage production.

The results of the correlation analysis show that there is a relationship between the profitability of companies operating in the food industry measured by the return on sales indicator and the variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio. We see that for all analyzed variables, a stastically significant dependence was found at the significance level of 1%. The results of the correlation analysis showed a negative weak correlation between return on sales and variables such as cash conversion cycle and current liabilities ratio. Furthermore, a negative very weak correlation between return on sales and current assets ratio was demonstrated. This means that if the period for which the company has to finance operating activities from sources other than trade payables (CCCs) increases, the return on sales is likely to decline. Similar conclusions apply to the relationship between return on sales and current liabilities ratio. If current liabilities and current assets increase with constant assets, the company is likely to see a decline in return on sales. On the contrary, a positive middle correlation between working capital ratio and return on sales was demonstrated. If the company has a higher volume of working capital, it will increase the return on sales. Table 4 presents the results of correlation analysis for the production of food products.

Table 3 presents the results of correlation analysis for the entire food industry. It must be stated that the food industry is divided into the production of food products and the production of beverages. For this reason, Table 4 presents the results of the correlation analysis only in the production of food products. The results of the correlation analysis showed a negative link for all analyzed variables. A negative very weak correlation at the level of statistical significance of 5% 10% was demonstrated between return on sales and variables such as cash conversion cycle (5% statistical significance) and working capital ratio (10% statistical significance). A 1% statistically significant negative weak correlation was demonstrated between return on sales and variables such as current assets ratio and current liabilities ratio. Table 5 presents the results of the correlation analysis for beverage production.

Table 5, on the other hand, presents the results of the correlation analysis only in the context of beverage production. We see that the resulting relationships in this field of business are developing similarly to the production of food products. The results of the correlation analysis showed negative binding at the level of 1%, 5% and 10% statistical significance for all analyzed variables. It can be stated that a negative very weak correlation between return on sales and variables such as current assets ratio and working capital ratio was demonstrated. Middle correlation was demonstrated between the return on sales and cash conversion cycles. On the contrary, a strong correlation was demonstrated between the return on sales and current liabilities ratio. Table 6 presents the results of the GMM method for the whole food industry.

The results of the correlation analysis showed the dependence between return on sales and variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio. However, correlation analysis does not determine the effect of independent variables on the dependent variable. In other words, correlation analysis cannot determine how the cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio affect return on sales. For this reason, the GMM method was used to determine how working capital affects the profitability of companies in the food industry. The results of the GMM method (Table 6) showed a negative effect of variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio on return on sales. This means that if the values of these variables increase, there will be a decrease in profitability measured by return on sales. As all the resulting relationships have been shown to be statistically significant, company managers should focus on the above independent variables. Therefore, if managers want to achieve higher profitability, they should reduce the values of cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio over a longer period of time. The robustness of the model is also indicated by the resulting J-statistic value, which is higher than 0.05. All resulting relationships were demonstrated at the 1% level of significance. Table 7 presents the results of the GMM method for the production of food products.

Table 6 presented the resulting relationships between return on sales and working capital in the food industry. The GMM method has now been used to find out how the analyzed variables will affect the profitability of companies only in the food-only sector. Using the GMM method, it has been shown that variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio have a negative effect on the profit of companies operating in the production of food beverages. If the variables in the company decrease, return on sales can be expected to increase. Again, the robustness of the model is also indicated by the resulting J-statistic value, which is higher than 0.05. All resulting relationships were demonstrated at the 1% level of significance. Table 8 presents the results of the GMM method for beverage production.

Based on Table 8, it can be stated that the effect of working capital on the profitability of companies engaged in the production of beverages was similar to the companies engaged in the production of food products throughout the analyzed period. It was found that if the company tries to reduce the value of variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio, there will be an increase in return

	CCC	CAR	CLR	WCR	J-statistic
ROS	-0.0192*	-0.0344*	-0.5224*	-0.0861*	34.7392

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 6: The results of the GMM method for the whole food industry.

	CCC	CAR	CLR	WCR	J-statistic
ROS	-0.2759*	-0.5707*	-0.1659*	-0.00941*	18.2428

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 7: The results of the GMM method for the production of food products.

	CCC	CAR	CLR	WCR	J-statistic
ROS	-0.0263*	-0.0193*	-0.0841*	-0.5385*	29.2083

Note: * denotes significance at 1% level, ** denotes significance at 5% level, *** denotes significance at 10% level
Source: authors' calculations

Table 8: The results of the GMM method for beverage production.

on sales. As in the production of food products, in the production of beverages, the robustness of the model is indicated by the resulting value of J-statistic, which is higher than 0.05. All resulting relationships were demonstrated at the 1% level of significance.

Discussion

As mentioned above, the results of the GMM method have shown that variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio have a negative effect on the return on sales of food industry companies. The decline in these variables is likely to cause food business enterprises to see an increase in return on sales. Aggressive working capital policies for food businesses can increase business performance. However, this effect is reduced if the company manages to reduce the cash conversion cycle (CCC). Reducing the cash conversion cycle (CCC) increases the value for its shareholders as working capital requirements decrease. Thus, the need to finance operating activities from sources other than trade payables is reduced. These findings are consistent with studies such as Lazaridis and Tryfonidis (2006), Anojan et al. (2010), Huynh (2012), Rehn (2012) and Golaś et al. (2013).

The current assets ratio, which is important for the company in particular because current assets represent the company's working capital, can be viewed in a similar way. Working capital represents the active items of the cash cycle (these are mainly items such as inventories, receivables and financial assets). The main problem in managing working capital is to determine the optimal level of investment in current assets and to find ways to finance it properly. Working capital is a part of working capital that is constantly circulating in the company and therefore works. The results of the GMM method showed that if the share of current assets in the balance sheet total in the company decreases, companies in the food industry may experience an increase in return on sales. On the other hand, the constant growth of current assets and their surplus causes unnecessary costs for their financing, which has a negative impact on the economic result. Every company should strive for an optimal level of working capital. The resulting solution is always a compromise between profitability and risk. The optimal option for companies would be to achieve the highest profitability at the lowest possible risk. It is quite evident that there is a link between working capital and return on capital. The working capital ratio, which is closely related to working capital, can be used to determine how many times a company can repay its current liabilities with its current assets. It has been shown that if companies want to increase return on sales, they should focus on reducing the values of this indicator. A company that generates a lower working capital ratio is likely to manage with lower cash, which the company may have tied up in stocks, which will increase sales and possibly also profit upon sale, which will be reflected in an increase in return on sales. This is in line with the Padachi study (2006).

On the contrary, if a company wants to support return on sales growth, it should focus on reducing the share of short-term liabilities in the balance sheet total. If an enterprise increases its current liabilities, for example from trading, it is likely that this will be reflected in the growth of inventories. If these stocks accumulate in stock and are not sold, this will have an impact on the decline in return on sales. This idea is consistent with the study by Lazaridis and Tryfonidis (2006) or Anojan et al. (2010).

As mentioned above, working capital management is a very key area for companies. In further research, it would be appropriate to examine the effects of individual components of working capital not only on the profitability of companies, but also on the economic added value of companies. It would be interesting to select companies according to the working capital management policy (aggressive working capital management policy, etc.). It is also necessary to eliminate significant difficulties, such as the fact that a company may have a significant share of receivables, but these receivables may be old. This may signal that customers are paying these corporate receivables more slowly, which may be hidden in the working capital. Some receivables may also be considered written off. There is also a need to focus on assets and liabilities. For example, if inventory cannot be sold and inventory accumulates, the results may be skewed and interpreted. The current working capital ratio may thus look favorable, but the company may be heading for failure.

Conclusion

The main branches of the Czech manufacturing industry include the production of food products, including the production of beverages. The sector is strategic in order to feed the population. The Czech Republic is characterized by high quality food production, with emphasis on health and food safety in the first place. The production of food products is linked to agriculture, but also cooperates with other branches of the processing industry. The majority of production is realized mainly through retail chains. Wide demand and strong competition in the food market puts strong pressure on innovation, resulting in a diverse range of fresh and durable foods for different categories of consumers.

The aim of the article was to find out the relationship between working capital and profitability of companies operating in the food industry in the Czech Republic and then to find out how working capital affects the profitability of these companies from 2009 to 2019. The first part of the research estimated the links between working capital measured cycle, current assets ratio, current liabilities ratio, working capital ratio and corporate profitability measured by return on sales. The next part of the research estimated the impact of working capital measured using variables such as cash conversion cycle, current assets ratio, current liabilities ratio, working capital ratio on corporate profitability measured by return on sales. Correlation analysis and the GMM method were used to determine the relationship between working capital and the profitability of companies and how working capital affects the profitability of these companies.

The results showed that return on sales and variables such as cash conversion cycle, current assets ratio, current liabilities ratio followed a similar trend across the food industry and within the production of food products and beverages. An alternating trend was recorded within the working capital ratio, when the values reached higher and alternating values. The results of the correlation analysis showed statistically significant links between return on sales and variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio both in the whole food sector and in the sector dealing only with food and beverage production. All links were estimated at 1%, 5% and 10% statistical significance. The results of the GMM method showed a statistically significant effect of variables such as cash conversion cycle, current assets ratio, current liabilities ratio and working capital ratio on the profitability of companies measured by the return on sales indicator. All mitigated effects have been demonstrated for companies operating in the food industry as a whole, as well as in the production of food products and beverages.

In conclusion, it can be stated that the food and beverage industry is one of the most active industries in the Czech Republic. Warehouse technology requirements are particularly high in this industry. Food is very prone to spoilage unlike other products. Therefore, it is important to ensure safe storage to keep the food fresh. The requirements for freshness and hygiene, the possibility of cooling, the setting of different temperature zones, the observance of continuous cooling chains during transport and the observance of the date of minimum durability are special conditions for companies for storage, handling and picking equipment. Regardless of whether the goods are sold in the traditional way or through online sales channels, the goal of the food and beverage industry is to ensure an ideal flow of goods from storage, through picking, to transport to the customer. From the above, it is clear that these companies must have a certain amount of inventory and must constantly pay attention to the management of inventories, receivables, liabilities and working capital. All this must be monitored by companies with regard to their liquidity and profitability. Only fresh food and the highest quality brings long-term satisfied customers and helps companies create a sustainable competitive advantage.

Acknowledgements

This paper ensued thanks to the support of the grant IGS/11/2021 "Working capital management in relation to the size and profitability of companies in the Czech Republic".

This paper was supported by the Ministry of Education, Youth and Sports Czech Republic within the Institutional Support for Long-term Development of a Research Organization in 2021.

Corresponding authors
Ing. Markéta Šeligová, Ph.D., assistant professor
Silesian University in Opava, School of Business Administration in Karvina
Univerzitní náměstí 1934, 733 40 Karviná, Czech Republic
Phone: +420 596 398 261, Email: seligova@opf.slu.cz

References

[1] Anojan, V., Arulalan, N. and Nimalathasan, B. (2010) "Working Capital Management and Its Impact on Profitability: A Study of Selected Listed Beverage, Food and Tobacco Companies in Colombo Stock Exchange", *The International Journal Of Business & Management*, Vol. 1, No. 6, pp. 15-20. ISSN 2321-8916.

[2] Baveld, M. B. (2012) "Impact of Working Capital Management on the Profitability of Public Listed Firms in the Netherlands during the Financial Crisis". [Online]. Available: https://essay.utwente.nl/61524/ [Accessed: June, 18, 2021].

[3] Chary, S. T., Kastury, R. and Kumar, K. S. (2011) "Relationship between working capital and profitability - a statistical approach", *International Journal of Research in Finance and Marketing*, Vol. 1, No. 7. ISSN 2231-5985.

[4] Cohen, J. and Cohen, P. (2014) "*Applied Multiple Regression/Correlaion Analysis for the Behavioral Sciences*", London, Psychology Press, 736 p.. ISBN 0-89859-268-2.

[5] Deloof, M. (2003) "Does Working Capital Management Affect Profitability of Belgian Firms"?, *Journal of Business Finance & Accounting*, Vol. 30, No. 3-4, pp. 573-588. ISSN 1468-5957. DOI 10.1111/1468-5957.00008.

[6] Gołaś, Z., Bieniasz, A. and Czerwińska-Kayzer, D. (2013) "The relationship between working capital and profitability in food industry firms in Poland", *Journal of Central European Agriculture*, Vol. 14, No. 1, pp. 52-63. ISSN 1332-9049. DOI 10.5513/JCEA01/14.1.1155.

[7] Howorth, C. and Westhead, P. (2003) "The focus of working capital management in UK small firms", *Management Accounting Research*, Vol. 14, No. 2, pp. 97-111. ISSN 1044-5005. DOI 10.1016/S1044-5005(03)00022-2.

[8] Huynh, N. T. (2012) "*The influence of working capital management on profitability of listed companies in the Netherlands*". [Online]. Available: https://essay.utwente.nl/62755/1/Master_thesis_-_Ngoc_Trinh_Huynh_-_final_version.pdf [Accessed: June 18,2021].

[9] Institute of Agricultural Economics and Information (2020) "*Panorama of the Food Industry 2019*", Prague, Ministry of Agriculture. ISBN 978-80-7434-588-3.

[10] Lazaridis, M. and Tryfonidis, D. (2006) "Relationship between Working Capital Management and Profitability of Listed Companies in the Athens Stock Exchange", *Journal of Financial Management and Analysis*, Vol. 19, No. 2, pp. 26-35. ISSN 0970-4205.

[11] Ministry of Industry and Trade (2019) "*Panorama of the Czech Manufacturing Industry 2018*", Prague, Ministry of Industry and Trade. ISBN 978-80-906942-6-2.

[12] Motlíček, Z., Matějková P. and Martinovičová, D. (2014) "Influence of Components of Net Working Capital on Costs of Companies Manufacturing Machinery and Equipment in the Czech Republic", *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, Vol. 63, No. 1, pp. 263-270. ISSN 2464-8310.DOI 10.11118/actaun201563010263.

[13] Padachi, K. (2006) "Trends in Working Capital Management and its Impact on Firms' Performance: An Analysis of Mauritian Small Manufacturing Firms", *International Review of Business Research Papers*, Vol. 2, No. 2, pp. 45-58. ISSN 1832-9543.

[14] Prucha, I. R. (2014) "Instrumental Variables/Method of Moments Estimation", In: Fisher, M. M. and Nijkamp, P, eds. "*Handbook of Regional Science*", Heidelberg: Springer. ISBN 978-3-642-23430-9. DOI 10.1007/978-3-642-23430-9_90.

[15] Rehn, E. (2012) "*Effects of Working Capital Management on Company Profitability*". [Online]. Available: https://helda.helsinki.fi/bitstream/handle/10138/32507/rehn.pdf. [Accessed: June 18, 2021].

Agris on-line Papers in Economics and Informatics

Volume XIV Number 3, 2022

The Contribution of Energy Use and Production to Greenhouse Gas Emissions: Evidence from the Agriculture of European Countries

Nikola Šubová

Department of Finances, Faculty of Economics, Technical University of Košice, Slovakia

Abstract

The submitted study investigates the role of energy use in agriculture and agricultural output in carbon dioxide emissions with the presence of instrumental variables such as rural population and urbanisation. The data set covers 27 European countries during the period 2010–2020. The quantitative approach was applied using cluster analysis with the previous identification of relations between variables by factor analysis. As the second approach, the Two-Stage Least Square (TSLS) model was estimated. Based on the results, three clusters were created. The heatmap demonstrated the similarity between the comprised countries. The most similar countries are Greece and Hungary, while the most different countries are Luxembourg and Malta. Performed TSLS analysis showed that an increase in energy use is associated with an increase in carbon dioxide emissions. On the other hand, greater agricultural output is associated with lower emissions. However, the statistical significance differs across the individual clusters.

Keywords

Agriculture, Energy, CO_2 emissions, cluster analysis, TSLS.

Šubová, N. (2022) "The Contribution of Energy Use and Production to Greenhouse Gas Emissions: Evidence from the Agriculture of European Countries", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 111-123. ISSN 1804-1930. DOI 10.7160/aol.2022.140309.

Introduction

Agriculture is the primary source of food security for human beings all over the world. It helps to fill the necessaries of life while supplies not only the food, but the clothing, medicine, and employment as well. In the past, agriculture was considered to be the clean industry which could be explained by the dependence of farmer`s life on the resource base of agriculture and the environmental quality. However, according to the Food and Agriculture Organization (FAO), it is expected that agricultural production will need to increase by 70 percent by 2050 to fill the needs of the growing population (FAO, 2022). Increasing demand for agricultural products for the sustenance of an increasing population encourages farmers to use various antifouling agents, antibiotics, and fungicides or requires higher consumption of energy that turns into environmental pollution. Despite the significance of agriculture, it is important to highlight that it is currently responsible for about one-third of all greenhouse gas (GHG) emissions that pollute the environment. Most of these GHG emissions are the results of the agricultural industry and therefore it is considered to be an important area to mitigate climate change (Engler and Krarti, 2021). Moreover, one-quarter of all GHG emissions may be caused by the global food system (Mrówczyńska-Kamińska et al., 2021). Although the food security, nutrition, and sustainable development are key interest points of policymakers at a national and international level, it is important to put attention not only on the supporting of agriculture as a center of food security, but on a clean, unpolluted, and healthy environment as well.

As the world population continues to grow, it is needed to increase agricultural production which is associated with greater energy consumption Much more effort and innovation are needed in order to effectively use resources with the aim to reduce environmental pollution. There are different theoretical perspectives explaining the relationship between greenhouse gas emissions and energy consumption. The theory of the Environmental Kuznets Curve (EKC) hypothesis presents the relationship between the economic performance of the agricultural sector and the environment as an inverted U-shape. It means that environmental pollution increases at the beginning of an economic expansion of the agricultural sector but after achieving a peak point, it starts to decline (Wang et al., 2022).

Existing studies demonstrate that the Kuznets Curve hypothesis is valid in developed (Gokmenoglu and Taspinar, 2018; Zhang et al., 2019) and developing countries as well (Xu and Lin, 2017; Rahman and Kashem, 2020) with the presence of investment into research and development.

The positive correlation between energy use across the economic sectors and its efficiency is known as Jevons's paradox. Jevons (1907) argues that technological innovations and development enhance energy efficiency and decrease the price of natural resources such as energy. According to this paradox, better energy efficiency might drive the energy consumption that turns to the rise in CO_2 emissions mainly through the existence of the rebound effect (York and McGee, 2015; Li and Xu, 2020).

To make agriculture more environment-friendly, it is important to introduce regulatory measures and energy-efficient innovations. The appropriateness of policy environmental regulation and its impact on innovation and technological growth is discussed in Porter's hypothesis (Porter and Linde, 1995). However, the effect of regulation on technology innovation can be twofold. Firstly, it is the compliance cost effect that is associated with an increase in the total cost of enterprises due to an increase in environmental protection costs. It produces a crowding-out effect on the technology investments of enterprises (He et al., 2020). Secondly, it is the innovation offset effect explaining that environmental regulations will encourage technological advancement which in turn increase productivity and offset the costs (Fang et al., 2020).

Except for the theoretical approaches, there are a lot of studies providing empirical evidence about the relationship between energy consumption and CO_2 emissions. Park et. al (2018) used Pooled Mean Group (PMG) estimator and found a long-run relationship with the CO_2 emissions that lower environmental quality. The study of Arshad et al. (2020) focused on the Asian and South Asian (SSEA) countries in the period 1990–2014 and relies on a different methodological framework that consisted of the Ordinary Least Squares (OLS), Generalized Method of Moments (GMM), and Dumitrescu-Hurlin causality test. The results showed the existence of bidirectional causality between CO_2 emissions and energy use. Another approach was applied in the study of Zhang et al. (2019) examining the factors increasing CO_2 emissions in China from 1996 to 2015. They employed cluster analysis and Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) panel regression model. According to the results, the most important factors influencing carbon dioxide emissions are investments in research and development, GDP, and energy cleanliness. Most of the mentioned studies examined the linkage between energy consumption and CO_2 emissions mainly in African or Asian countries. Several papers describe the determinants of carbon dioxide emissions in European countries as well. For example, Dogan and Aslan (2017) estimated the nexus between tourism, GDP, energy consumption, and CO_2 emissions. The results revealed a negative relationship between energy consumption and CO_2 emissions, but on the other hand, the effect of tourism and GDP was positive. Dogan and Seker (2016) and Bekun et al. (2019) found that carbon emissions are mitigated mainly by nonrenewable energy. On the other hand, non-renewable energy increases CO_2 emissions.

In the existing literature, we can also find studies that analyse the linkage between agricultural production and CO_2 emissions. The study using Vector Error Correction Model (VECM) applied to Pakistan during the period 1990–2014 concluded that agricultural production positively and significantly affects CO_2 emissions (Mushtaq et al., 2007). Jebli and Yousef (2017), who used Vector Error Correction Model (VECM), confirmed that an increase in agricultural production boost CO_2 emissions in Tunisia during the years 1980–2011. Contrary to this, Jebli and Youssef (2016) found that increase in agricultural production reduces CO_2 emissions. Similarly, Nwaka et al. (2020) confirmed that agricultural production reduces CO_2 emissions only from liquid sources, but it increases the total emissions.

Additionally, Haldar and Sharma (2021) found, that increasing energy consumption resulted in higher greenhouse gas emissions as a consequence of urbanization and population. The similar results that urbanization and rural population are considerable factors for energy consumption, agricultural production, and their role in CO_2 emissions were confirmed in the study of Iheke (2015), and Malik and Ali (2015).

Although agriculture fills the necessities of human life, in order to achieve sustainable development growth and meet the objectives of the Sustainable Development Strategy (Eurostat, 2016), policymakers should put attention to the effect of agriculture on the environment.

The submitted paper aims to group the countries according to agricultural indicators and analyse the importance of agriculture in carbon dioxide emissions in individual clusters. The paper addresses the following research question: „Is greater use of energy in agriculture and agricultural output associated with the increase of CO_2 emissions? "„Is the energy use in agriculture and agricultural output significant in relation to CO_2 emissions?"

The article contributes to the existing literature in several ways. Firstly, most of the papers analyze the role of the total energy use in CO_2 emissions in developing countries. The submitted paper focused on the agriculture in European countries helps to fill this gap. Moreover, existing studies apply the analysis to a whole sample, so it does not take into account the different characteristics of each country. Provided cluster analysis allows to group countries according to the basic economic characteristics and then analyses the relationship individually in each cluster including the most similar countries. Besides, findings from this paper offer new insights to policymakers on various ways of making the energy consumption in agriculture and agricultural output more environmentally friendly with the aim to achieve the goals of sustainable development indicators.

The remaining section of the paper is structured as follows: The second part introduces the data and methods used in this paper. The next section provides and discusses the results of the analysis. Firstly, the empirical study focuses on the similarities and differences between the European countries according to the basic indicators of sustainable development. Secondly, the role of energy consumption in agriculture and agricultural output in CO_2 emissions is analysed. The fourth part of the paper concludes with important remarks and offers recommendations for policymakers as well.

Materials and methods

The analysis presented in the paper utilized a time series dataset sourced from the World Bank, the Global Carbon Project, and European Commission database (Eurostat) to examine the role of energy use in agriculture and agricultural production in carbon dioxide emissions in EU member states. The analysis covered two dimensions: a territorial angle of a view involving 27 countries of the European Union (without Great Britain) and a time perspective represented by the period from 2010 to 2020. An observed dataset consisted of the following countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

The variable of carbon dioxide emissions was used as an explained variable, while the energy representing the energy consumption in agriculture and agricultural output as an explanatory variable. Moreover, following the existing literature, population, and urbanisation were used as control variables (Iheke, 2015; Malik and Ali, 2015; Chakamera and Alagidede, 2018; Han et al., 2022).

Several quantitative methods were applied in a comprehensive analysis concerning an econometric point of view: factor analysis, cluster analysis, and regression analysis.

The main assumption for the cluster analysis is no correlation between variables. Therefore, as a first step, the factor analysis was applied to the normalized data. The factor analysis helps to identify the relations between variables and leads to its reduction associated with combining variables into a single factor (Blbas, 2017). The suitability of the correlation matrix for the factor analysis was checked by Bartlett's Test of Sphericity. The null hypothesis H0 states that the correlation matrix of the variables is an identity matrix. It means that the variables are unrelated and not suitable for factor analysis (Bartlett, 1951). The technique used to determine the appropriate number of factors

Variable	Description	Source
Carbon dioxide (CO_2)	CO_2 emissions per capita (thousand tonnes)	Global Carbon Project
Energy	Final energy consumption by agriculture per hectare of utilised agricultural area (million tonnes of equivalent)	Eurostat
Production	Agricultural output at basic price (miliard euros)	Eurostat
Population	Rural population (% of total population)	The World Bank
Urbanisation	Share of population living in rural areas (% of total population)	Eurostat

Source: own processing

Table 1: Variable's description.

(or the number of significant components) was based on the Kaiser criterion (Kaiser, 1960). It explains that eigenvalues higher than 1 are considered significant in the Principal Component Analysis (PCA) (Granato et al., 2018). While some variables recorded a higher correlation with other variables, their assigning to the individual factor could be ambiguous. The varimax rotation solved this issue. Varimax rotation maximizes the variance shared among items and represents how data correlate with each principal component (Allen, 2017). The results of the factor analysis, the factor scores, were used as an input for the cluster analysis.

The second econometric approach applied in the submitted paper was the cluster analysis that allows to group countries based on their similarity (Bardhoshi et al., 2020). The cluster analysis begins with computing the Euclidean distance that computes the similarity of countries based on the selected indicators. The Euclidean distance of two objects p, q defined by the Cartesian coordinates (p_1,p_2) and (q_1,q_2) is given by the following equation (Cohen, 2004):

$$d_{p,q} = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2} \quad (1)$$

Where q represents the first country, p is the second country, and $d_{p,q}$ is the Euclidean distance of the first country p and the second country q.

After determining the optimum number of clusters by the majority rule, the EU countries were included in different clusters using Ward's minimum variance method with squared Euclidean distance (Murtagh and Legendre, 2014; Pelau and Chinie, 2018; Arshad et al., 2020).

In order to validate importance of Energy and Agricultural output in CO_2 emissions, the regression analysis was used in individual clusters. The paper considered the following empirical model:

$$CO2_{i,t} = \alpha_i + \beta_{i,t} Energy_{i,t} + \beta_{i,t}\, Production_{i,t} + \\ + \delta_{i,t}\, Z_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where CO_2 is an explained variable, *Energy* and *Production* represent an explanatory variable. Z is a set of control variables (rural population and urbanisation), ε is the disturbance term, β and δ are estimated coefficients, while the parameter α stands for an intercept. The index i is the analysed cluster (i = 1,2,3,4), and t is the time period covering the years 2010–2020

However, the problem of endogeneity could arise due to several reasons, such as the simultaneous linkage between CO_2 emissions and Energy or CO_2 emissions and Production, the correlation of Energy and Production with the error terms, and the problem of omitted variable bias. It could be solved using instrumental variables in Two-Stage Least Squares (TSLS) regression (Al-Mulali et al., 2015; Chakamera and Alagidede, 2018; Majeed and Khan, 2018). While Energy and Output represent the endogenous regressors and principal variables in Equation 2, in order to deal with the potential endogeneity, the TSLS approach first regresses Energy and Production on all explanatory variables (i.e. Z) in Equation 2. Therefore, the first stage models applied in the paper were as follows:

$$Energy_{i,t} = \gamma_0 + \gamma_1 Urbanisation_{i,t} \\ + \gamma_2\, Population + \varepsilon_{i,t} \quad (3)$$

$$Production_{i,t} = \theta_0 + \theta_1 Urbanisation_{i,t} + \\ + \theta_2\, Population + \varepsilon_{i,t} \quad (4)$$

In the second stage, the following regression model was estimated:

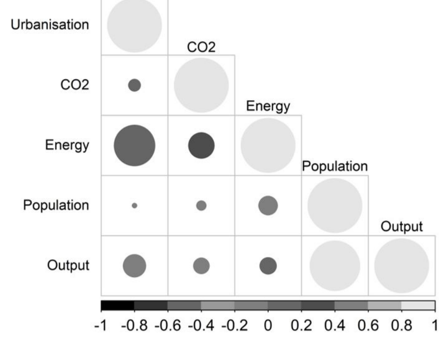
$$CO2_{i,t} = \alpha_i + \beta_{i,t} \widehat{Energy}_{i,t} + \beta_{i,t}\, \widehat{Production}_{i,t} + \\ + \delta_{i,t}\, Z_{i,t} + \varepsilon_{i,t} \quad (5)$$

Where $\widehat{Energy}$ and $\widehat{Production}$ denote the fitted values from the first stage regression model.

The whole analysis was executed in the R statistical environment through the programming language R (R Core Team, 2018) with the additional help of the NbClust package (Charrad et al., 2014), psych (Revelle, 2021), car (Fox et al., 2020), ivreg (Fox et al., 2021).

Results and discussion

While the cluster analysis is associated with no or low correlation (Blbas, 2017), firstly the correlation between variables was checked. The results are displayed in Figure 1.



Source: own processing

Figure 1: Correlation between input variables.

As it can be seen, the greatest correlation was found between the agricultural output and the rural population (84.93%) followed by the correlation between urbanization and energy use (-56.50%). On the other hand, the lowest correlation was recorded between the rural population and CO_2 emissions with a value of -3.11%.

Regarding the correlation between the input variables, the factor analysis was used in the next step of the provided analysis. Results of Bartlett's Test of Sphericity (with the p-value $9.60*10^{-7}$) led to the H0 rejection, which indicated the suitability of the data for the factor analysis. This result was confirmed by Kaiser-Meyer-Olkin (KMO) statistic with the value of 0.66. Kaiser criterion showed that the eigenvalue was greater than one in three cases. It indicated that three components of PCA explained 90.14% of the total variance (Table 2).

According to the results of PCA, variables such as trade recorded a higher correlation with more variables, and their assigning to the individual factor was ambiguous. Therefore, the PCA with the rotation varimax was used. The results are presented in Table 3.

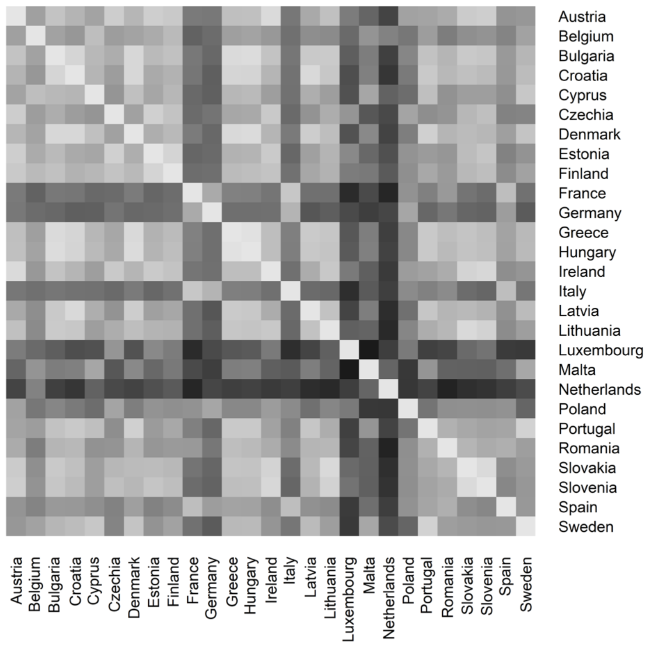
The shades of grey indicate the participation of input variables in individual components. As it can be seen, the first component including agricultural output and rural population explains 37% of the data variability. The second component consists of the energy use and urbanisation contributes to the explanation of data variability by 32%. The third component includes only the CO_2 emissions and explains 21% of the variability. While communalities (h2) of all variables were greater than 0.50, it was not necessary to remove any variable and repeat the factor analysis.

The output of the factor analysis, factor scores that are not correlated, was used as an input variable in the cluster analysis. Firstly, the similarity of countries based on the analysed variables was displayed (Figure 2). A lighter color depicts bigger

Variables	Component 1	Component 2	Component 3	h2	u2
CO_2	-0.03	0.05	0.98	0.97	0.030
Energy	-0.04	0.87	0.26	0.83	0.173
Output	0.96	0.14	-0.06	0.94	0.064
Population	0.97	-0.10	0.00	0.94	0.058
Urbanisation	-0.08	-0.89	0.16	0.83	0.168
Proportion var	*0.37*	*0.32*	*0.21*		

Source: own processing

Table 2: Results of PCA after the rotation varimax.



Source: own processing

Figure 2: Heatmap of European countries.

similarities of countries according to the Euclidean distance. The greatest Euclidean distance was found between Luxembourg and Malta (5.25), Netherlands and Lithuania (4.86) followed by the Netherlands and Latvia with a Euclidean distance of 4.76. Contrary to this, the most similar countries are Greece and Hungary with a Euclidean distance of 0.10, or Bulgaria and Hungary (0.23).

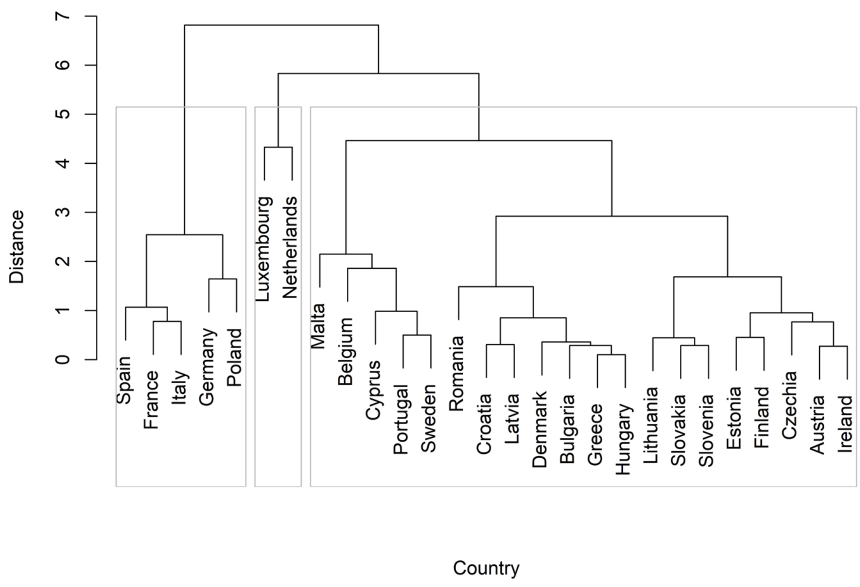
According to the majority rule, eleven indices proposed 3 as the best number of clusters. Indices defining an optimum number of clusters at the value 3 and their values (in parentheses) are: Scott (40.87); Marriot (6135.31); TrCovW (269.13); TraceW (9.99); Silhouette (0.45); PseudoT2 (10.58); Ratkowsky (0.40); Ball (15.54); PtBiserial (0.74); McClain (0.33); and Dunn (0.32). The process of clustering is showed in Figure 3.

The development of analysed variables in individual clusters is displayed in Figure 4. The values are given by the average for all countries included in a certain cluster. While environmental pollution caused by greenhouse gas emissions has become a serious problem, governments of European countries adopted various environmental regulations with the aim to turn the European Union into a resource-efficient, green, and competitive low-carbon economy (Mohammed et al., 2021). As a result, the level of CO_2 emission has decreased (Alola et al., 2020; Mrówczyńska-Kamińska et al., 2021). It can be seen in all clusters during the analysed period. The same trend can be observed in the case of the share of the rural population. As presented by Romanenko et al. (2020), the share of the rural population in EU countries decreases annually. On the other hand, agricultural production has increased in all clusters. According to Toma et al. (2017), Western European countries are more agriculturally productive than those in Eastern Europe. High concentration of energy consumption in agriculture is characteristic for countries with the largest agricultural sector, such as Poland and France (Rokicki et al., 2021). It is confirmed by the comparison of the first, second, and third clusters. Also, the urbanisation in rural areas have increased in the first and second cluster in comparison with 2010 and the energy consumption in agriculture has increased in the first and third cluster as well.

The first cluster created by Spain, France, Germany, Italy, and Poland represented by the red line recorded the highest agricultural output and rural population. The level of CO_2 emissions and energy consumption are comparable with the third cluster.

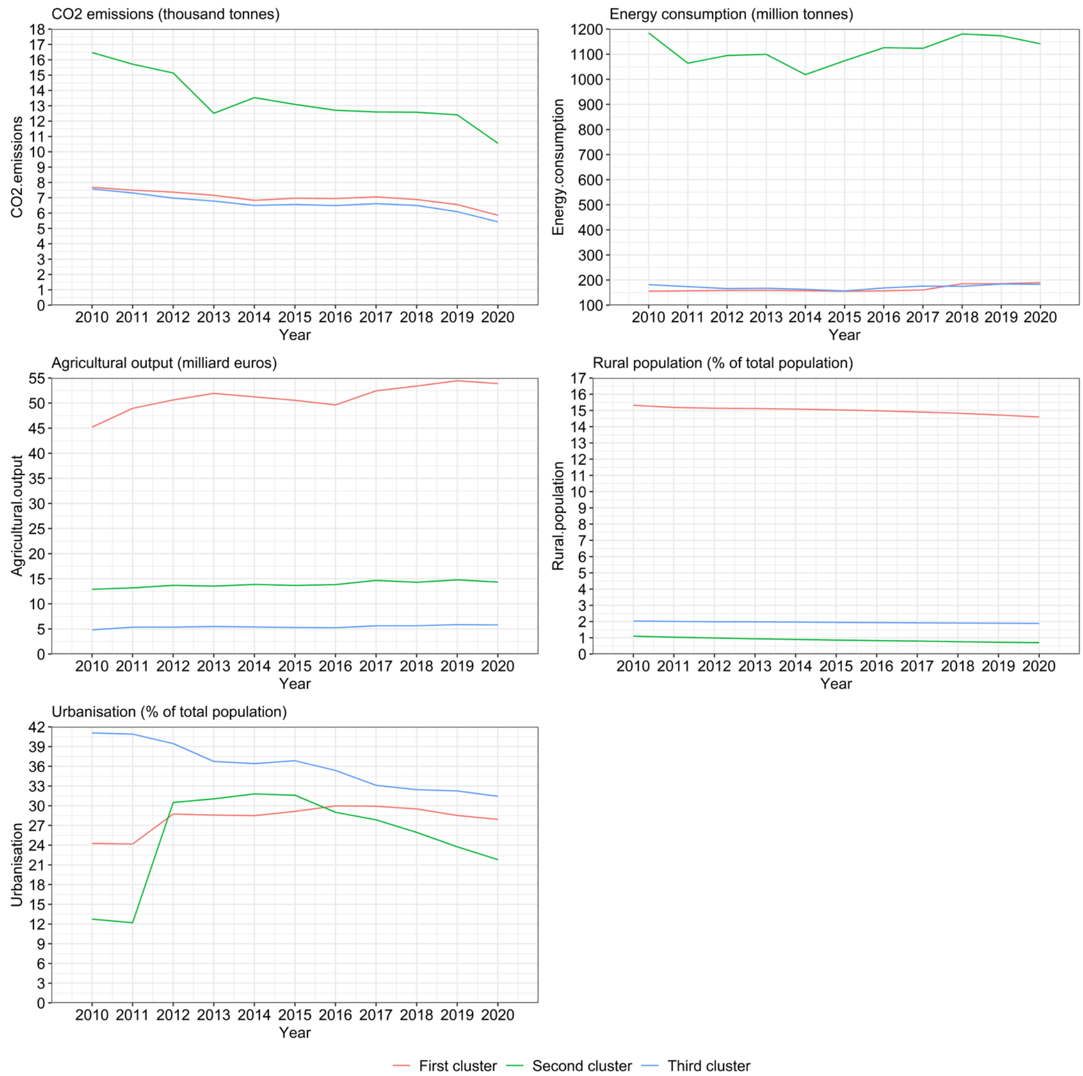
The second cluster which consists only of two countries – the Netherlands and Luxembourg recorded the greatest value of CO_2 emissions and energy consumption in agriculture. This group of countries can be characterized by the lowest share of rural population and urbanization almost during the whole analysed period.

Within the third cluster, countries with the greatest



Source: own processing

Figure 3: Dendrogram of European countries.



Source: own processing

Figure 4: Development of analysed variables according to the clusters.

share of urbanisation in rural areas can be observed. In the case of other variables, these countries are characterised by the lowest CO_2 emissions and agricultural output.

Based on the characteristics of each cluster, it could be assumed that higher CO_2 emissions are associated with higher energy use (Cluster 1) and lower CO_2 emissions with lower agricultural output (Cluster 3). The role of energy use in agriculture and agricultural output in CO_2 emission was further analysed using a TSLS estimation. Each model was checked for fulfilling key assumptions for regression models. While the heteroskedasticity and autocorrelation were confirmed, to estimate the model, heteroskedasticity, and autocorrelation consistent (HAC) variance-covariance matrix was used for the parameters. Results are presented in Table 3.

According to the results of the TSLS estimation technique, greater energy use in agriculture is associated with an increase in CO_2 emission in all clusters. It confirms the results of existing empirical research (Zaman and Abd-el.Moemen, 2017). The greatest increase of CO_2 associated with an increase in energy was recorded in the third cluster with the coefficient value 0.139 followed by the first cluster (0.026). The use of energy involves the release of emissions that pollute the environment (Weili et al., 2021). Also, Liu et al. (2017) explain that the agricultural industry is considered to be the main contributor to CO_2 emission mainly due to the utilization of energy with the aim to increase agricultural production. Therefore, to achieve sustainable agricultural

Clusters/ Coefficients	Estimates and t-statistics according to the cluster					
	Cluster 1		Cluster 2		Cluster 3	
Intercept	2.723		14.159	***	1.105	*
	(1.578)		(4.163)		(2.396)	
Energy	0.026	***	0.021	***	0.139	.
	(4.183)		(3.156)		(1.717)	
Output	-0.001		-1.703		0.044	
	(-0.067)		(-1.454)		(0.631)	
Diagnostic tests						
Weak instruments	(12.850)	***	(14.586)	***	(54.498)	***
Wu-Hausman	(85.066)	***	(15.287)	***	(20.547)	***
Sargan	(1.756)		(1.210)		(22.895)	***
R^2	*0.715*		*0.732*		*0.800*	

Note: t-statistics in parentheses
***; **; *; . indicate statistical significance at 0.001; 0.01; 0.05; and 0.1 significance levels
Source: own processing

Table 3: Results of the estimation of TSLS model in each cluster.

development in the European Union, more and more countries developed technologies that allow the use of renewable energy in the agricultural sector (Rokicki et al., 2021). On the other hand, there is also a study (Goundar and Appana, 2018) that found that energy use reduces carbon dioxide emissions through efficient energy patterns of production and consumption (Coroama et al., 2012). Although energy efficiency can be improved by these technologies, according to Amin and Rahman (2019), it boosts the energy demand much more and results in environmental degradation. The differences between the results of compared papers can be attributed to different countries that participated in analysis, different time periods, methodology, or variables used in these studies.

Additionally, based on the TSLS results, a greater agricultural output is connected with higher CO_2 emissions. Saudi et al. (2019) discusses that higher dependence on energy in agriculture tends to reduce environmental sustainability. These results are in line with existing empirical research that found a positive relationship between agricultural output and CO_2 emissions such as Mushtaq et al. (2007), Jebli and Yousef (2017). Results obtained from the first and the second cluster differ, while a greater agricultural output is associated with higher CO_2 emissions. According to Nwaka et al. (2020), greater agricultural output lowers the CO_2 emissions but only from the liquid sources. Also, Poeplau and Don (2015) explain that agriculture can induce carbon sequestration due to modified agricultural practices and as a result, the CO_2 emissions decrease.

Regarding the statistical significance of the results, energy use in agriculture plays a statistically significant role in CO_2 emission in all analysed clusters. The level of statistical significance differs across the clusters. However, the statistical significance of agricultural output in CO_2 emissions was not provided in TSLS analysis.

Moreover, the table includes the results of diagnostic tests for each cluster. Durbin-Wu-Hausman's test of endogeneity compares the OLS estimate with the TSLS one. A p-value lower than the critical value $\alpha = 0.05$ led to rejection of the null hypothesis. It implies that one or more regressors are endogenous, so the TSLS estimator is consistent. As it can be seen, the partial first stage statistics for weak instruments were statistically significant as well, mostly at 0.1% significance level. It indicates that the instruments included in the submitted paper are considered strong. Urbanisation and rural population are important factors for agriculture and could reflect in the level of CO_2 emissions (Iheke, 2015; Malik and Ali, 2015; Zhang et al., 2021). The last Sargan test of instrument exogeneity is used only in the case when there are more instruments than endogenous variables and the model is overidentified. While the p-value was greater than the critical value in all cases except for the third cluster, it can be concluded, that the instruments are valid in the two clusters.

Conclusion

In the last decades, food security has become a key interest point of policymakers at a national and international level. With the increasing population, it is expected that agricultural production will need to increase. It requires not only the use of various antifouling agents, antibiotics, and fungicides but higher energy consumption that turns into environmental pollution as well. Therefore, despite the significance of agriculture, it is important to put on a clean, unpolluted, and healthy environment as well.

The submitted paper investigates the role of energy consumption in agriculture and agricultural output in the CO_2 emissions in 27 European countries during the period 2010–2020. While there is previous empirical evidence that the level of urbanization and rural population are important determinants of carbon dioxide emissions, these characteristics of each country were included in the analysis as instruments as well.

First of all, the European countries were clustered using the cluster analysis with the previous application of factor analysis to solve the problem of correlation between the input variables. Based on the results, the most similar countries with the lowest Euclidean distance are Greece and Hungary, or Bulgaria and Hungary. Contrariwise, the greatest difference was recorded between Luxembourg and Malta followed by Euclidean distance between Netherlands and Lithuania.

Secondly, with the aim to analyse the role of energy use and agriculture and agricultural output in carbon dioxide emission, the Two-Stage Least Squares estimation technique was utilized in individual clusters. In response to the research questions, according to the results, an increase in energy consumption is associated with an increase in CO_2 emissions in all created clusters. The opposite result was found in the case of production, however only in the first and the second clusters. Greater agricultural production is associated with lower emissions in all clusters except for the third one, where the coefficient recorded a negative sign. Moreover, the results suggest that instruments used in the submitted paper (rural population and urbanization in rural areas) are valid in all clusters. It means that these variables require considerable attention in the analysis of energy consumption in the agriculture-CO_2 emissions nexus or agricultural production-CO_2 emissions nexus as well.

Obtained results can be served as background for the preparation of common directives of the policy framework for environmental regulation. Based on the empirical evidence that greater energy consumption in agriculture is associated with an increase in carbon dioxide emissions, policy responses are required. Although energy use has become integral part of agriculture, it is needed to focus on its disadvantages. The source of energy that is necessary, comes mostly from the resources that pollute the environment significantly. Further, most of the energy relies on nonrenewable sources. It is important to support and subsidize mainly technologies and agricultural projects with lower or no dire environmental consequences. The support for the project that uses nonrenewable energy could be transferred to clean energy research which might highlight the importance of this issue. However, all policy measures should be implemented very carefully while it might affect the growth rates and prosperity of countries.

Corresponding authors
Ing. Nikola Šubová, PhD.
Department of Finances, Faculty of Economics, Technical University of Košice
Němcovej 32, 040 01, Košice, Slovakia
Phone: 0556022146, E-mail: nikola.subova@tuke.sk

References

[1] Allen, M. (2017) "*Factor Analysis: Varimax Rotation*", The SAGE Encyclopedia of Communication Research Methods, pp. 532-533. ISBN 978-1-483-38143-5, DOI 10.4135/9781483381411.

[2] Al-Mulali, U., Sheau-Ting, L. and Ozturk, I. (2015) "The global move toward Internet shopping and its influence on pollution: an empirical analysis", *Environmental Science and Pollution Research*, Vol. 22, No. 13, pp. 9717-9727. E-ISSN 1614-7499. DOI 10.1007/s11356-015-4142-2.

[3] Alola, A. A., Akadiri, S. S. and Usman, O. (2020) "Domestic material consumption and greenhouse gas emissions in the EU-28 countries: Implications for environmental sustainability targets", *Sustainable Development*, Vol. 29, No. 2, pp. 388-397. E-ISSN 1099-1719. DOI 10.1002/sd.2154.

[4] Amin, S. B. and Rahman, S. (2019) "*The role of ICT in energy sector: Towards a Digital Bangladesh by 2021*", In *Energy Resources in Bangladesh*, Springer, Cham. E-ISBN 978-3-030-02919-7. DOI 10.1007/978-3-030-02919-7_6.

[5] Arshad, Z., Robaina, M. and Botelho, A. (2020) "The role of ICT in energy consumption and environment: an empirical investigation of Asian economies with cluster analysis", *Environmental Science and Poullution Research*, Vol. 27, No. 26, pp. 32913-32932, E-ISSN 1614-7499. DOI 10.1007/s11356-020-09229-7.

[6] Bardhoshi, G., Um, B. and Erford, B. T. (2020) "Conducting a custer anaysis in couseling research: Four easy steps", *Counseling Outcome Research and Evaluation*, Vol. 12, No. 1, pp. 54-62, ISSN 2150-1378. DOI 10.1080/21501378.2020.1768522.

[7] Bartlett, M. S. (1951) "The effect of standardization on a Chi-square approximation in factor analysis", *Biometrika*, Vol. 38, No. 3-4, pp. 337-344. E-ISSN 1464-3510. DOI 10.1093/biomet/38.3-4.337.

[8] Bekun, F. V., Alola, A. A. and Sarkodie, S. A. (2019) "Toward a sustainable environment: Nexus between CO_2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries", *Science of the Total Environment*, Vol. 657, pp. 1023-1029. ISSN 1879-1026. DOI 10.1016/j.scitotenv.2018.12.104.

[9] Blbas, H. (2017) "A Comparison results of factor analysis and cluster analysis to the migration of young people from the Kurdistan Region to Europe", *ZANCO Journal of Pure and Applied Sciences*, Vol. 29, No. 4, pp. 44-55. E-ISSN 2412-3986, ISSN 2218-0230. DOI 10.21271/ZJPAS.29.4.5.

[10] Cohen, D. (2004) "*Precalculus: A Problems-Oriented Approach*", 6th ed., Cengage Learning, p. 698, ISBN 978-0-534-40212-9.

[11] Coroama, V. C., Hilty, L. M. and Birtel, M. (2012) "Effects of Internet-based multiple-site conferences on greenhouse gas emissions", *Telemat Informatics*, Vol. 29, No. 4, pp. 362-374. ISSN 0736-5853. DOI 10.1016/j.tele.2011.11.006.

[12] Dogan, E. and Aslan, A. (2016) "Exploring the relationship among CO_2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence", *Renewable and Sustainable Energy Reviews*, Vol. 77, pp. 239-245. ISSN 1364-0321. DOI 10.1016/j.rser.2017.03.111.

[13] Dogan, E. and Seker, F. (2016) "Determinants of CO_2 emissions in the European Union: The role of renewable and non-renewable energy", *Renewable Energy*, Vol. 94, pp. 429-439. ISSN 1364-0321. DOI 10.1016.j.renene.2016.03.078.

[14] Engler, N. and Krarti, M. (2021) "Review of energy efficiency in controlled environment agriculture", *Renewable and Sustainable Energy Reviews*, Vol. 141. ISSN 1364-0321. DOI 10.1016/j.rser.2021.110786.

[15] Eurostat (2015) "*Sustainable Development in the European Union: Monitoring Report of the EU Sustainable Development Strategy*", European Statistical Office. [Online]. Available: https://ec.europa.eu/eurostat/documents/3217494/9940483/KS-02-19-165-EN-N.pdf/1965d8f5-4532-49f9-98ca-5334b0652820?t=1573202053000 [Accessed: Feb. 11, 2022].

[16] Eurostat (2016) "*Resource efficiency-Environment - European Commission*", European Statistical Office. [Online]. Available: https://ec.europa.eu/environment/resource_efficiency/targets_indicators/scoreboard/pdf/EU%20Resource%20Efficiency%20Scoreboard%202015.pdf. [Accessed: May 20, 2022].

[17] Eurostat (2022) "*Renewable energy statistics*", European Statistical Office. [Online]. Available: https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Renewable_energy_statistics [Accessed: Feb. 11, 2022].

[18] Fang, J., Gao, C. and Lai, M. (2020) "Environmental regulation and firm innovation:evidence from national specially monitored firms program in China", J*ournal of Cleaner Production*, Vol. 271, p. 122599. ISSN 0959-6526. DOI 10.1016/j.jclepro.2020.122599.

[19] Food and Agriculture Organization (FAO) (2022) "*A third more mouths to feed*", Food and Agriculture Organization of the United Nations. [Online]. Available: https://www.fao.org/news/story/en/item/35571/icode/en/ [Accessed: May. 20, 2022].

[20] Fox, J., Weisberg, S., Price, B., Adler, D., Bates, D., Baud-Bovy, G., Bolker, B., Ellison, S., Firth, D., Friendly, M., Gorjanc, G., Graves, S. and Heiberger, R. (2020) "*Package car*", R Foundation for Statistical Computing, Nov. 2020. [Online]. Available: https://cran.r-project.org/web/packages/car/car.pdf [Accessed: Feb. 11, 2022].

[21] Fox. J., Kleiber, Ch., Zeileis, A. and Kuschnig, N. (2021) "*Package ivreg*", R Foundation for Statistical Computing. [Online]. Available: https://cran.microsoft.com/snapshot/2021-10-23/web/packages/ivreg/ivreg.pdf [Accessed: Feb. 11,2022].

[22] Gokmenoglu, K. and Taspinarm, N. (2018) "Testing the agriculture-induced EKC hypothsis: the case of Pakistan", *Environmental Science and Pollution Research*, Vol. 25, pp. 22892–22841. E-ISSN 1614-7499. DOI 10.1007/s11356-018-2330-6.

[23] Goundar, S. and Appana, S. (2018) "Mainstreaming Development Policies for Climate Change in Fiji: A Policy Gap Analysis and the Role of ICTs", *Sustainable Development: Concepts, Methodologies, Tools, and Applications*, p. 31. E-ISBN 13 9781522538189, ISBN 13 9781522538172, ISBN 10 1522538178. DOI 10.4018/978-1-5225-3817-2.ch020.

[24] Granato, D., Santos, J. S., Escher, G. B., Ferreira, B. L., Maggio, R. M. (2018) "Use of principal component analysis (PCA) and hierarchical cluster analysis (HCA) for multivariate association between bioactive compounds and functional properties in food: A critical perspective", *Trends in Food Science & Technology*, Vol. 72, pp. 83-90. ISSN 0924-2244. DOI 10.1016/j.tifs.2017.12.006.

[25] Haldar, S. and Sharma, G. (2021) "Impact of urbanization on per capita energy use and emissions in India", *Journal of Energy Sector Management*. ISSN 1750-6220. DOI 10.1108/IJESM-01-2021-0010.

[26] He, W., Tan, J., Liu, J. and Zhang, H. (2020) "Property roghts protection, environmental regulation and corporate financial performance: revisting the Porter Hypothesis", *Journal of Cleaner Production*, Vol. 264, p. 24. ISSN 0959-6526. DOI 10.2139/ssrn.3740853.

[27] Chakamera, Ch. and Alagidede, P. (2018) "Electricity crisis and the effect of CO_2 emissions on infrastructure-growth nexus in Sub Saharan Africa", *Renewable and Sustainable Energy Reviews*, Vol. 94, pp. 945-958. ISSN 1364-0321. DOI 10.1016/j.rser.2018.06.062.

[28] Charrad, M., Ghazzali, N., Boiteau, V. and Niknafs, A. (2014) "NbClust: An R Package for Determining the Relevant Number of Clusters in a Data Set", *Journal of Statistical Software*, Vol. 61, No. 6, pp. 1-36. ISSN 1548-7660. DOI 10.18637/jss.v061.i06.

[29] Iheke, O. R. (2015) "Effect of Urbanization on Agricultural Production in Abia State", *International Journal of Agricultural Science, Research, and Technology in Extension and Education System*, Vol. 5, No. 2, pp. 83-89. ISSN 2251-7596.

[30] Jebli, M. and Youssef, S. (2016) "Renewable energy consumption and agriculture: evidence for cointegration and Granger causality for Tunisian economy", *International Journal of Sustainable Development and World Ecology*, Vol. 24, No. 2, pp. 149-158. ISSN 1350-4509. DOI 10.1080/13504509.2016.1196467.

[31] Jebli, B. M. and Youssef, S. B. (2017) "The role of renewable energy and agricultre in reducing CO_2 emissions: Evidence for North Africa countries", *Ecological Indicators*, Vol. 74, pp. 295-301. ISSN 1470-160X. DOI 10.1016/j.ecolind.2016.11.032.

[32] Jevons, W. S. (1907) "The Coal Question", *Nature*, Vol. 75, pp. 244-245. E-ISSN 1476-4687, ISSN 0028-0836. DOI 10.1038/075244b0.

[33] Kaiser, H. F. (1960) "The application of electronic computers for factor analysis", *Educational and Psychological Measurement*, Vol. 20, No. 1, pp. 141-151. ISSN 0013-1644. DOI 10.1177/001316446002000116.

[34] Khan, D. N., Baloch, M. A., Saud, S. and Fatima, T. (2018) "The effect of ICT on CO_2 emissions in emerging economies: does the level of income matters?", *Environmental Science and Pollution Research*, Vol. 25, pp. 22850-22860. ISSN 1614-7499. DOI 10.1007/s11356-018-2379-2.

[35] Li, X. and Xu, H. (2020) "The energy-conservation and emission-reduction paths of industrial sectors: evidence from Chinas 35 industrial sectors", *Energy Economics*, Vol. 86. ISSN 0140-9883. DOI 10.1016/j.eneco.2019.104628.

[36] Liu. X., Zhang, S. and Bae, J. (2017) "The nexus of renewable energy-agriculture-environment in BRICS", *Applied Energy*, Vol. 204, pp. 489-496. ISSN 0306-2619. DOI 10.1016/j.apenergy.2017.07.077.

[37] Majeed, M. T. and Khan, F- N. (2019) "Do information and communication technologies (ICTs) contribute to health outcomes? An empirical analysis", *Quality & Quantity*, Vol. 53, No. 2, pp. 183-206. E-ISSN 1573-7845, ISSN 0033-5177. DOI 10.1007/s11135-018-0741-6.

[38] Malik, R. and Ali, A. (2015) "The Impact of Urbanization on Agriculture Sector: A Case Study of Pashewar, Pakistan", *Journal of Resources Development and Management*, Vol. 8, pp. 79-86. ISSN 2422-8397.

[39] Mohammed, S., Gill, A. R., Hijazi, O., Yadav, K. K. Hasan. M. A., Husain, A., Cabral-Pinto, M. M. S. and Harsanyi, E. (2021) "An overview of greenhouse gases emissions in Hungary", *Journal of Cleaner Production*, Vol. 314, No. 10. ISSN 0959-6526. 10.1016/j.jclepro.2021.127865.

[40] Murtagh, F. and Legendre, P. (2014) "Ward's hierarchical agglomerative clustering method. Which algorithms implement ward's criterion?", *Journal of Classification*, Vol. 31, pp. 274-295. E-ISSN 1432-1343, ISSN 0176-4268. DOI 10.1007/s00357-014-9161-z.

[41] Mushtaq, K., Abbas, F. and Ghafour, A. (2007) "Energy use for economic growth:cointegration and causality analysis from the agriculture sector of Pakistan", *Pakistan Development Review*, Vol. 46. No. 4, pp. 1065-1073. ISSN 0030-9729.

[42] Mrówczyńska-Kamińska, A., Bajan, B., Pawlowski, K. P., Genstwa, N. and Zmyślona, J. (2021) "Greenhouse gas emissions intensity of food production systems and its determinants", *Plos One*, Vol. 16, No. 4, pp. 1-20. ISSN 1932-6203. DOI 10.1371/journal.pone.0250995.

[43] Nwaka, I. D., Nwogu, M. U., Uma, K. E. and Ike, G. N. (2020) "Agricultural production and CO_2 emissions from two sources in the ECOWAS region: New insight from quantile regression and decomposition analysis", Vol. 748. ISSN 0048-9697. DOI 10.1016/j.scitotenv.2020.141329.

[44] Park, Y., Meng, F. and Baloch, M. A. (2018) "The effect of ICT, financial development, growth, and trade openness on CO_2 emissions: an empirical analysis", *Environmental Science and Pollution Research*, Vol. 25, pp. 30708-30719. E-ISSN 1614-7499. DOI 10.1007/s11356-018-3108-6.

[45] Pelau, C. and Chinie, A. C. (2018) "Cluster Analysis for the Determination of Innovative and Sustainable Oriented Regions in Europe", *Studia Universitatis "Vasile Goldis" Arad – Economics Series*, Vol. 28, No. 2, pp. 36-47. ISSN 1584-233. DOI 10.2478/sues-2018-0008.

[46] Poeplau, C. and Don, A. (2015) "Carbon sequestration in agricultural soils via cultivation of cover crops–a meta-analysis", *Agriculture, Ecosystems & Envionment*, Vol. 200, pp. 33-41. ISSN 0167-8809 DOI 10.1016/j.agee.2014.10.024.

[47] Porter, M. E. and Linde, C. (1995) "Green and Competitive: Ending the Stalemate", *Harvard Business Review*, Vol. 73, No. 5, pp. 120-134. ISSN 0017-8012.

[48] Rahman, M. M. and Kashem, M. A. (2017) "Carbon emissions, energy consumption and industrial growth in Bangladesh: empirical evidence from ARDL cointegration and causality analysis", *Energy Policy*, Vol. 110, pp. 600-608. ISSN 0301-4215. DOI 10.1016/j.enpol.2017.09.006.

[49] Revelle, W. (2021) "*Package psych*", R Foundation for Statistical Computing, Sep. 2021. [Online]. Available: https://cran.r-project.org/web/packages/psych/psych.pdf [Accessed: Feb. 11, 2022].

[50] R CORE TEAM (2018) "*R: A language and environment for statistical computing*", R Foundation for Statistical Computing. [Online]. Available: https://www.Rproject.org. [Accessed: Feb. 11, 2022].

[51] Rokicki, T., Perkowska, A., Klepacki, B., Bórawski, P., Bełdycka-Bórawska, A. and Michalski, K. (2021) "Changes in Energy Consumption in Agriculture in the EU Countries", *Energies*, Vol. 2021, No. 14, No. 6, pp. 1-21. ISSN 1996-1073. DOI 10.3390/en14061570.

[52] Romanenko, Y., Boiko, V. O. and Schevchuk, S. M. (2020) "Rural development by stimulating agro-tourism activities", *International Journal Management*, Vol. 11, No. 4, pp. 695-693. ISSN 0976-6502.

[53] Saudi, M. H. N. and Sinaga, O. (2019) "Industrial, Commercial and Agricultural Energy Consumption and Economic Growth Leading to Environmental Degradation", *Ekoloji*, Vol. 28, No. 107, pp. 299-310. ISSN 1300--1361.

[54] Toma, P., Miglietta, P.P., Zurlini, G., Valente, D. and Petrosillo, I. (2017) "A non-parametric bootstrap-data envelopment analysis approach or environmental policy planning and management of agricultural efficiency in EU countries", *Ecological Indicators*, Vol. 83, pp. 132-143. ISSN 1470-160X. DOI 10.1016/j.ecolind.2017.07.049.

[55] Wang, X., Zhang, T., Nathwani, J., Yang, F. and Shao, Q. (2022) "Environmental regulation, technology innovation, and low carbon development: Revisiting the EKC Hypothesis, Porter Hypothesis, and Jevons' Paradox in China's iron & steel industry", *Technological Forecasting and Social Change*, Vol. 176. ISSN 0040-1625. DOI 10.1016/j.techfore.2022.121471.

[56] Weili, L., Khanm H., Kham I. and Han, L. (2021) "The impact of information and communication technology, fnancial development, and energy consumption on carbon dioxide emission: evidence from the Belt and Road countries", *Environmental Science and Pollution Research*, Vol. 29, pp. pages 27703-27718. ISSN 09441344. DOI 10.1007/s11356-021-18448-5.

[57] Xu, B. and Lin, B. (2017) "Assessing CO_2 emissions in China's iron and steel industry: a nonparametric additive regression approach", *Renewable Sustainable Energy Review*, Vol. 72, pp. 325-337. ISSN 1364-0321. DOI 10.1016/J.RSER.2017.01.009.

[58] York, R. and Mcgee, J. A. (2015) "Understanding the Jevons paradox", *Environmental Sociology*, Vol. 2, No. 1, pp. 77-87. ISSN 2325-1042. DOI 10.1080/23251042.2015.1106060.

[59] Zaman, K. and Moemen, M. A. (2017) "Energy consumption, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth", *Renewable and Sustainable Energy Reviews*, Vol. 74, pp. 1119-1130. ISSN 1364-0321. DOI 10.1016/j.rser.2017.02.072.

[60] Zhang, Y., Chen, Y., Shuai, Ch. and Shen, L. (2019) "The environmental Kuznets curve of CO_2 emissions in the manufacturing and construction industries: A global empirical analysis", *Environmental Impact Assessment Review*, Vol. 79. ISSN 0195-9255. DOI 10.1016/j.eiar.2019.106303.

[61] Zhang, D., Wang, Z., Li, S. and Zhang, H. (2021) "Impact of Land Urbanization on Carbon Emissions in Urban Agglomerations of the Middle Reaches of the Yangtze River", *International Journal of Environmental Research and Public Health,* Vol. 18, No. 4. E-ISSN 1660-4601. DOI 10.3390/ijerph18041403.

Agris on-line Papers in Economics and Informatics

Volume XIV Number 3, 2022

Shareholder Value Generation within the Agro-Food Financial Supply Chain

Zdeněk Toušek[1], Jana Hinke[1], Barbora Malinská[2], Martin Prokop[1]

[1] Department of Trade and Finance, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

[2] Institut of Economic Studies, Faculty of Social Sciences, Charles University in Prague, Czech Republic

Abstract

The article aims to define the Czech Agro-Food supply chain and develop financial metrics to quantify the economic value added generated within the supply chain. The study is based on a sample of complete financial statements from 2011 to 2018 from the agro-food organisations. The authors prove that the retail sale sector generates high shareholder value. Contrary to that, the wholesale sector´s shareholder value deteriorated over the respective period owing to reinforced capital intensity measures, resulting in low profitability. A special case is primary agricultural production, where the low shareholder value is offset by public transfers influencing all value drivers either directly or non-directly. These constantly changed, both in the single sector and financial supply chain, thus concluding the latter is dynamic in its nature. The primary agricultural production (Agro) faced specific conditions due to significant public transfers in the form of subsidies etc., thus influencing non/directly all shareholders´ value drivers and consequently reducing the originally expected vulnerability. The authors have found that the shareholder value is not generated and distributed evenly within the Czech Agro-Food supply chain; therefore, the "scissors" are expending in favour of the Retail sector at the expense of the others, especially of the Agro sector.

Keywords

Agro-Food sector, Economic Value Added, shareholder value, supply chain.

Toušek, Z., Hinke, J., Malinská, B. and Prokop, M. (2022) "Shareholder Value Generation within the Agro-Food Financial Supply Chain", *AGRIS on-line Papers in Economics and Informatics*, Vol. 14, No. 3, pp. 125-135. ISSN 1804-1930. DOI 10.7160/aol.2022.140310.

Introduction

Shareholder value can be viewed as a financial variable, a method of valuation, but also a concept of management with regard to maximizing the shareholder value, not only in the form of profit shares, but also in the form of profits resulting from the share price growth. The advantage of this concept is the fact that it measures performance considering changes in value, and furthermore that it relates to expected future cash flows, i.e., it is focused on the future - be it the future of the company, the industry, or the entire supply chain. In particular, the Agro-Food chain is specific because it is about food safety for humans, animal welfare and the sustainable use of natural resources. Therefore, the authors focus their interest in this direction.

The paper consists of five parts - the introduction is followed by a literature overview summarizing the relevant literature sources leading to the definition of three hypotheses. The data set is explained in the third part. The next part presents the results divided into the single sector perspective and the supply chain network perspective. Concluding comments summarise whether or to what extent the hypotheses have been confirmed or refuted.

Literature overview

"The supply chain can be seen as a series of consecutive markets involving input providers and producers, then producers and processors, then processors and wholesalers/traders and finally wholesalers/traders and retailers. Each of these markets is shaped by its own specific supply and demand accounting for price formation. The consecutive markets are interlinked and depend on each other. For a full picture, an understanding of the evolution of prices and value added at all stages of the supply chain would be useful" (Agricultural Markets Task Force 2016).

The value chain structure has been discussed by many scholars in literature, e.g., Blackman and Holland (2006) and Wheelen and Hunger (2002) offering a basis for the construction of the physical value chain structure for industry based rather on cooperative than adversarial strategies among market players. A study by Zhao et al. (2021) examined the impact of agro-food supply chain integration (which consisted of the internal integration of suppliers and customers) on the agro-food product quality and financial performance on a sample of 162 Chinese agro-food enterprises. Their findings show that the product quality fully mediates the relationship between the internal integration and financial performance and the relationship between the supplier integration and financial performance. Four important insights are also provided by Isakson (2014), having evaluated the literature from the political economy point of view. The first one is the finding that the line between finance and food provisioning has been fading away in recent decades, as financial entities are becoming more and more interested in food and agriculture and agro-food firms are increasing participating in financial activities (also supported by Krippner´s research 2005). The key finding is the fact that financialization has strengthened the role of food retailers as the key players within the agro-food chain, although they have to mostly follow the dictates of finance capital and compete again with grain traders who can profit from the financial transformation of food very well. The above-mentioned author also asserts that financialization has increased the food workers´ exploitation and made their jobs even more insecure. The last finding is the fact that financialization has impacted most on small farmers, for their livelihoods are becoming more and more uncertain and their market power has been weaking compared to the other players in the agro-food supply chain. In connection with these findings, the authors have decided to bring evidence from the Czech Republic, focusing on the shareholder value generation within the Agro-Food financial supply chain.

According to Crotty (2009) or Baud and Durand (2012), since the so-called "shareholder revolution" in the 1990s, corporate managers have redirected their businesses in order to satisfy shareholders´ demands which they consider to be the top priority.

According to the shareholder value theory, a company creates value when it meets or exceeds a cost of capital that correctly reflects its investment risk, i.e., business is worth of net present value of its future cash flows discounted at the appropriated cost of capital (Balakrishnan et al. 2021). Probably the most commonly accepted thought on interlinking company's performance and shareholder value is Economic Value Added (EVA) concept introduced by Stern (1990) and used in a number of studies (e.g., Maia and Di Serio 2017 or Kucera et al. 2021), or the alternatives such as Operating EVA (OEVA) and the Total EVA (TEVA) defined by Ibragimov and Velez-Pareja (2019).

Lambert and Burduroglu (2000) or Elrod et al. (2013) established link between Economic Value Added and financial supply chain management. Based on the mutual interactions among supply chain participants, they identified four main value drivers influencing companies' Economic Value Added, namely:

- revenues – Beyer and Hinke (2020) highlight the need to compare this variable for enterprises reporting according to the same legislative framework (whether national or e.g., IAS/IFRS) and to use data from accrual accounting.
- operating costs – total or in breakdown e.g., into material, personal, etc. Grau and Reig (2020) report that in the agricultural sector, due to the uneven use of subsidies (recorded in revenues), operating costs are more suitable for inter-company comparisons.
- working capital – as for this aspect, reference can be made to the publication of Oleghe (2019), who designed a model to determine the long-term impact of a company´s working capital management within the agribusiness and aquaculture supply chain. Thus, this author claims that there is a systematic approach to working capital management that can be used to prevent financial difficulties or value chain disruption.
- fixed assets or more precisely fixed asset intensity, which is used in research by many authors. Beyer and Hinke (2020) present aggregate results for the Czech agricultural sector, which show a high level of fixed asset intensity compared to nine other European countries.

As stated by Pohlen and Coleman (2005), there is no doubt that supply chain excellence leads to the ability to create shareholder value.

Following the above-mentioned theses, the authors have decided to test the following hypotheses:

H1: Sectors of national economy closer to the final customer tend to produce higher value added for its shareholders, i.e., the law of diminishing downstream value added decomposition is confirmed.

H2: Value added characteristics remain stable over the observed period of time both on supply chain as well as individual sector's level.

H3: Primary agricultural production as starting production sector (i.e., the most remote from the final customer) is the most vulnerable in its value added generation due its subordinated position within the Czech Agro-Food financial supply chain.

Authors believe that the originality of the proposed text lies in discussed topic itself, since very limited number of papers is covering issue of Agro-Food financial supply chain in general and especially in the context of the Czech Republic is the empirical evidence even more scarce. According to Chakuu et al. (2019) majority of papers focus on industrial sectors, manufacturing, and logistics. Also, majority of studies examine predominantly publicly traded companies (due to accessible financial data) for example study Hall (2018) or Otekunrin et al. (2018), thus omitting significant part of relevant economy (typically SME/family businesses) that are facing different and very often more severe market or financial conditions (Gambelli et al. 2021 or Redlichova et al. 2019). At the same time majority of literature tends to employ working capital measures only, predominantly cash conversion cycle, rather than more complete set of economic indicators (e.g., Deepa et al. 2016) at least in the context of the Czech Agro-Food supply chain (e.g., Jirsak, 2018 or Mokrejšová et al., 2018).

Materials and methods

This study is based on the data sample composed of complete individual financial statements (audited where available) of firms conducting their business in the Czech Republic over period 2011-2018 and belonging to the Czech Agro-Food supply chain. These are data from accrual accounts kept for all firms according to the accounting regulations of the Czech Republic.

To form the Czech Agro-Food supply chain, we follow an approach suggested by Lobisher and Rothbock (2006) linking industrial sectors which typically interact with each other under following assumptions: i) anticipated relationships within predefined supply chain are exclusive (Retail sale sector is exclusively supplied by Wholesale sector etc.) and ii) potential mutual competitiveness among sectors/other supply chains is neglected, i.e., exclusive manufacturing of goods in each supply chain.

This value chain is defined as individual sectors represented mainly by following NACE (NACE stands for Nomenclature statistique des Activités économiques dans la Communauté Européenne) codes: A1 - Crop and animal production, hunting and related service activities, C10 - Manufacture of food products, C11 - Manufacture of beverages, G46.3 - Wholesale of food, beverages and tobacco and G47.2 - Retail sale of food, beverages and tobacco in specialized stores. In contrast to Lind et al. (2012), no cut off thresholds of turnover were applied. Thus, data sample is incorporating both small and large, as well as publicly traded and private companies. Final balanced dataset contains of 276 firms with complete annual financial figures from period 2011-2018, thus consisting of 2.208 firm - year observations.

Please note that some companies may belong to multiple sectors. For our purposes, we assigned each company to single sector only based on prevailing production. Following aggregation and adjustments were made to achieve consistent and comparable financial figures across all firms in the sample. The accounts receivables and payables are representing only tradable ones (e.g., intragroup accounts receivable are not considered) and are including both due pay and overdue within one year. The inventory counts for raw material, work in progress and finished goods. Advance payments received or paid are not considered as part of working capital calculation because do not represent significant item on balance sheet. Companies' performance variable turnover is adjusted by other operating income item (where prevailing volume of subsidies is booked).

This paper is developing from approached suggested by Losbichler et al. (2008) and extended by broader list of shareholder value drivers employed by e.g., Effinger et al. (2011), Hall (2018).

Following variables were defined as proxies of main value drivers:

i. Year-on-year change of revenues (TO Y/Y) as a measure of annual growth,

ii. EBITDA margin (EBITDAm) as a proxy of operating cost, resp. efficiency,

$$EBITDA\ margin = \frac{\text{Operationg profit(loss)} + Depreciation\ and\ amortization}{\text{Turnover}} \quad (1)$$

iii. Working capital requirements measured by Cash conversion cycle (CCC),

iv. Fixed assets utilization (FA_TO) measured as ratio of Fixed assets scaled by Revenues.

Cash conversion cycle (CCC) as the indicator of how long cash is tied up between procurement and sales developed by Richards and Laughlin (1980) is used as a time-based characteristic. As presented by Lind et al. (2012) cash conversion cycle consists of cycle times of inventories, account receivables and account payable and is defined as:

CCC = DIO + DSO - DPO, where DIO represents days of inventory outstanding, DSO represents days sales (receivables) outstanding and DPO represents days payables outstanding:

$$DIO = \frac{\text{Inventory}}{\text{Turnover}} * 365 \quad (2)$$

$$DSO = \frac{\text{Accounts receivable}}{\text{Turnover}} * 365 \quad (3)$$

$$DPO = \frac{\text{Accounts payable}}{\text{Turnover}} * 365 \quad (4)$$

Results and discussion

Single sector perspective

In this section attention shall be paid to the description of shareholder value drivers of individual sectors within predefined Czech Agro-Food supply chain.

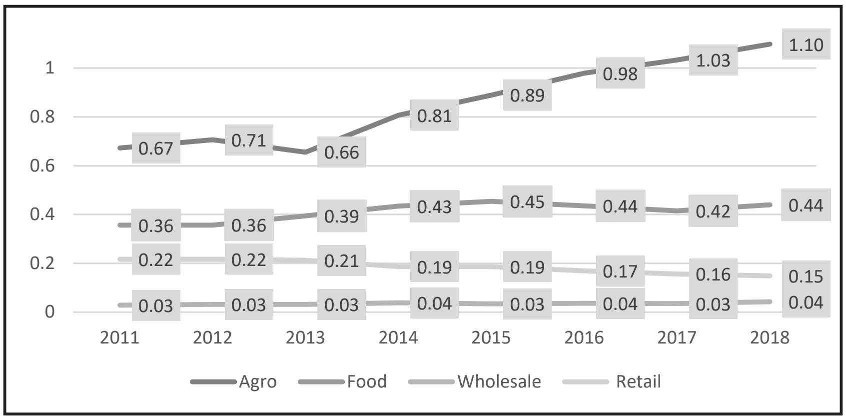
Development of fixed assets utilization (fixed assets scaled by revenues) as a proxy of fixed assets usage in the production of the particular sectors of national economy is depicted in Figure 1. It is clear that primary agricultural production is employing far the most fixed assets to generate one unit of output. We observe clear upward trend since 2013, with the latest data showing aggregated volume of fixed assets to be higher that achieved final output reaching 110% in 2018.

With the exception of Agro production sector that experienced significant increase by 64%, fixed assets utilization ratio remains relatively stable for the remaining sectors over the observed period. We suspect the difference to be probably driven by higher fixed assets purchase promoted by public support (different form of investment subsidies).

Figure 2 is representing average values (average of annual median values over the respective period of time) of profitability measured by EBITDA margin and performance captured by year to year Turnover change. At first sight, only Agro sector is achieving double digit profitability and surprisingly is managing constantly (with the exception of year 20017 and 2018) to outperform the other sectors. However, if public transfers effects (EU and national subsidies etc.) are suppressed, situation significantly changes and Agro sector average profitability falls down to -2% under no public support scenario, whereas Food sector was experiencing limited reduction only by -1.4%, and other sectors remain unchanged. Average performance is rather stable, where highest average growth was achieved by Retail sale sector during the analysed period.

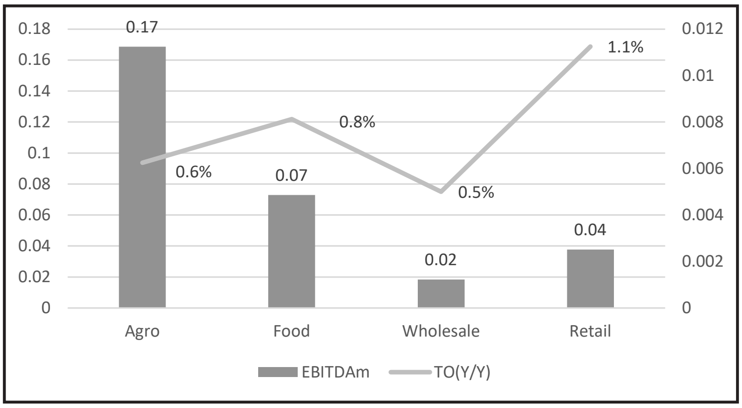
Cash conversion cycle as time-based characteristic is reflecting intensity of working capital employment on the company's level and is defined as by payment conditions to customer (ARDOH), suppliers (APDOH) and requirement for amount of inventories (INVDOH). Please note that due to undue weighting from outliers medians were utilized for all components and are reflected in days.

As depicted in Figure 3, for Agro sector cash conversion cycle has increased by significant



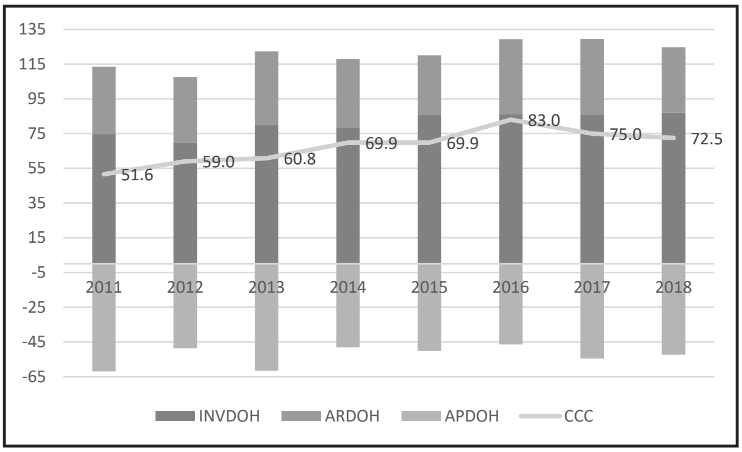
Source: own processing

Figure 1: Fixed assets utilization (annual median values).



Source: own processing

Figure 2: Annual growth and profitability (average values).



Source: own processing

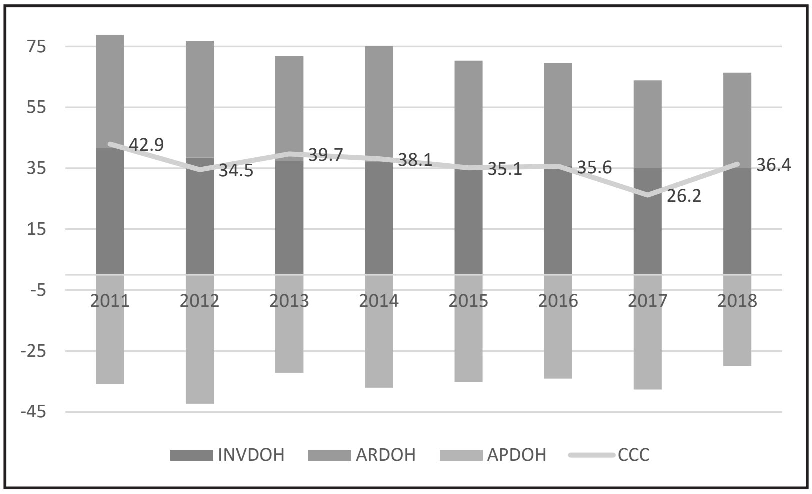
Figure 3: Agro sector Cash conversion cycle

20.9 days (highest increase among observed sectors) ending with median value 72.5 days. Which is predominantly driven by extension of days inventory outstanding (+12.4 days) and simultaneously reduction of days account payables outstanding (+9.6 days). Level of inventories also remain relatively high (compare to other sectors) above 70 days.

As showed by Figure 4, Cash conversion cycle for Food sector has experienced reduction by 6.5 days ending with median value of 36.4 days. This change was caused by simultaneous decline of all components, namely days inventory outstanding (-6.5 days), days account receivables outstanding (- 5.95 days) and days account payables outstanding (-5.9 days). At the same time particular components of Food sector cash conversion cycle are the most evenly distributed among observed sectors.

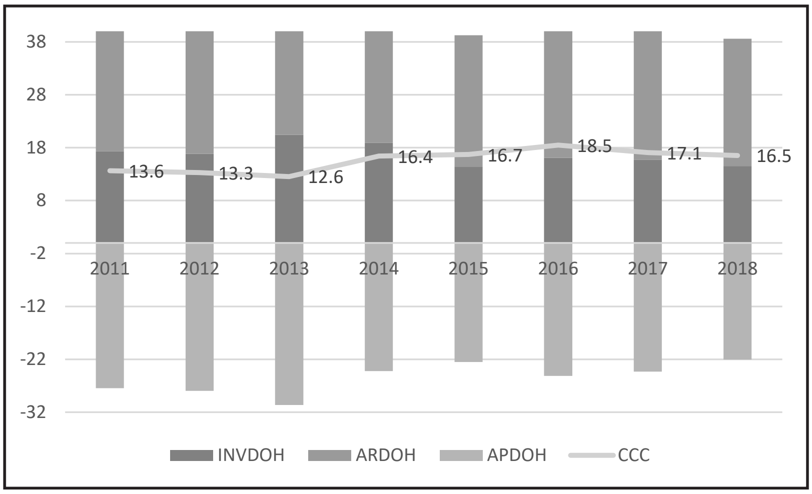
In Figure 5, Wholesale sector similar to Food sector has witnessed increase of cash conversion cycle by 2.6 days generated by days account payables outstanding shortening by 5.4 days. Simultaneously prolongation of days account receivables outstanding by 2.8 days.

Cash conversion cycle of Retail sale sector has experienced a slight reduction by 2.5 days and ending with median value of 10.5 days as depicted in Figure 6. All components of cash conversion cycle have experienced changes over the time, highlighting days account receivables outstanding having declined by 7 days. At the same time days account receivables outstanding are achieving the lowest figures across all sectors, which is predominated by nature of its business (majority sale as cash operation). Days account payables outstanding were shortened by 6.3 days.



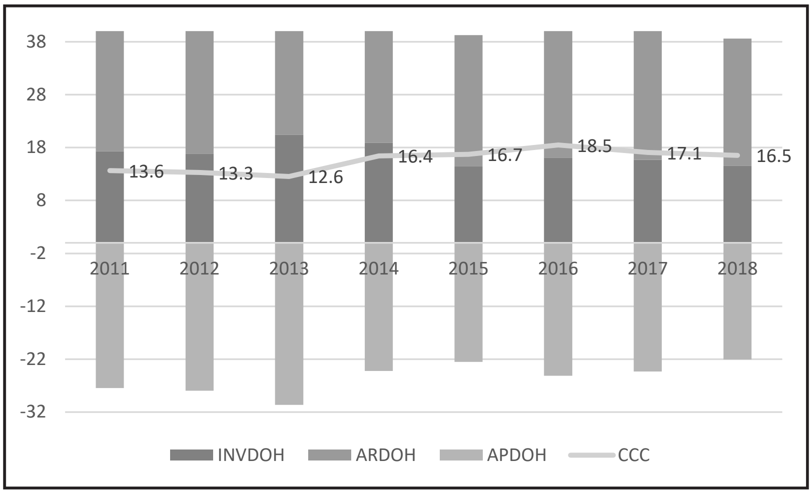
Source: own processing

Figure 4: Food sector Cash conversion cycle



Source: own processing

Figure 5: Wholesale sector Cash conversion cycle



Source: own processing

Figure 6: Retail sale sector Cash conversion cycle.

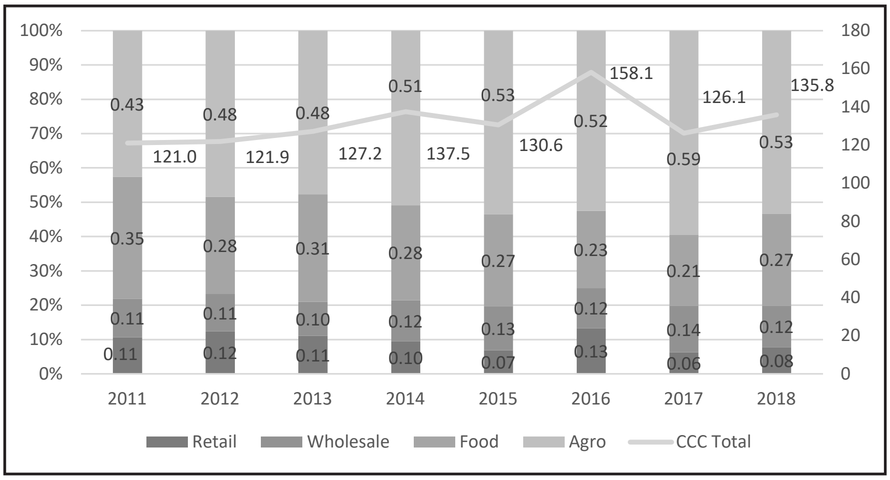
Supply chain network perspective

In this section we aim to put value drivers to a general supply financial value chain concept in order to explore the particular sector dynamics on the Czech Agro-Food financial supply chain shareholder value generation. Therefore, supply chain cash conversion cycle is defined as the sum of all subsectors cash conversion cycles, similar to Hofman and Kotzab (2010) approach and extended to sectoral value drivers' comparison.

As can be seen in Figure 7 cash conversion cycle for all sectors is positive, i.e., the Czech Agro-Food supply chain ties up significant amount of working capital for relatively long period of time, which has even extended over the observed period of time by 14.8 days (+12.2%). Agro sector jointly with Wholesale sector have experienced extension over the 2011-2018 period (rather significant in the case of Agro sector) by 20.9 days and 2.9 days, respectively. Contrary to it Food sector (both C10 and C11) and Retail sale have reversely witnessed reduction by 6.5 days and 2.5 days, respectively.

The average share of particular sector is decreasing the closer its product gets to the final customer (valid almost throughout all years). In other words, Agro sector has achieved the highest share value contrary to the Retail sale sector with the lowest ones implicating more efficient working capital management in line with similar findings of Viskari et al. (2011) and Losbichler et al. (2008).

As in Table 1, it seems that Agro sector has experienced biggest changes within the Czech Agro-Food financial supply chain with respect to the capital intensity both on working capital (Cash conversion cycle +40.5%) and fixed assets (fixed assets utilisation +63.3%) engagement



Source: own processing

Figure 7: Share of particular sectors on supply chain cash conversion cycle.

NACE	Name	Description	Year	INVDOH	ARDOH	APDOH	CCC	FA Utilization	Annual growth	EBITDA m
A1	Agro	"Primary agricultura production"	2011	74.60	38.87	61.91	51.56	0.67	-0.04	0.15
			2018	86.95	37.79	52.29	72.45	1.10	-0.02	0.16
			Δ (%)	*16.6%*	*-2.8%*	*-15.5%*	*40.5%*	*63.3%*	*-50.0%*	*6.8%*
C10&11	Food	Food & Drink production	2011	2011.00	41.67	-37.18	-35.90	0.67	-0.04	0.06
			2018	2018.00	35.14	-31.23	-29.96	1.10	0.03	0.09
			Δ (%)	*0.3%*	*-15.7%*	*-16.0%*	*-16.5%*	*63.3%*	*-192.9%*	*33.1%*
G46	Wholesale	Wholesales	2011	2011.00	17.33	-23.78	-27.48	0.36	-0.02	0.01
			2018	2018.00	14.53	-24.08	-22.07	0.44	0.00	0.02
			Δ (%)	*0.3%*	*-16.2%*	*1.3%*	*-19.7%*	*23.4%*	*-100.0%*	*34.1%*
G47	Retail	Retail sales	2011	2011.00	25.62	-17.58	-30.30	0.03	-0.01	0.04
			2018	2018.00	23.90	-10.51	-23.96	0.04	0.04	0.04
			Δ (%)	*0.3%*	*-6.7%*	*-40.2%*	*-20.9%*	*52.6%*	*-500.0%*	*4.9%*

Source: own processing

Table 1: Summary of Economic Value Added drivers (median values).

level, which jointly negatively influenced EVA and consequently shareholder value generation over the respective period of time. These effects were offset by relatively high (achieved highest values within predefined supply chain sectors) profitability (annual median values of EBITDA margin fluctuated around 17%) that is without any doubts driven by generous public support in place. Without these transfers profitability was continuously negative (with exception of 2012).

From capital intensity point of view, the Food sector has improved its working capital management (Cash conversion cycle -15.2%) which was partly offset by increased capital expenditures leading to higher Fixed assets utilization (+23.4%). Relatively high profitability (annual median values oscillated above 7%) has increased over the time (+33.1%) and is less dependent on public support compared to Agro sector (only -1.4% drop in the case of public transfer suppressed scenario). Since Food sector is defined as a set of food producers and drink makers, it would be interesting to further decompose it to observe any potential inconsistency and dissimilarities between these two.

Wholesale sector experienced (similar to Agro sector) capital intensity reinforcement both on working capital management (Cash conversion cycle +21.3%) and capital expenditure (Fixed assets utilization +52.6%) level. Profitability measures seems to improve over the respective period of time significantly (-34.1%), but relatively low absolute values shall be considered as well as (average annual value oscillated bellow 2%).

Retail sale sector has accomplished the best results with respect to the capital intensity measures. Both working capital management (Cash conversion cycle -19%) and capital expenditures (Fixed assets utilization -31.6%) characteristics experienced reduction. EBITDA margin with average value around 4% was the most stable one across Agro-Food supply chain (only +4.9% change).

If we focused for simplicity and comparability on the most commonly used metric, i.e. cash conversion cycle, it can be stated that there is with high probability a leading sector within the Czech Agro-Food supply chain. Retail sale sector with its shortest cash conversion cycle (10,45 days in 2018), thus the lowest share on the total Czech Agro-Food supply chain cash conversion cycle (7,7% in 2018), reinforcing its position even further by reducing length of its cash conversion cycle over the respective period of time (-19%) seems to be leading sector. Above stated findings are suggesting that within the Czech Agro-Food supply chain self-serving approach seems prevailing, i.e., leading most influential sector optimize it performance at the expenses of other downstream supply chain partners.

These results confirm findings obtained by Lobisher and Rothbock (2006) that studied almost 7.000 European companies including "Food stores" over the decade (1995-2004). The European Food stores (similar to Retail sale sector) have experienced significant reduction of cash conversion cycle from 1,5 days in 1995 to -11,6 days in 2004.

Conclusion

The intention of this text was to define the Czech Agro-Food financial supply chain and develop economic metrics in order to quantified potential economic value added generation and distribution among participating sectors within supply chain network.

Hypothesis 1 is valid only partly. Retail sale sector, which can be considered as an "interface" between the Czech Agro-Food financial supply chain and final customer is generating high shareholder value (cash conversion cycle lowest values, the second lowest fixed assets utilization, highest revenues growth and stable profitability). Contrary to it, Wholesale sector is experiencing deteriorating of shareholder value over the respective period of time by reinforcement of capital intensity measures (cash conversion cycle prolongation and fixed assets utilization increase) accompanied with very low profitability level. Special case is primary agricultural production (Agro), where expectations of very low shareholder value (the most remote sector from final customer within predefined financial supply chain) is offset by significant public transfers influencing all value drivers either directly or non-directly.

As can be seen from the text above, all value drivers are constantly changing over the respective period of time (years 2011-2018), both on single sector and financial supply chain network level leading to conclusion that financial supply chain is dynamic in its nature. Thus hypothesis 2 has to be rejected.

As already mentioned, primary agricultural production (Agro) faced specific conditions due to the significant public transfers in the form of subsidies etc. influencing non/directly all shareholders value drivers consequently reducing originally expected vulnerability. Especially overall sector profitability is driven by these transfers serving as "cushions" for related capital intensity.

Therefore hypothesis 3 has to be rejected.

Since, we employed four main value drivers influencing companies' economic value added, namely revenues growth, operating margin, cash conversion cycle and fixed assets utilization similar to Effinger et al. (2011), Hall (2018) instead of one single measure, the interpretation of obtained results may not be so straightforward.

Nevertheless, based on the comparison of obtained values of all employed value driver's metric, it seems that generation of shareholder value is not evenly distributed within the Czech Agro-Food supply chain and these "scissors" are expending over the respective period of time in favour of Retail sector (sector closes to the final customer) at the expense of others, especially of Agro sector.

These findings are rising further questions about organization and management of the Czech Agro-Food supply chain. More detail elaboration and research on potential optimization that would benefit all supply chain counterparts and overcome current rather "self-serving" approach of supply chain echelons would be desired and needed.

Acknowledgements

We would like to thank to Česká spořitelna, a.s. for its support and making the sample of its internal client database available for this research. This paper and conclusions present solely authors´ opinions and they do not present any official statement of Česká spořitelna, a.s.

Corresponding authors
Jana Hinke
Department of Trade and Finance, Faculty of Economics and Management
Czech University of Life Sciences, Prague, Kamýcká 129, 165 00, Prague 6, Czech Republic
Phone: +420 224 382 249, E-mail: hinke@pef.czu.cz

References

[1] Agricultural Markets Task Force (2016) "*Improving Market Outcomes: Enhancing the Position of Farmers in the Supply Chain*", Nov. 2016. [Online]. Available: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/ amtf-report-improving-markets-outcomes_en.pdf [Accessed: Feb. 20, 2021].

[2] Balakrishnan, K., Shivakumar, L. and Taori P. (2021) "Analysts' estimates of the cost of equity capital", *Journal of Accounting & Economics*, Vol. 71, No. 2-3. ISSN 0165-4101. DOI 10.2139/ssrn.3724862.

[3] Baud, C. and Durand., C. (2012) "Financialization, globalization, and the making of profits by leading retailers", *Socio-Economic Review*, Vol. 10, pp. 241-266. ISSN 1475-1461. DOI 10.1093/ser/mwr016.

[4] Beyer, D. and Hinke, J. (2020) "European benchmarking of determinants of profitability for companies with accrual accounting in the agricultural sector", *Agricultural Economics-Czech*, Vol. 66, No. 11, pp. 477-488. ISSN 0139-570X. DOI 10.17221/128/2020-AGRICECON.

[5] Blackman, I. D. and Holland, C. (2006) "The Management of Financial Supply Chains: From Adversarial to Cooperative Strategies", In: Suomi, R., Cabral, R., Hampe, J. F., Heikkilä, A., Järveläinen, J. and Koskivaara, E. (eds) "*Project E-Society: Building Bricks*", IFIP International Federation for Information Processing, 226. Springer, Boston, MA. ISBN 978-0-387-39229-5. DOI 10.1007/978-0-387-39229-5_8.

[6] Chakuu, S., Masi, D., and Godsel, J. (2019) "Exploring the relationship between mechanisms, actors and instruments in supply chain finance: A systematic literature review", *International Journal of Production Economics*, Vol. 216, pp. 35-53. ISSN 0925-5273. DOI 10.1016/j.ijpe.2019.04.013.

[7] Crotty, J. (2009) "Structural causes of the global financial crisis: a critical assessment of the 'new financial architecture' ", *Cambridge Journal of Economics*, Vol. 33, No. 4, pp. 563-580. ISSN 0309-166X. DOI 10.1093/cje/bep023.

[8] Deepa, N., Sivakumar, S. D., Deshmukrh, S. S. and Malarkodi, M. (2016) "Influence of Cash Conversion Cycle on Financial Performance of Coconut Oil Mills in Western Tamil Nadu", *Indian Journal of Economics and Development*, Vol. 12, No. 1, pp. 143-150. ISSN 2277-5412. DOI 10.5958/2322-0430.2016.00016.0.

[9] Effinger, A., Natarajarathinam, M., Adams, F. G., Gray, J. B., Hofman, D. and O'Marah, K. (2011) "Supply Chain Management Competency and Firm Financial Success", *Journal of Business Logistics*, Vol. 32, No. 3, pp. 214-226. ISSN 0735-3766. DOI 10.1111/j.2158-1592.2011.01018.x.

[10] Elrod, C., Murray S. and Bande, S. (2013) "A Review of Performance Metrics for Supply Chain Management", *Engineering Management Journal*, Vol. 25, No. 3, pp. 39-50. ISSN 1042-9247. DOI 10.1080/10429247.2013.11431981.

[11] Gambelli, D., Solfanelli, F., Orsini, S. Solfanelli, F., Orsini, S. and Zanoli, R. (2021) "Measuring the Economic Performance of Small Ruminant Farms Using Balanced Scorecard and Importance-Performance Analysis: A European Case Study", *Sustainability*, Vol. 13, No. 6. E-ISSN 2071-1050. DOI 10.3390/su13063321.

[12] Grau, A. and Reig, A. (2020) "Operating leverage and the cost of debt in European agri-food firms", *Spanish Journal of Agricultural Research*, Vol. 18, No. 3. ISSN 1695-971X. DOI 10.5424/sjar/2020183-16254.

[13] Hall, J. H. (2018) "Value creation measures: an industry-based study", *International Journal of Productivity and Performance Management*, Vol. 67, No. 2, pp. 426-444. ISSN 1741-0401. DOI 10.1108/IJPPM-08-2016-0178.

[14] Hofmann, E. and Kotzab, H. (2010) "A Supply Chain-Oriented Approach of Working Capital Management", *Journal of Business Logistics*, Vol. 31, pp. 305-330. ISSN 0735-3766. DOI 10.1002/j.2158-1592.2010.tb00154.x.

[15] Ibragimov, R. G., and Velez-Pareja, I. (2019) "Toward Better Measurement of Financial Performace: a robust OEVA-TEVA Alternative to Biased EVA", *Rossijskij Zurnal Menedzhmenta - Russian Management Journal*, Vol. 17, No. 2, pp. 139-158. ISSN 1729-7427. DOI 10.21638/spbu18.2019.201.

[16] Isakson, S. R. (2014) "Food and finance: the financial transformation of agro-food supply chains", *Journal of Peasant Studies*, Vol. 41, No. 5, pp. 749-775. ISSN 0306-6150. DOI 10.1080/03066150.2013.874340.

[17] Jirsak, P. (2018) "Analyzing an impact of industry 4.0 on logistics and supply chain", In: *Analyzing the Impacts of Industry 4.0 in Modern Business Environments*, pp. 121-146. ISBN 978-152253468-6. DOI 10.4018/978-1-5225-3468-6.ch007.

[18] Krippner, G. (2005) "The financialization of the American economy", *Socio-Economic Review,* Vol. 3, No. 2, pp. 173-208. Nov. 2005. [Online]. Available: https://ssrn.com/abstract=811461 [Accessed: Nov. 18, 2021]. DOI 10.1093/SER/mwi008.

[19] Kučera, J., Vochozka, M. and Rowland, Z. (2021) "The Ideal Debt Ratio of an Agricultural Enterprise", *Sustainability*, Vol. 13, No. 9. E-ISSN 2071-1050. DOI 10.3390/su13094613.

[20] Lambert, D.M. and Burduroglu, R. (2000) "Measuring and Selling the Value of Logistics", *The International Journal of Logistics Management*, Vol. 11, No. 1, pp. 1-18. ISSN 09574093. DOI 10.1108/09574090010806038.

[21] Lind, L., Pirttilä, M., Viskari, S., Schupp, F. and Kärri, T. (2012) "Working capital management in the automotive industry: Financial value chain analysis", *Journal of Purchasing and Supply Management*, Vol. 18, No. 2, pp. 92-100. ISSN 1478-4092. DOI 10.1016/j.pursup.2012.04.003.

[22] Losbichler, H., Mahmoodi, F. and Rothboeck, M. (2008) "Creating Greater Shareholder Value from Supply Chain Initiatives", *Supply Chain Forum: International Journal*, Vol. 9, No. 1, pp. 82-91. ISSN 1625-8312. DOI 10.1080/16258312.2008.11517192.

[23] Maia, J. L. and Di Serio, L.C. (2017) "A multi-source bibliometric analysis about shareholder value generation and project, portfolio and program management", *Revista De Gestao E Projetos*, Vol. 8, No. 2, pp. 87-108. ISSN 2236-0972. DOI 10.5585/gep.v8i2.466.

[24] Mokrejšová, V., Filipová, A. and Zeman, J. (2018) "Effects of food supply chain regulation", *Argumenta Oeconomica*, Vol. 41, No. 2, pp. 337-356. ISSN 1233-5835. DOI 10.15611/aoe.2018.2.15.

[25] Oleghe, O. (2019) "System dynamics analysis of supply chain financial management during capacity expansion", *Journal of Modellin in Management*, Vol. 15, No. 2, pp. 623-645. ISSN 1746-5664. DOI 10.1108/JM2-05-2019-0100.

[26] Otekunrin, A. O., Nwanji, T. I., Olowookere, J. K., Lawal, A. I., Oye, O. O., Agba, D. Z., Falaye, A. J. and Awonusi, F. D. (2018) "Liquidity and Profitability of Selected Qouted Agricultural and Agro-Allied firms in Nigeria", In: *32nd Conference of the International-Business-Information-Management-Association (IBIMA)*, Spain: Seville, pp. 8494-8505. ISBN 978-0-9998551-1-9.

[27] Pohlen, T. L. and Coleman, B. J. (2005) "Evaluating Internal Operations and Supply Chain Performance Using EVA and ABC", *S.A.M. Advanced Management Journal*, Vol. 7, No. 2, pp. 45-59. [Online]. Available: https://www.proquest.com/openview/6994708dd9465a49d2fae2da92641be1/1?pq-origsite=gscholar&cbl=40946 [Accessed: Jan. 23, 2021].

[28] Redlichová, R., Chmelíková, G., Blažková, I. and Tamáš, V. (2019) "Role of Companies' Size in Socio-Economic Development of Regions in the Czech Republic", *Ekonomski Pregled,* Vol. 70, No. 6, pp. 833-848. E-ISSN ISSN 1848-9494, ISSN 0424-7558. DOI 10.32910/ep.70.6.2.

[29] Richards, V. and Laughlin, E. (1980) "A Cash Conversion Cycle Approach to Liquidity Analysis", *Financial Management*, Vol. 9, No. 1, pp. 32-38. [Online]. Available: http://www.jstor.org/stable/3665310 [Accessed: Feb. 12, 2021]. DOI 10.2307/3665310.

[30] Stern, J. M. (1990) "One way to build value in your firm, a la executive compensation", *Financial Executive*, Vol. 6, No. 6. ISSN 0895-4186.

[31] Viskari, S., Pirttilä, M. and Kärri, T. (2011) "Improving profitability by managing working capital in the value chain of pulp and paper industry", *International Journal of Managerial and Financial Accounting*, Vol. 3, No. 4, pp. 348-366. ISSN 1753-6715. DOI 10.1504/IJMFA.2011.043333.

[32] Wheelen, T. L. and Hunger, D. J. (2012) "*Strategic Management and Business Policy*", 13th ed. Prentice-Hall, Pearson Education Limited, New Jersey. ISBN 978-0-13-215322-5.

[33] Zhao, X., Wang, P. and Pal, R. (2021) "The effects of agro-food supply chain integration on product quality and financial performance: Evidence from Chinese agro-food processing business", *International Journal of Production Economics*, Vol. 231. ISSN 0925-5273. DOI10.1016/j.ijpe.2020.107832.

Agris on-line Papers in Economics and Informatics

Volume XIV Number 3, 2022

Agris on-line Papers in Economics and Informatics

The international reviewed scientific journal issued by the Faculty of Economics and Management of the Czech University of Life Sciences Prague.

http://online.agris.cz

ISSN 1804-1930